Review of Environmental Factors

South Jerrabomberra 132 kilovolt Powerline

Project No. 499313

May 2023

Revision History	
Version	**Nature of Revision**
Draft01	Draft prepared for Essential Energy's Environmental Services peer review.
Final	Final version for Essential Energy determination

Contact: Brett Hayward

E: brett.hayward@essentialenergy.com.au

Essential Energy ABN 37 428 185 226

PO Box 5730
Port Macquarie NSW 2444

Table of Contents

Tables

Figures

Acronyms and Abbreviations

AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
ADSS	All-dielectric self-supporting. A type of fibre optic cable which is nonconductive, self-supporting and is capable of being erected under tension between supports.
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASS	Acid Sulfate Soils
AASS	Actual Acid Sulfate Soils
AEMO	Australian Energy Market Operator
BDAR	Biodiversity Development Assessment Report
CEMP	Construction Environmental Management Plan
Consequence	The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain.
dB(A)	Decibels (A) weighted
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DPE	Department of Planning and Environment
DP	Deposited Plan
EMF	Electric and Magnetic Fields
Environmental Aspect	Any element of an organisation’s activities, products or services that can interact with the environment.
Environmental Impact	Any change in the environment whether adverse or beneficial, wholly or partially resulting from organisation activities, products or services.
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Reg	*Environmental Planning and Assessment Regulation 2021*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPIs	Environmental Planning Instruments
ES Act	*Electricity Supply Act 1995*
ESD	Ecologically Sustainable Development
EWP	Elevated Work Platforms
FSC	Field Service Centre (Essential Energy)
FM Act	*Fisheries Management Act 1994*
GHG	Greenhouse Gas

Ha	Hectare
IPC	Independent Planning Commission
kV	Kilovolts
LALC	Local Aboriginal Land Council
Likelihood	A qualitative description of probability or frequency
LEP	Local Environmental Plan
LG Act	*Local Government Act 1993*
LGA	Local Government Area
mG	Milligauss
MVA	Mega Volt Amps
NES	National Environmental Significance
NO_X	Oxides of Nitrogen
NPW Act	*National Parks and Wildlife Act 1974*
PASS	Potential Acid Sulfate Soils
POEO Act	*Protection of the Environment Operations Act 1997*
REF	Review of Environmental Factors
RF Act	*Rural Fires Act 1997*
Roads Act	*Roads Act 1993*
RMS	Roads and Maritime Service
SCADA	Supervisory control and data acquisition. A computer-based system for gathering and analysing real-time data to monitor and control equipment that deals with critical and time-sensitive materials or events.
SEE	Statement of Environmental Effects
SEPP	State Environmental Planning Policy
SHI	State Heritage Inventory
SHR	State Heritage Register
SIS	Species Impact Statement
SWMP	Soil and Water Management Plan
T&I SEPP	*State Environmental Planning Policy (Transport and Infrastructure) 2021*
WM Act	*Water Management Act 2000*

Review of Environmental Factors Approval Form

REF name	South Jerrabomberra 132 kilovolt Powerline Project No. 499313
REF prepared by	Brett Hayward
Title	Environmental Services Manager
Qualifications	Bachelor of Environmental Science Master of Environmental Law (with Merit)
Proponent Name	Essential Energy
Proponent Address	8 Buller St Port Macquarie NSW 2444

This Review of Environmental Factors (REF) assesses the potential impacts that may result from the proposed and associated activities as outlined in “Description of the Proposal” section of this report.

Essential Energy is a state-owned corporation and is a determining authority as defined in the *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal satisfies the definition of an ‘activity’ under the EP&A Act, and as such Essential Energy must assess and consider the environmental impacts of the proposal before determining whether to proceed. This REF has been prepared in accordance with section 5.5 of the EP&A Act and clause 171 of the *Environmental Planning and Assessment Regulation 2021* (EP&A Reg). The EP&A Act requires Essential Energy to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity. The EP&A Reg sets out environmental factors to be considered in making that assessment. If the activity is considered likely to significantly affect the environment, additional assessment requirements under the EP&A Act would be required.

Section 5.7 of the EP&A Act states that a determining authority shall not carry out an activity, or grant an approval in relation to an activity, that is likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats, unless the determining authority has examined and considered an Environmental Impact Statement or Species Impact Statement in respect of the activity.

The REF has addressed the matters that are required to be considered by Part 5 of the EP&A Act, with the conclusion that if the activity is carried out as described, it is not likely to have a significant effect on the environment (including critical habitat) or threatened species, populations, ecological communities or their habitats, and accordingly an Environmental Impact Statement is not required. The mitigation strategies forming part of the activity are fully considered and discussed in the REF.

The activity was also assessed against the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). As the proposed activity will not have, and is not likely to have, a significant impact on matters of national environmental significance, a referral to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) is not required.

The proposed activity is permissible under all relevant state and federal legislation, including the EPBC Act and the *Biodiversity Conservation Act 2016* (NSW) (BC Act).

Under *State Environmental Planning Policy (Transport and Infrastructure) 2021* (T&I SEPP) the activity is classified as development for the purpose of an electricity transmission or distribution network undertaken by or on behalf of a public authority, and is hence permitted on the land without the requirement for development consent.

Declaration

The Review of Environmental Factors for the proposed activity has been assessed by Essential Energy.

Considering the assessment of the impacts, including sections 1.7 and 5.5 of the *Environmental Planning and Assessment Act 1979* and clause 171 of the *Environmental Planning and Assessment Regulation 2021*, it is concluded that:

- there is not likely to be a significant environmental effect as a result of the construction, operation and maintenance of the activity, and an Environmental Impact Statement is not required; and
- a Species Impact Statement (SIS), or Biodiversity Development Assessment Report (BDAR), is not required.

<table>
<tr><td colspan="2">Site and Assessment Review – I affirm that the information provided within this assessment is accurate to the best of my knowledge, belief and information.</td></tr>
<tr><td>Brett Hayward Digitally signed by Brett Hayward
Date: 2023.05.23 15:15:01 +10'00'

Brett Hayward
Environmental Services Manager
(Author)
Date:</td><td>Chris Dunn Digitally signed by Chris Dunn
Date: 2023.05.23 15:45:49 +10'00'

Chris Dunn
Environmental Engineer
(Peer Review)
Date:</td></tr>
</table>

<table>
<tr><td colspan="2">The assessment has been reviewed and it is recommended that the Activity may now proceed subject to the implementation of the recommendations and mitigation measures contained in the REF documentation.</td></tr>
<tr><td>Peter van Niekerk
Project Manager
Date:</td><td>Peter van Niekerk Digitally signed by Peter van Niekerk
Date: 2023.05.23 15:51:23 +10'00'</td></tr>
</table>

<table>
<tr><td>1. Considering the assessment of the impacts, including sections 1.7 and 5.5 of the Environmental Planning and Assessment Act 1979 and clause 171 of the Environmental Planning and Assessment Regulation 2021, it is determined that there is not likely to be a significant environmental effect as a result of the construction, operation and maintenance of the South Jerrabomberra 132/11kV Zone Substation. Neither an Environmental Impact Statement (EIS), nor SIS, nor BDAR is required.

2. The Activity may now proceed subject to obtaining and complying with the relevant approvals as identified in the REF, and subject to the implementation of the recommendations and mitigation measures contained in the REF documentation.</td></tr>
<tr><td>Amalie Smith Digitally signed by Amalie Smith
Date: 2023.05.24 12:41:12 +10'00'

Amalie Smith
Chief Human Resources Officer
Date:</td></tr>
</table>

Executive Summary

Background / Justification

Essential Energy is proposing to design, construct, operate and maintain a new section of electricity network, known as the South Jerrabomberra High Voltage Supply Project (SJHVSP). The SJHVSP will deliver electricity supply to the new South Jerrabomberra Development Project (SJDP). When complete, the SJDP will deliver 1,500 residential lots, a business park, industrial estate, Innovation Precinct, Regional Sports Complex, and a new high school to the Jerrabomberra area. It will also house NSW's third Regional Job Precinct, creating regional economic opportunities and job growth in the area.

The SJHVSP involves the construction of approximately 6 kilometres (km) of new dual circuit 132 kilovolt (kV) powerline from near TransGrid's Queanbeyan Bulk Supply point (BSP), located in the Australian Capital Territory (ACT) (Oaks Estate), south through a non-operational rail corridor in New South Wales (NSW), and connecting to a new 132/11kV Zone Substation (ZS) located within the Poplars Innovation Precinct (PIP), which forms part of the broader SJDP. The proposed new 132kV dual circuit powerline is the subject of this Review of Environmental Factors (REF) report, with the proposed new 132/11kV ZS being assessed under a separate REF.

Construction and operation of the new SJHVSP will ensure the local electricity infrastructure meets the current and future needs of the new SJDP. The new SJHVSP will also strengthen Essential Energy's existing electricity network in the broader area, as well as increase its capacity, which will help support future electricity connections. The South Jerrabomberra development will allow thousands of new customers to connect to Essential Energy's network, which will ultimately contribute to reducing electricity prices for all customers and increase network reliability.

The Proposal

The proposal comprises the construction, operation and maintenance of a new dual circuit 132kV powerline from the NSW border to the proposed new South Jerrabomberra 132/11kV ZS (subject to a separate REF). The project will support the SJDP and strengthen Essential Energy's electricity network in the broader area.

A small 230 metre (m) section of the powerline and its connection point into the existing 975 powerline to the east of TransGrid's BSP is within the ACT, and will be subject to ACT planning and assessment processes. An environmental impact statement (EIS) has been prepared and submitted, and a development application lodged for this small component within the ACT.

The proposal will involve the construction of a new dual circuit overhead powerline from the NSW border, south into a currently disused railway corridor where it will be located to the northern and western side of the railway corridor immediately adjoining the NSW/ACT border. Towards the southern end of the route, near Lanyon Drive, the powerline will extend in an easterly direction across Queanbeyan Nature Reserve (QNR) and the intersection of Lanyon Drive and Tompsitt Drive. After crossing this intersection, the powerline will change to an underground configuration and will either extend along the northern side of Tompsitt Drive, or proceed diagonally to the southern side of Tompsitt Drive. The unground powerline will then extend through an easement across Lot 6 of the PIP subdivision and into the substation land parcel (Lot 5).

Project Alternatives

One option would be to refrain from undertaking any further development of the network in the area. The consequences of Essential Energy doing nothing would render the SJDP unviable due to supply constraints associated with the existing electrical infrastructure. Due to Essential Energy's network licence obligations, the 'do nothing' option is not a viable alternative to the proposed new SJHVSP, of which the proposed new 132kV dual circuit powerline is a vital component.

Planning for the electricity supply to the SJDP area began in 2007 in response to an invitation to Essential Energy to comment on the Tralee Local Environmental Plan. Several options to supply the development were canvassed including supply from the TransGrid and ACT (Actew AGL) networks. Over several years, multiple route options were investigated leveraging Essential Energy's existing network configuration. In 2021, the final preferred route of the powerline that had the least societal and environmental impacts was identified as the inactive rail corridor along the ACT and NSW border. The location of the powerline alignment and the ZS site has been selected to facilitate a connection to the preferred powerline route, be in close proximity to high demand customers, and minimise environmental impacts.

Statutory Planning and Legislation

Clause 2.44 of *State Environmental Planning Policy (Transport and Infrastructure) 2021* (T&I SEPP) applies to electricity transmission and distribution activities undertaken by an energy supply authority. Clause 2.44 states that development for the purpose of a transmission or distribution network may be carried out by or on behalf of an electricity supply authority or public authority without consent on any land, with additional requirements for land reserved under the *National Parks and Wildlife Act 1974*.

As the activity does not require development consent, Essential Energy is the designated determining authority. Additionally, whilst Essential Energy does not require development consent to undertake the proposed activity, it has an obligation under Part 5, Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to consider the environmental impacts of the activity.

Specifically, Essential Energy has a statutory obligation to examine and take into account, to the fullest extent possible, all matters affecting or likely to affect the environment by reason of this activity. This REF has been prepared to facilitate the determination through consideration of the relevant factors specified in section 5.5 of the EP&A Act, clause 171 of the *Environmental Planning and Assessment Regulation 2021*(EP&A Reg) and Department of Planning and Environment Guidelines for Division 5.1 Assessments (DPE Guideline).

Environmental Impact Assessment

This REF has been prepared in accordance with Part 5, Division 5.1 of the EP&A Act to assess the environmental impacts associated with the construction, operation and maintenance of the proposed activity. The REF has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the project.

A number of potential environmental impacts associated with the project have been avoided or reduced to acceptable levels during the design development and assessment stages. However, the project may still result in some impacts including ecology, noise, vegetation, traffic, waste generation, and visual amenity during construction and operation, as outlined in **Section 6**. Management and mitigation measures to alleviate these impacts have been developed as part of this REF and would be implemented during construction and operation of the proposal.

Considering the assessment of the impacts detailed in this REF, it is concluded that the proposed activity is not likely to have a significant impact on the environment. On balance, the project is justified on the basis of supporting the SJDP and strengthening Essential Energy’s electricity network in the broader area, whilst minimising potential environmental impacts.

1. Introduction

1.1 The Proposal

This Review of Environmental Factors (REF) assesses the potential environmental impacts associated with the construction, operation and maintenance of the proposed South Jerrabomberra 132 kilovolt (kV) dual circuit powerline project. The significance of impact has been determined and appropriate mitigation measures recommended.

1.2 Context and Justification of the Proposal

Essential Energy is proposing to design, construct, operate and maintain a new section of electricity network, known as the South Jerrabomberra High Voltage Supply Project (SJHVSP). The SJHVSP will deliver electricity supply to the new South Jerrabomberra Development Project (SJDP). When complete, the SJDP will deliver 1,500 residential lots, a business park, industrial estate, Innovation Precinct, Regional Sports Complex and a new high school to the Jerrabomberra area. It will also house NSW's third Regional Job Precinct, creating regional economic opportunities and job growth in the area.

The SJHVSP involves the construction of approximately 6 kilometres (km) of new dual circuit 132 kV powerline from near TransGrid's Queanbeyan Bulk Supply point (BSP), located in the Australian Capital Territory (ACT) (Oaks Estate), south through a non-operational rail corridor in New South Wales (NSW), and connecting to a new 132/11kV Zone Substation (ZS) located within the Poplars Innovation Precinct (PIP), which forms part of the broader SJDP. The proposed new 132kV dual circuit powerline is the subject of this REF report, with the proposed new 132/11kV ZS being assessed under a separate REF.

Construction and operation of the new SJHVSP will ensure the local electricity infrastructure meets the current and future needs for the new SJDP. The new SJHVSP will also strengthen Essential Energy's existing electricity network in the broader area, as well as increase its capacity, which will help support future electricity connections. The South Jerrabomberra development will allow thousands of new customers to connect to Essential Energy's network, which will ultimately contribute to reducing electricity prices for all customers and increase network reliability.

Refer to **Figure 1-1** and **Figure 1-2** for an overview of the SJDP.

1.3 Network Investment Criteria

Network asset investment by Essential Energy is generally required to:

- Meet Essential Energy's duty of care
- Connect customers to the supply network and
- Provide a satisfactory standard of supply to customers.

The overall performance of the network is driven by the reliability of individual network components and the redundancy provided by the network to enable maintenance of supply at times when critical parts of the network are out of service (due to maintenance or repair requirements). To maintain acceptable standards of customer service it is necessary to ensure:

- Infrastructure performance (reliability) is maintained at acceptable levels and
- The network design provides adequate security (redundancy).

The reliability performance of equipment and infrastructure is managed through maintenance and replacement of that infrastructure and construction of new infrastructure. For Essential Energy, the decision to replace or construct new infrastructure is based on an assessment of equipment condition and consideration of the strategic needs of the network.

1.4 Proposal Objectives

The primary objective of the project is to design, construct, operate and maintain a 132kV dual circuit powerline, which will form part of the SJHVSP to service the SJDP, while also strengthening Essential Energy's existing electricity network in the broader area. Secondary objectives associated with the project are to:

- Maximise social and economic benefits and minimise the environmental and social impacts.

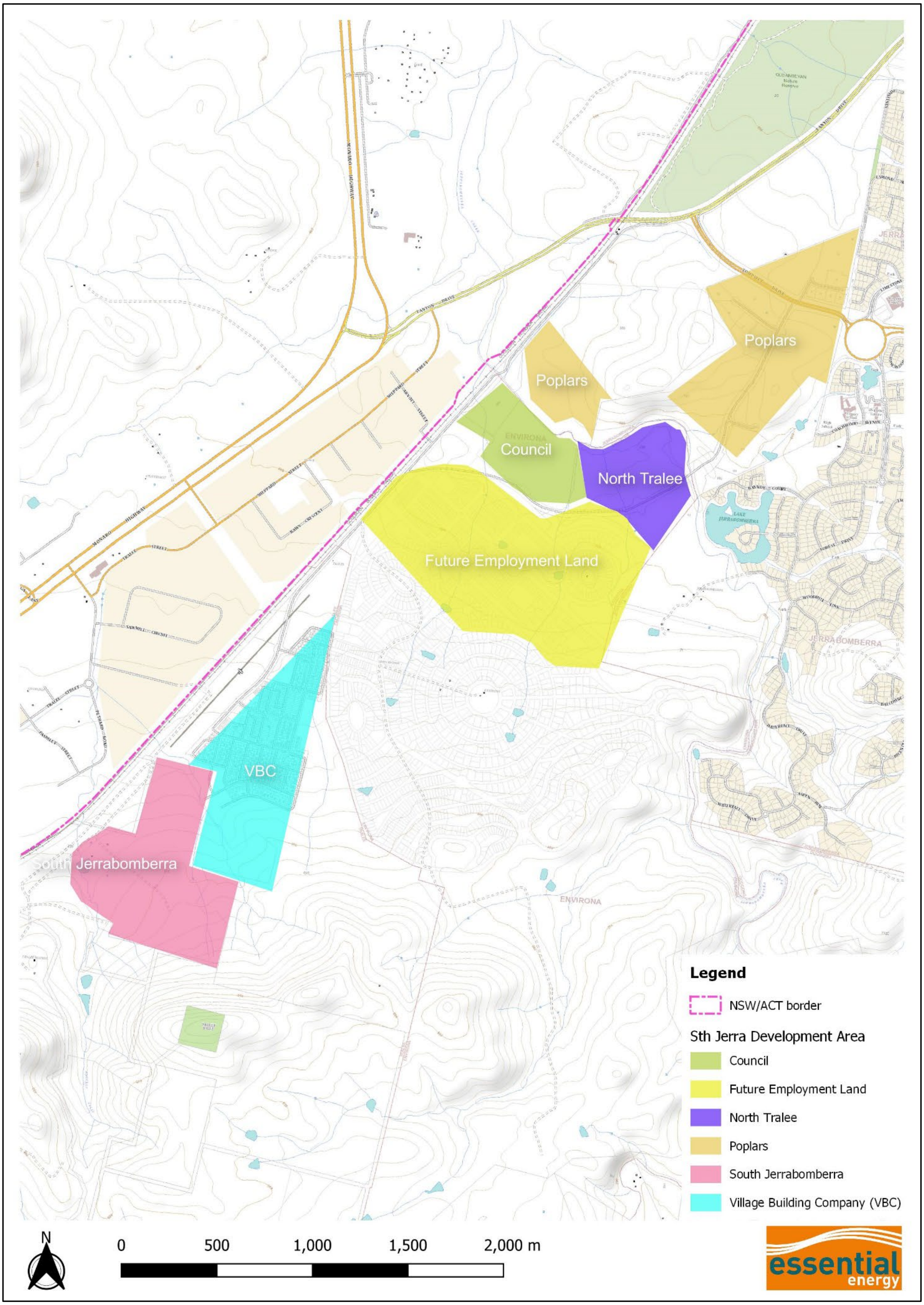


Figure 1-1: Overview of SJDP lands

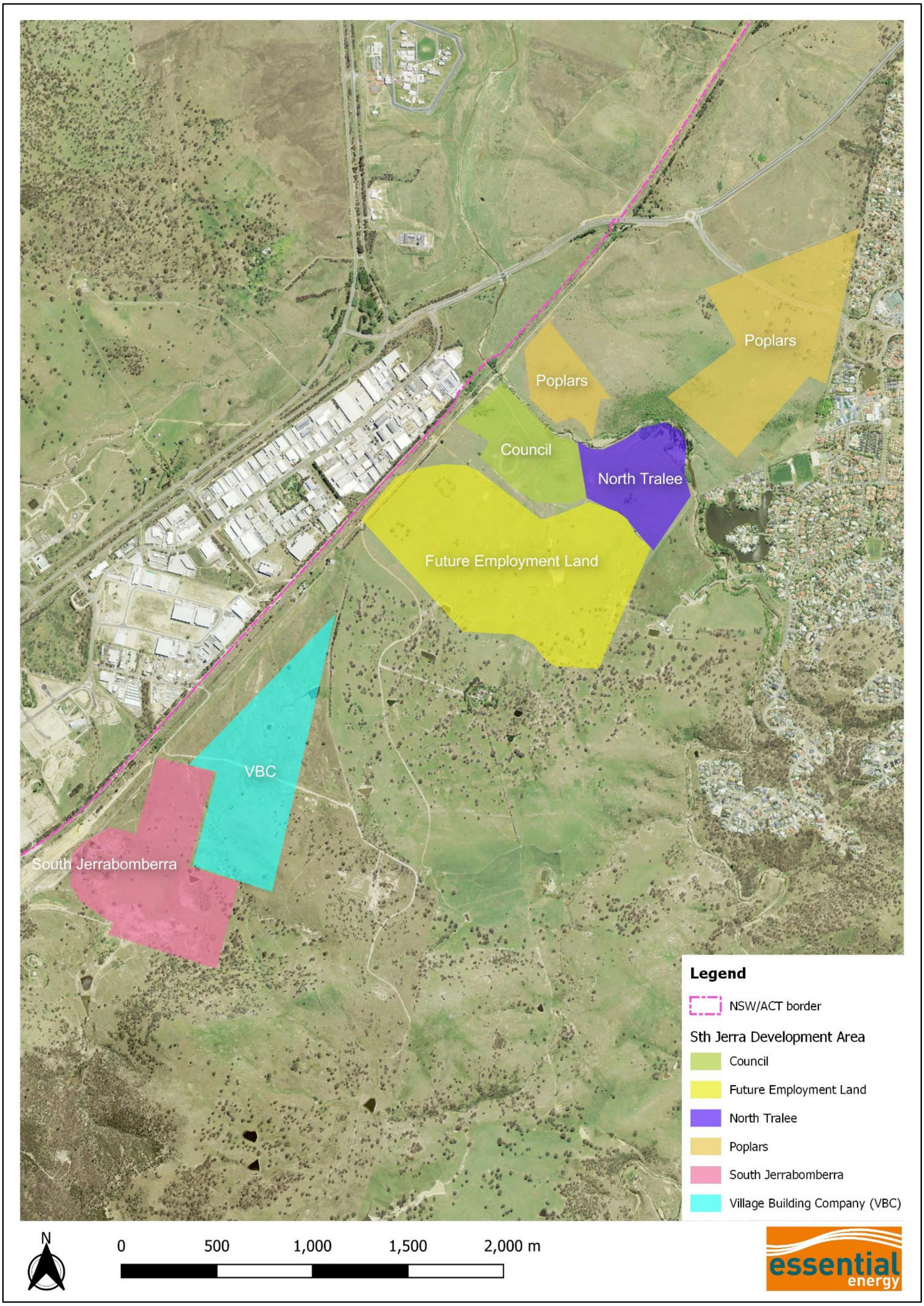


Figure 1-2: Overview of SJDP lands (aerial)

1.5 Proposal Site

The proposal site extends along an approximately 6km route from within the ACT and into NSW. The ACT component involves the erection of six poles (numbered one through to six) at three locations across a small 230 metre (m) section in the ACT. Pole locations within the ACT are within highly disturbed and exotic grasslands with no vegetation clearing required, with the exception of the pole/pad locations and any extension to access tracks. Such clearing would be limited to exotic ground/grass species.

No Aboriginal objects are likely to be harmed in the ACT, with limited impact upon pink tailed worm lizard habitat.

From poles numbered seven and eight, the powerline is contained wholly within NSW and this component is the subject of this REF. The powerline within NSW is largely contained within an existing highly disturbed and currently disused railway corridor. To minimise visual impacts, the powerline has been designed to sit within the northern and western side of the railway corridor. This location will maximise the distance between the poles and residences within the Crestwood residential area, and maintain the current railway corridor vegetation/tree screening along Henderson Road.

The condition of the railway corridor can be characterised as a highly disturbed landscape with some opportunistic re-growth comprising a mix of native an exotic species. There are pockets of high ecological value with some sections comprising habitat for threatened flora species and threatened ecological communities. Threatened fauna species habitat is also present.

Once in the railway corridor, the alignment heads in a generally west-southwesterly direction along the northern side of the railway corridor. This section, and the immediate adjoining land, has been subject to various disturbance activities including the installation of powerlines and other infrastructure. Near Canberra Avenue, the alignment extends in a southwesterly direction past HMAS Harmon, with the Queanbeyan industrial area to the distant east (other side of the railway corridor).

The alignment landscape then changes to a more rural outlook with large lots and the Queanbeyan Racecourse. Further south, the landscape comprises conservation lands on either side of the railway corridor, with the Queanbeyan Nature Reserve (in NSW) to the east, and the Jerrabomberra East Grasslands Nature Reserve (in the ACT) to the west. Approximately 200m to the north of Lanyon Drive, the powerline extends in an easterly direction towards the Lanyon Drive and Tompsitt Drive intersection. After crossing the intersection, the powerline changes to an underground configuration and will either continue along the northern side of Tompsitt Drive before entering the substation land parcel via Lot 6 of the PIP subdivision, or proceed in a diagonal manner to the southern side road reserve, before entering the substation site (Lot 5) via Lot 6 in the PIP subdivision.

Excluding the small section in the ACT, the proposal sits within the Queanbeyan-Palerang Regional Council (QPRC) Local Government Area (LGA), comprising the following zones according to the *Queanbeyan-Palerang Regional Local Environmental Plan 2022* (QPR LEP):

- SP2 Infrastructure (rail corridor and Tompsitt Drive road reserve)
- E1 (taken to be C1) National Parks and Nature Reserves (QNR) and
- B7 Business Park (PIP).

Figure 1-3 to **Figure 1-6** provide an overview of the broader area site context, including land use zonings and proximity of the activity in relation to the SJDP lands.

1.6 Study Area

The broader study area includes the surrounding predominantly cleared rural areas, and the urban areas of Jerrabomberra to the east. Sensitive environmental areas within the broader region include waterways, wetlands, biodiversity, Aboriginal and non-Aboriginal heritage, and other environmental values, that form part of the immediate surrounding landscape.

1.7 Purpose of REF

The purpose of this REF is to document the assessment of potential environmental impacts of the proposal, and identify if there are likely to be any significant environmental impacts. It informs Essential Energy's determination of the proposal under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

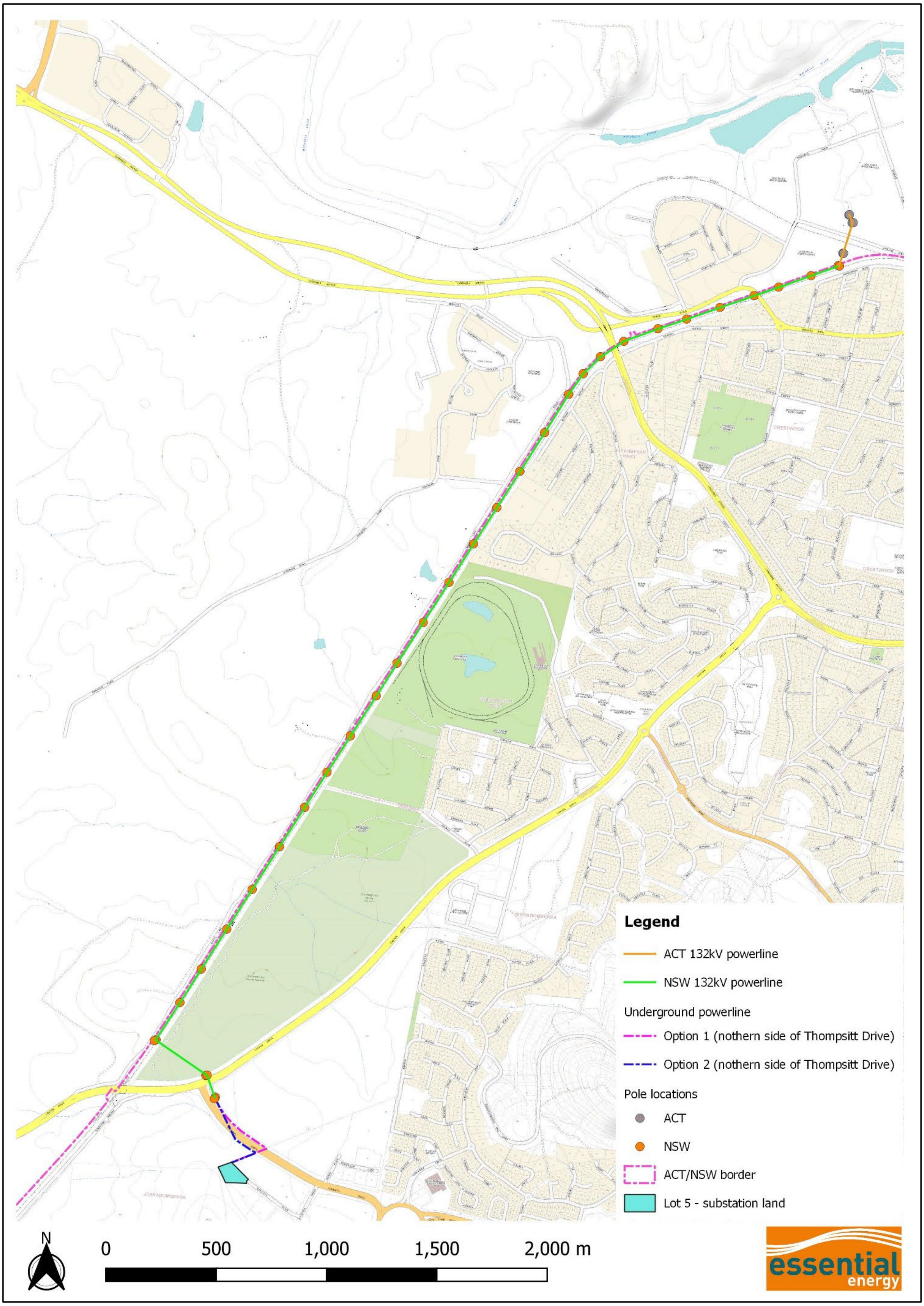


Figure 1-3: Overview of proposed activity components

Figure 1-4: Overview of proposed activity components (aerial)

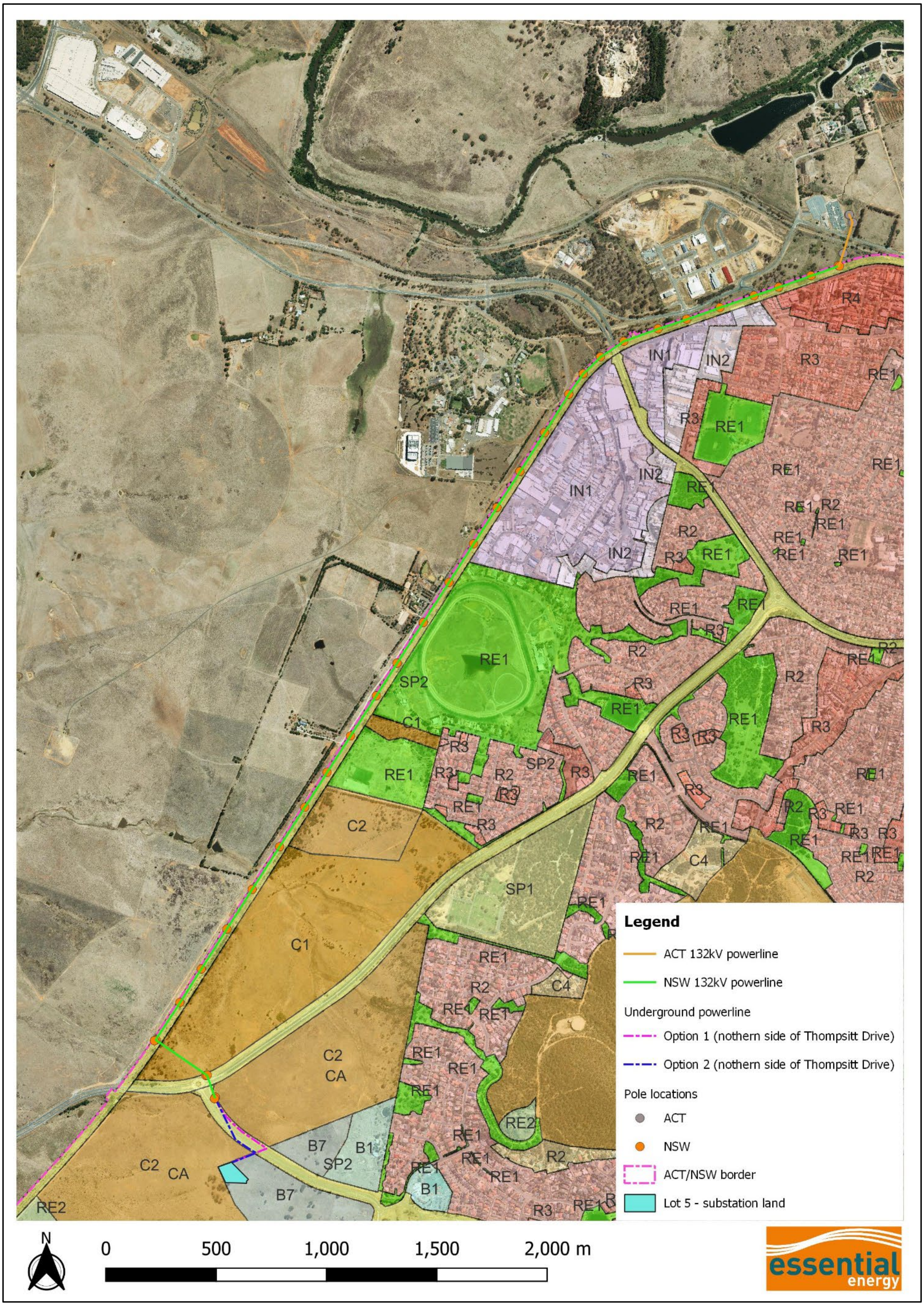


Figure 1-5: QRP LEP land use zones

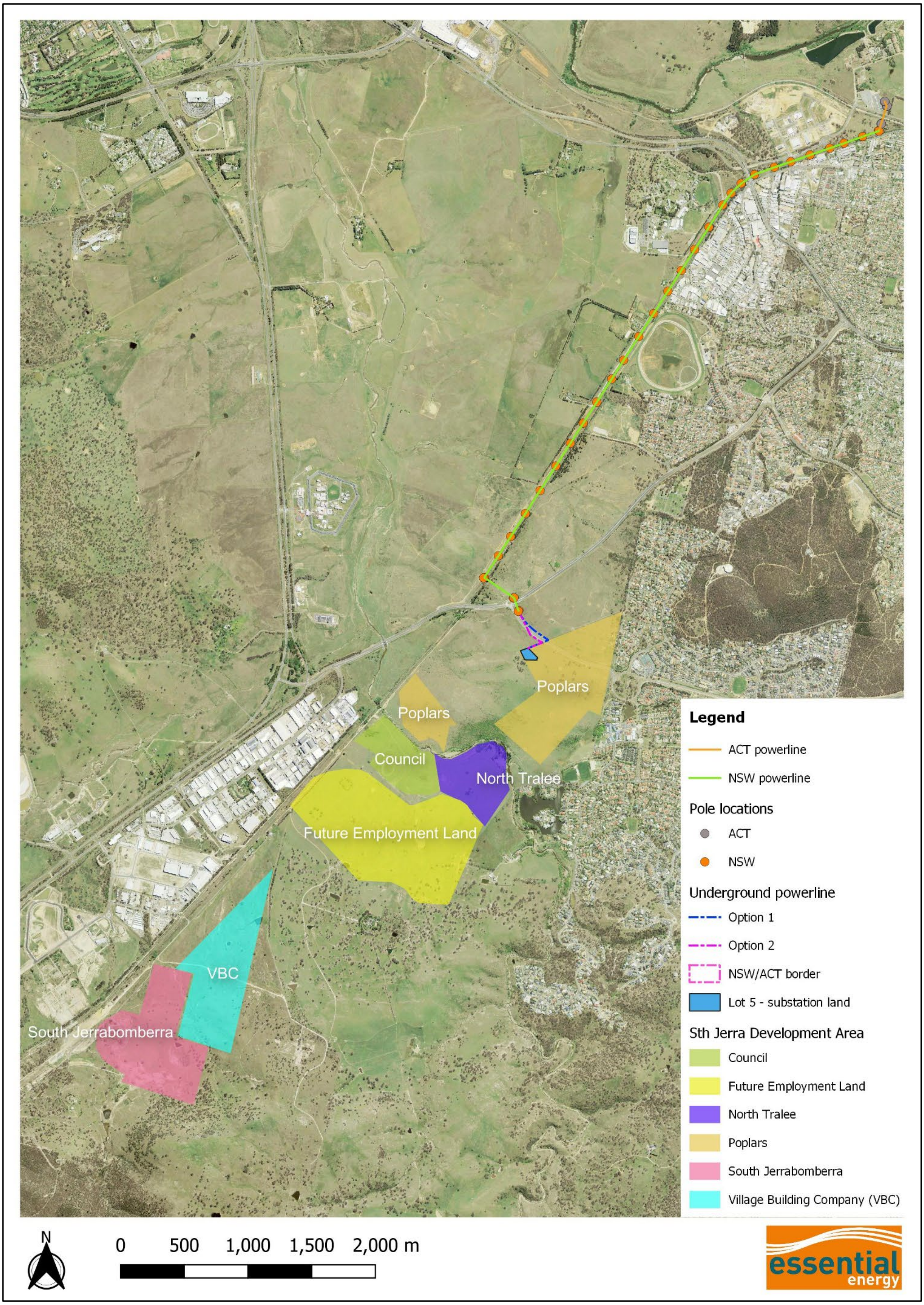


Figure 1-6: Overview of the SJHVSP and SJDP

2. Description of the Proposal

2.1 Scope of Works

The proposal involves the construction of a new 132kV dual circuit powerline from near the TransGrid Queanbeyan BSP to a lot in part of the PIP.

The following works are proposed to be carried out:

- Site establishment and laydown areas
- Vegetation clearing along some sections of the railway corridor
- Identification of access and improvement of access tracks (where required)
- Disturbance of ground for pole installation and footings
- Augering for pole footings to depths that range from 3.8m to 10.5m
- Construction of pole footings, including transport of concrete to site
- Transport of poles and equipment to site
- Use of heavy vehicles and cranes to join poles together (if in segments), move them into position, and attach to footings
- Stringing conductors to each pole, including the use of light vehicles and, potentially, drones
- Underboring and trenching the underground cable component along Tompsitt Drive and into the substation site and
- Commissioning of the powerline once works in the ACT are complete.

Figure 2-1 to **Figure 2-4** provide a detailed overview of the proposed activity, including pole locations. Further detail is provided in the attached design plans in **Appendix A**.

2.2 Design Criteria

The proposed new 132kV dual circuit powerline will be primarily constructed to form a component of the SJHVSP and increase electricity reliability in the broader region. The component of the powerline within NSW has been designed to sit within the state band not impact upon land in the ACT from a blow out perspective. No vegetation clearing will be required, as a consequence, in the ACT, thereby avoiding impacts on sensitive ecological values that adjoin the railway corridor in some sections of the ACT.

Siting of the powerline supporting infrastructure has been designed in careful consideration of UGL Country Rail operator and Transport for NSW (TfNSW) requirements for railway operations. Despite being a non-operational single railway line, the powerline has been designed to cater for the duplication of railway tracks within the corridor, whilst still maintaining the necessary separation distances.

Minimising impacts on the broader community was a key consideration in the design of the powerline. Where the powerline alignment enters into NSW, the poles were designed to be located on the northern and western side of the railway corridor. Siting infrastructure here has had the twofold benefit of increasing the separation distance to residents in Crestwood and reducing the need to clear the current tree-lined vegetation screen along Henderson Road.

The design also avoids other sensitive and critical infrastructure within the immediate vicinity through consultation with important nearby stakeholders.

The design has been developed to meet the following criteria:

- Meet the design life requirements
- Be cost-effective when assessed on a life cycle cost basis
- Provide durability and reliability of the intended function
- Minimise potential environmental impacts.

Figure 2-1: Proposed works

Figure 2-2: Proposed works

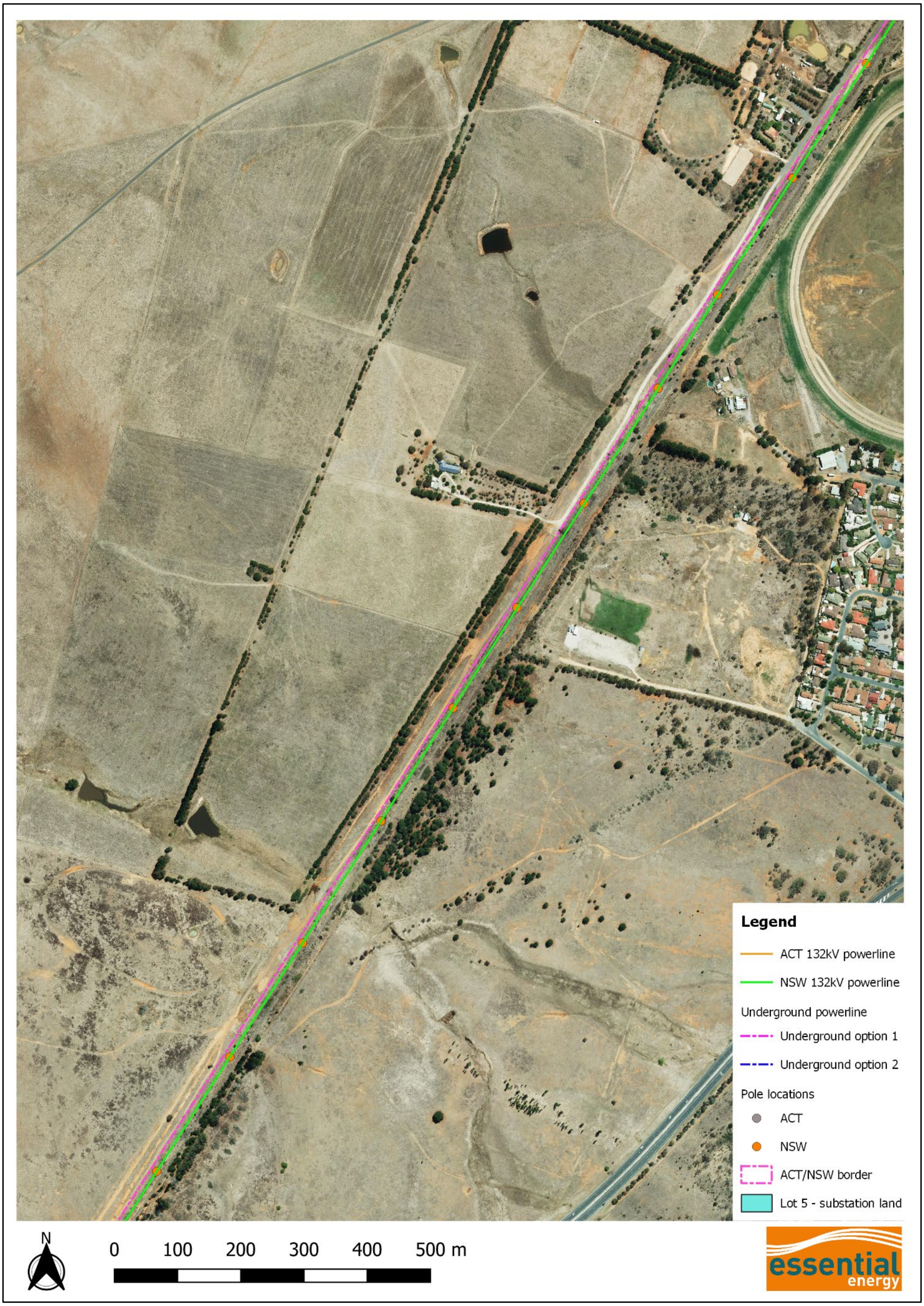


Figure 2-3: Proposed works

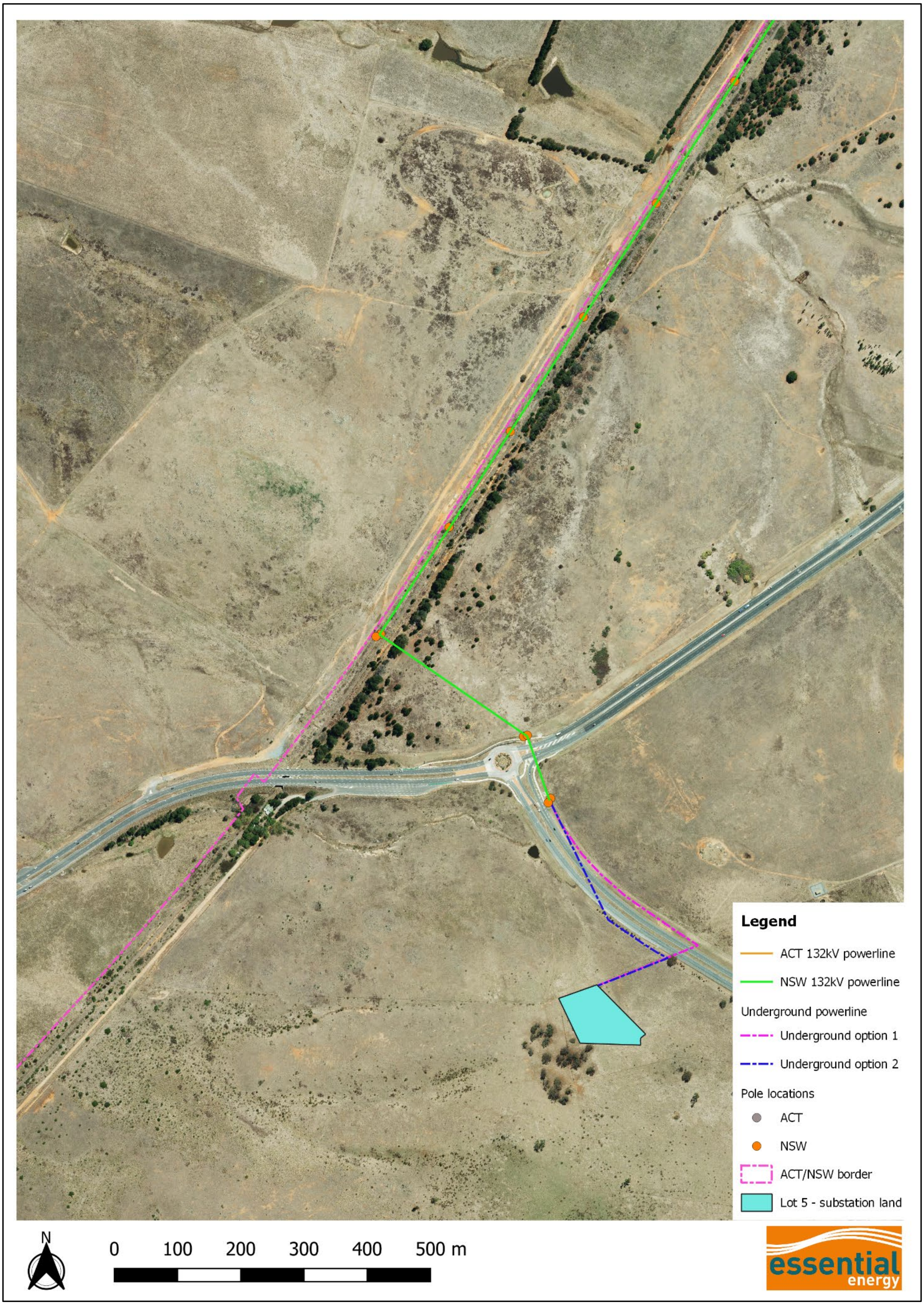


Figure 2-4: Proposed works

2.3 Construction Activities

2.3.1 Timing and work hours

Construction work is expected to commence in mid-2023, and take approximately 12 months to complete, weather dependant.

In considering the remote nature of the majority of the powerline alignment away from sensitive residential receivers (excluding near Crestwood), work hours will be between 7am and 6pm Monday to Friday with Saturday works between 8am to 1pm. No works are proposed on Sundays or Public Holidays. On occasions, works outside these hours may be undertaken where the following requirements are met:

- Neighbours (and other sensitive receivers) adjacent to the works, or the local council, or the Environment Protection Authority (EPA) have been notified, and
- The works are justified on the basis that they are emergency works, or, because of supply security network outages or construction limitations, it is deemed that the works can only be achieved outside these hours.

2.3.2 Resources and equipment

Vegetation clearing and trimming along the alignment would be undertaken by a contractor in the first instance to clear the corridor. Existing access tracks/pathways would be used, wherever possible, with no new access tracks anticipated to be required in the NSW section.

Once the corridor has been cleared, the pole footings would be constructed using heavy plant and equipment, for example, excavator and concrete trucks. Poles can be brought to site to join together, with a crane used to lift the poles onto the footings.

The following equipment is likely to be used on site to complete the work:

- Vegetation clearing equipment, including chainsaws and mulchers
- Excavator
- Concrete trucks
- Flatbed trucks and other equipment transporters
- Elevated work platforms
- Cable drums and trucks, and
- Light vehicles

2.3.3 Impact mitigation

The mitigation measures as detailed in **Section 6** form part of the proposed activity and will be implemented, as required, as part of the construction and operational phases.

2.4 Operation and Maintenance Requirements

Once the project is constructed, periodic maintenance will be required. Regular inspections of the infrastructure will be undertaken to help identify defects and hazards such as damaged components and vandalism. The site will not accommodate staff or contractors on a permanent basis. Periodic collection of waste may be required.

Likely maintenance activities include:

- Vegetation maintenance to maintain safety clearances, and
- Regular maintenance of electrical equipment.

3. Consultation

3.1 Overview

Community consultation defines the processes we use to seek views or provide information about projects. The term consultation can describe processes ranging from simply delivering information to residents, community information displays, or holding meetings with community representatives designed to actively seek feedback from local communities into a particular project.

The population as a whole is more aware than ever of their social, environmental and economic needs. They want to know about what is planned for their area and how it would impact on them.

Incorporating community consultation as a key business practice is both a necessary and a desirable path for Essential Energy to take. It must be undertaken in good faith and be transparent in all activities.

Essential Energy has in place a policy for community consultation on all major projects. The policy ensures that the community is informed about proposed development, and that concerns and issues are taken into consideration.

The engagement approach for the broader SJHVSP is based on Essential Energy's Stakeholder Engagement Framework, prescribing to the IAP2 public participation spectrum. As part of the broader project consultation strategy, residents in NSW and ACT were consulted with regarding the project. Key elements of the consultation approach are summarised below:

- Letterbox drop of project information newsletter to 2250 residences in the ACT and NSW
- Project information made available on Essential Energy's website
- Establishment of a free call line and email address.

Matters raised during the broader consultation process related to the powerline component of the SJHVSP include the use of overhead powerlines and safety of the powerline to people (bushfire) and the environment.

3.2 Engaging the Community

In addition to letterbox drops and providing information to respondents, Essential Energy has also directly engaged with a number of community-based organisations.

Table 3-1 details approaches to targeted consultation.

Table 3-1: Essential Energy's engagement with relevant stakeholders

Title	Organiser	Occurrence	Objective	Attendees
South Jerrabomberra Development Coordination Meeting	Council	Monthly	To identify, review, consider and resolve matters associated with the development of the South Jerrabomberra Innovation Precinct	QPRC VBC Poplars Development Essential Energy
Jerrabomberra Residents Association (JRA)	JRA	Monthly (3rd Wed every month)	Represents the interests of the Jerrabomberra community at the local, state and federal level in relation to issues directly affecting the Jerrabomberra community within the postcode of 2619.	Volunteers with periodic attendance by some of the key stakeholders and local community groups such as the police, conservation groups, sporting groups, and schools. Essential Energy has attended a number of meetings both virtually and in-person to provide information and respond to questions

3.2.1 Other Customer and Stakeholder Engagement

In addition to attendance at the meetings described in **Table 3-1**, Essential Energy has used various forms of engagement to reach out to community members potentially impacted by the project, including:

- Ministerial and Member of Parliament (MP) briefings
- One-on-one meetings with the NSW Government, including the Biodiversity Conversation Trust, Department of Planning and Environment, Transport for NSW, and Department of Regional NSW
- E-mails and other direct correspondence with impacted landholders.

Ongoing engagement and project progression updates have also been facilitated via the Essential Energy Engagement website (https://engage.essentialenergy.com.au/).

3.3 Consultation and its Requirements under the T&I SEPP 2021

Under the EP&A Act, Essential Energy is the determining authority for certain developments defined under the T&I SEPP as being permissible without consent. While the nature of work being undertaken does not require council consent, Division 1 of the T&I SEPP does provide consultation requirements with the local council where works are anticipated to impact upon council infrastructure, local heritage items, flood liable land and certain land within the coastal zone. In addition, consultation may be required with the State Emergency Service (flood liable land) and other specified public authorities in certain circumstances.

The proposal site is not located within a mapped area of local heritage, according to QPR LEP. Consultation with the local council is therefore not triggered under clause 2.11 of the T&I SEPP.

The proposal is not located on flood liable land, or located within the coastal zone. Consultation with the local council is therefore not triggered under clause 2.12 or 2.14, and consultation with State Emergency Services (SES) is not triggered under clause 2.13, of the T&I SEPP.

The proposal is not located on land, or adjacent to land, that would trigger consultation with other specified public authorities under clause 2.15 of the T&I SEPP.

In addition to consultation requirements, additional notification and approval requirements are outlined in **Table 5-2**.

4. Project Alternatives

4.1 Do Nothing (Maintain Current Supply Infrastructure)

One option would be to refrain from undertaking any further development of the network in the area. The consequences of Essential Energy doing nothing would be that, as years passed, supply interruptions would occur more frequently and affect more people, and there is insufficient capacity within the existing electricity supply network to meet the demand anticipated to be required by the SJDP.

The proposed 132kV dual circuit powerline is an integral component of the SJHVSP and without the augmentation of high voltage supplies, additional electricity supplies at the distribution level are not possible.

Due to Essential Energy's network licence obligations, the 'do nothing' option is not a viable alternative to the proposed new SJHVSP, of which the proposed new 132kV dual circuit powerline is a vital component.

4.2 Project Planning Options

Planning for the electricity supply to the SJDP area began in 2007 in response to an invitation to Essential Energy to comment on the Tralee Local Environmental Plan. Several options to supply the development were canvassed including supply from the TransGrid and ACT (Actew AGL) networks.

Over several years, multiple route options were investigated from Essential Energy's existing network configuration. In 2021, the final preferred route of the powerline that had the least societal and environmental impacts was identified as the inactive rail corridor along the ACT and NSW border. The location of the ZS site within the PIP has been selected for ease of connection into the new powerline, is within close proximity to large loads, and will minimise environmental impact.

5. Environmental Legislation

The following section addresses the regulatory and statutory context of the proposed activity including its definition, land use permissibility, and compliance with the relevant environmental planning instruments (EPIs).

5.1 Environmental Planning and Assessment Act, 1979 (EP&A Act)

The EP&A Act is the primary piece of legislation regulating land use planning in NSW. It provides the framework for the development of state and local planning instruments which, through their hierarchy, determine the statutory process for environmental impact assessment. Under the EP&A Act there are two distinct processes, which are:

- Part 4 - 'development' proposals which require consent, including state significant development, and
- Part 5, which regulates 'activities' and requires an approval by a determining authority (e.g. Essential Energy). Part 5 also includes an assessment pathway for state significant infrastructure.

The proposal satisfies the definition of an activity under Part 5 of the EP&A Act given the proposal:

- May be carried out without development consent
- Is not exempt development, and
- Would be carried out by a determining authority or requires the approval of a determining authority.

A determining authority, for the purposes of this activity, is defined in Part 5 of the EP&A Act to include, but not be limited to, a state-owned corporation within the meaning of the *State Owned Corporations Act 1989*. Essential Energy is listed as a state-owned corporation, and would therefore be the determining authority for the activity covered by this REF.

In accordance with state and local EPIs (described below), this REF has been prepared under Part 5, Division 5.1 of the EP&A Act to assess the possible environmental outcomes of the proposed activity. In determining the proposal and degree of impact, Essential Energy is required to consider section 5.5 of the EP&A Act, and clause 171 of the EP&A Reg (which are summarised in **Section 9**) and the Department of Planning and Environment Guideline for Division 5.1 Assessments (the **Guideline**).

In accordance with clause 171(4) of the EP&A Reg, Essential Energy is required to publish this REF on the NSW planning portal or its own website, as the capital value of the powerline will exceed $5 million, prior to the activity commencing.

5.2 Environmental Planning Instruments

EPIs regulate the permissibility to undertake an activity and the type of assessment process that is required. EPI is the generic term used to describe state environmental planning policies, regional environmental plans[1] and local environmental plans (LEPs). EPIs that apply to this development are outlined below.

5.2.1 State Environmental Planning Policies

5.2.1.1 State Environmental Planning Policy (Transport and Infrastructure) 2021

State Environmental Planning Policy (Transport and Infrastructure) 2021 (T&I SEPP) consolidates and updates the planning process for new infrastructure. Subject to certain exemptions, the T&I SEPP allows development for the purpose of an electricity transmission or distribution network to be carried out by or on behalf of an electricity supply authority or public authority without consent on any land.

Exemptions to this broad (on any land) application include developments which require Part 4 approval under *State Environmental Planning Policy (Planning Systems) 2021* (Planning Systems

[1] The *Environmental Planning and Assessment Amendment Act 2008 No 36* repealed the power to make regional environmental plans. Regional environmental plans still in force are now considered to be state environmental planning policies.

SEPP) or activities triggering designated development under *State Environmental Planning Policy (Resilience and Hazards) 2021.*

The proposed activity falls within the scope of the T&I SEPP as being permissible without development consent.

Consultation requirements under the Infrastructure SEPP are addressed in **Section 3.3**, whilst notification provisions are detailed in **Table 5-2**.

5.2.2 Local Environmental Plans (LEP)

LEPs are developed by councils (they become law only after Ministerial approval) and guide planning decisions for local government areas. According to the Department of Planning and Environment (DPE), LEPs, through zoning and development controls, allow councils to regulate the ways in which land is used. Council LEPs also list heritage items that are of local heritage significance.

The application of the T&I SEPP overrides the need to consider zoning controls, as developments covered by the T&I SEPP are permissible on *any land* without consent. However, the T&I SEPP provides consultation and notification provisions where activities are likely to substantially impact upon council-related infrastructure, or items of local heritage significance.

5.3 Key Legislation

5.3.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) requires the approval of the Commonwealth Minister for the Environment for actions that may have a significant impact on matters of national environmental significance (NES). Approval from the Commonwealth is in addition to any approvals under NSW legislation.

The EPBC Act lists nine matters of NES which must be addressed when assessing the impacts of a project. An assessment of how the project may impact on matters of NES is provided in **Table 5-1**.

Table 5-1: Matters of national environmental significance

Matter of national environmental significance	Impact
World heritage properties	There are no world heritage properties proximate to the proposed development, or that would potentially be affected by the proposal.
National heritage places	There are no national heritage places proximate to the proposed development, or that would potentially be affected by the proposal.
Wetlands of international importance	There are no Ramsar wetlands proximate to the proposed development, and the proposal is not likely to have a significant impact on the ecological character of a Ramsar wetland.
Commonwealth listed threatened species and ecological communities	The proposal is not expected to have any significant impact on threatened species, populations or ecological communities listed within Commonwealth (or State) legislation (refer **Section 6.5**).
Great Barrier Reef Marine Park	The proposal would not result in any impacts to the Great Barrier Reef Marine Park.
Commonwealth listed migratory species	The proposal is not expected to have an impact on listed migratory species (refer **Section 6.5**).
Nuclear action	The proposal would not result in any nuclear action, nor would the activity require any nuclear action to be undertaken.
Commonwealth marine areas	There are no Commonwealth marine areas proximate to the proposed development, or that would potentially be affected by the proposal.
Impacts on water resources resulting from large coal mining and coal seam gas developments	The proposal is not related to any large coal mining or coal seam gas developments. The project would not impact on water resources.

Given the project would not significantly impact on matters on NES and would not be carried out on

Commonwealth land, the EPBC Act is not triggered and approval from the Commonwealth Minister for the Environment is not required.

5.3.2 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides the process for listing threatened species, threatened ecological communities, and areas of outstanding biodiversity value, and details the process for assessing impacts on those matters.

Section 1.7 of the EP&A Act requires that assessment of an activity must consider its impact on threatened species, threatened populations, and threatened ecological communities or their habitats in accordance with Part 7 of the BC Act. The assessment for determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats, referred to in section 7.3 of the BC Act, determines whether the proposed works are likely to have a significant impact. If a significant impact is determined, a species impact statement (SIS) is required, or if the proponent so elects, a Biodiversity Development Assessment Report (BDAR) can be prepared.

Potential impacts to listed threatened species, ecological communities or their habitats is addressed in **Section 6.5** and **Appendix B**.

5.3.3 Biosecurity Act 2015

The *Biosecurity Act 2015* (Biosecurity Act) provides for the prevention, elimination, minimisation and management of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers or potential carriers. Section 22 of the Biosecurity Act requires that any person who deals with biosecurity matter, or a carrier, and who knows, or ought reasonably to know, the biosecurity risk posed or likely to be posed by the biosecurity matter, carrier or dealing, has a biosecurity duty to ensure that, so far as is reasonably practicable, the biosecurity risk is prevented, eliminated or minimised. This obligation is referred to elsewhere within the Biosecurity Act as the “general biosecurity duty”.

A number of weed species have been identified within the project site. Essential Energy has a biosecurity duty to reasonably manage biosecurity risks.

5.3.4 Electricity Supply Act, 1995 (ES Act)

The *Electricity Supply Act 1995* (ES Act) establishes a comprehensive wholesale and retail market in electricity and regulates the network operations, wholesale trading, and electricity supply in the retail market. The ES Act confers special powers on Essential Energy in respect of development and maintenance of electricity infrastructure and sets out the licencing regime. In particular, it allows Essential Energy to trim and remove trees, carry out works on public roads, and acquire land.

The ES Act also requires that no works (other than routine repairs or maintenance works) may be carried out unless 40 days’ notice has been given to the local council to make a submission in relation to the proposal. Any submission must be considered by Essential Energy.

5.3.5 Heritage Act, 1977 (Heritage Act)

The *Heritage Act 1977* (Heritage Act) provides for the protection of heritage items of local and state significance. Such items may include places, buildings, works, relics, moveable objects, or precincts with historical, scientific, cultural or aesthetic value to the state. Where works are likely to impact upon an item listed on the State Heritage Inventory (SHI), approval may be required under two sections of the Heritage Act:

- Section 60 approval relating to impacts on items listed on the SHI, and
- Section 140 approval requiring an excavation permit for activities with potential to excavate or disturb a relic.

As described in **Section 6.7.2** there is no foreseeable likelihood that an item listed on the SHI would be impacted by the proposal, therefore further assessment and a permit from the Department is not required. Further discussion of potential impacts and measures to minimise impacts to items of local heritage significance is provided in **Section 6.7**.

5.3.6 Local Land Services Act, 2013 (LLS Act)

The *Local Land Services Act 2013* (LLS Act), established Local Land Services, a government agency with the responsibility for providing advice on biosecurity, natural resources and agricultural advisory services in NSW. The LLS Act includes provisions for the regulation of native vegetation including the approval of certain activities.

Under the LLS Act, approval is required from the Minister for the Environment or delegate to clear native vegetation (exemptions apply). Exemptions include, but are not limited to, urban areas, electricity line maintenance and Part 5 activities under the EP&A Act.

The LLS Act is administered by the various local land services under delegated authority by the Minister for the Environment.

Given that the proposal will be assessed under Part 5 of the EP&A Act, the provisions relating to the LLS Act are not applicable.

5.3.7 National Parks and Wildlife Act, 1974 (NPW Act)

The *National Parks and Wildlife Act 1974* (NPW Act) provides for the management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas and state game reserves. It also provides for the protection and care of native flora and fauna, and Aboriginal places and objects throughout NSW. Under the NPW Act it is an offence, without authorisation, to:

- Harm an Aboriginal object or place without consent,
- Pick or harm any plant or animal that is protected or is a threatened species, population or ecological community, or
- Damage any critical habitat, or habitat of a threatened species, an endangered population or an endangered ecological community or reserved land.

When an activity is likely to harm an Aboriginal object or place, approval under section 90 is required.

The NPW Act also serves to direct the management and protection of reserved land[2]. In relation to utility installations, the Minister for the Environment may grant easements or rights of way through reserved land for the conveyance or transmission of electricity.

The proposal site extends across Queanbeyan Nature Reserve (QNR), which is reserved land under the NPWS Act. Approval under the NPW Act, will, therefore, be required in respect of the proposed activity.

As described in **Section 6.6,** based on the design, and mitigation measures, the proposal is not likely to impact upon Aboriginal objects.

5.3.8 Protection of the Environment Operations Act, 1997 (POEO Act)

The *Protection of the Environment Operations Act 1997* (POEO Act) provides a framework for the licencing of activities that have potential to result in pollution of the environment. The POEO Act is administered by OEH. An environment protection licence is not required for the proposed activities as they do not fall within Schedule 1 of the POEO Act; however, the following restrictions apply:

- The proposal must not pollute waters;
- Waste from the works must not be wilfully or negligently disposed of in a manner that harms or is likely to harm the environment;
- Waste must not be transported to a place that cannot lawfully be used as a waste facility for that waste;
- There must be no litter in or on a public place or an open private place caused by workers; and
- Any environmental incident that involves actual or potential harm to the health or safety of human beings or to ecosystems must be reported to the Environment Protection Authority (EPA).

During construction, there is limited potential for discharge to surface waters from excavation activities. A number of management strategies are available to Essential Energy for the discharge to surface waters, including discharging water over grassed or well vegetated areas away from waterways, or the use of filter bags in urban environments.

[2] Land being a national park, historic site, state conservation area, regional park, karst conservation reserve, nature reserve or an Aboriginal area.

5.3.9 Roads Act 1993 (Roads Act)

The *Roads Act 1993* (Roads Act) provides for the ownership and management of public roads, and also requires the consent of the appropriate roads authority for various works in respect of certain public roads.

Section 138 of the Roads Act requires the consent of the appropriate roads authority for various works in respect of public roads and classified roads. Under Schedule 2 (5) (1) of the Roads Act Essential Energy is exempt from obtaining approval for works on or over an unclassified road other than a Crown road. However, works that require a connection to or crossing of a classified[3] road must be approved by Transport for NSW (TfNSW).

The proposed activity will be limited to largely private property. One span of the powerline extends over Lanyon Drive (MR52), which is a classified road. Approval from RMS is, therefore, required under section 138 of the Roads Act.

5.3.10 Water Act, 1912 (Water Act)

Under the *Water Act 1912*, for any temporary or permanent works not defined in a gazetted water sharing plan under the *Water Management Act 2000* (WM Act), a licence or permit is required to:

Extract water from a stream, river or water course via a pump or other work; or

Extract groundwater via any type of bore, well, spear point or groundwater interception scheme (including dewatering).

It is unlikely that the shallow excavation and trenching works (to a maximum of approximately 2m depth) will require dewatering during construction of the proposal.

5.3.11 Water Management Act, 2000 (WM Act)

The *Water Management Act 2000* (WM Act) governs the issue of new water licences and the trade of water licences and allocations for those water sources (rivers, lakes and groundwater) in NSW where water sharing plans have commenced. Under the WM Act, should water need to be extracted from a surface water source, defined in gazetted water sharing plan, then three licence/approvals must be obtained including:

- An Access Licence to obtain access to a share of the water source;
- A Works Approval to obtain permission to install and use the works for water supply, drainage or flood mitigation work. For groundwater extraction or dewatering, an Aquifer Interference Approval may be required. A Controlled Activity Approval may be required for a works location in, on, or under waterfront land; and
- A Water Use Approval to obtain permission for how the water would be used.

Under the WM Act, a controlled activity means:

a) the erection of a building or the carrying out of a work (within the meaning of the *Environmental Planning and Assessment Act 1979),* or

b) the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or

c) the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or

d) the carrying out of any other activity that affects the quantity or flow of water in a water source.

The WM Act defines an aquifer interference activity as involving any of the following:

a) the penetration of an aquifer,

b) the interference with water in an aquifer,

c) the obstruction of the flow of water in an aquifer,

d) the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations,

[3] Classified Roads include main roads, highways, freeways, a controlled access road, a secondary road, a tourist road, a tollway, a transitway and State work.

e) the disposal of water taken from an aquifer as referred to in paragraph.

The proposal would not include works in locations that would trigger the above licences/approvals (including wetlands). In addition, Essential Energy, a public authority, is exempt from section 91E (1) of the WM Act in relation to all controlled activities that it carries out in, on, or under waterfront land.

5.4 Summary of Licences, Permits, Approvals and Notifications

Specific approvals required for the construction, maintenance and operation of the proposal are outlined in **Table 5-2**.

Table 5-2: Summary of licences, permits, approvals and notifications

Legislation	Authority	Requirement
Electricity Supply Act 1995	Local Council	40 days notice of the proposed works must be given. Essential Energy's Design Services will be responsible for this notification. This notification has been sent.
National Parks and Wildlife Service Act 1974	National Parks and Wildlife Service	Approval to construct and issue an easement across the QNR.
Roads Act 1993	Roads and Maritime Services	Approval from RMS to construct one span of the powerline across Lanyon Drive. Design Services will be responsible for obtaining this approval.

6. Environmental Assessment

6.1 Air Quality and Greenhouse Gases

6.1.1 Existing environment

The project site is located within a predominantly rural environment situated on the edge of a major city. The main air quality influences on the existing environment would be transport, comprising road and rail traffic, and other activities being undertaken in the area, including the development of the SJDP.

The nearby sensitive receivers vary depending on the alignment with the closest receivers being those in the Crestwood residential area and people residing along Woods Lane. The closest residences along Henderson Road are located approximately 50m away.

6.1.2 Assessment of impact

6.1.2.1 Air quality during construction

It is expected that during excavation and backfilling works there will be minor amounts of dust generated from the disturbance of soil, and wind erosion of any exposed stockpiles. Soil material removed by the boreholes will be utilised on site or removed and disposed of a facility lawfully capable of receiving the material.

There will be minimal exhaust emissions from vehicles. Exhaust emissions from construction equipment are likely to include nitrogen oxides (NOx), carbon monoxide (CO), sulphur oxides (SO2), hydrocarbons, and total suspended particulates. All vehicles will be fitted with approved exhaust systems to maintain vehicle exhaust emissions within accepted standards.

The work sites and impacts would be transitory in nature with works progressing along the alignment and will be small in intensity over the 12 month construction period. It is unlikely that there will be an odour impact. Any impacts on air quality will be short-term and localised.

6.1.2.2 Air quality during operation

Once constructed and works are complete, the new powerline will have negligible impacts on air quality. All of Essential Energy’s assets are subject to regular maintenance and monitoring to ensure all equipment is operating effectively.

6.1.3 Environmental mitigation measures

Appropriate dust minimisation measures will be implemented as required, including:

- Any potential dust-borne materials transported to and from the activity site will be covered at all times during transportation
- Any temporary stockpiles of surplus excavated material will be managed effectively. Potential reasonable and feasible options include covering or wetting down materials during dry and windy conditions
- All vehicles and machinery will be well maintained according to manufacturer requirements to ensure emissions are kept within acceptable limits.

6.1.4 Conclusion

The proposal is not anticipated to result in substantial or uncontrollable dust or exhaust emissions in the area during construction or operation. Any air quality impacts would be short-term and minor during construction or future maintenance. Given the mitigation measures outlined in this assessment the overall environmental risk is considered to be low.

6.2 Geology and Soil

6.2.1 Existing environment

Reference to the NSW Geology Plus website indicates the proposal site is underlain by Silurian S-type volcanic rocks and sedimentary rocks. A north-south linear volcanic belt extends from Wellington to south of Canberra with many of the hills around Canberra comprised of these rocks. Composition varies from felsic to intermediate and associated sedimentary rocks. Lithologies include pyroclastic flows (ignimbrite), tuff, sandstone, shale, and minor limestone. Sedimentary rocks are dominated by quartz-rich sandstone, siltstone and mudstone deposited in turbidity currents along the continental slope and deeper ocean water.

Review of the Mitchell Landscapes Mapping V3 (Department of Environment, Climate Change and Water [DECCW] 2010a) indicates that the proposal site is located on the Canberra Plains soil landscape, comprising open grassy plains with meandering channels and terraces in Quaternary alluvium of loams and sandy clays, with small areas of red-brown sands of source bordering dunes over Silurian rhyolite and rhyodacite. General elevation is between 650m and 800m, with peaks to 1000m.

Despite the undulating topography with pockets of steep land, the project site is located on gently sloping land with large flat areas. As the powerline alignment will be constructed within a disused railway corridor, the gentle undulations have been altered for large portions of the alignment.

Soils are characterised by shallow stony uniform loams on steeper slopes, stony harsh red-brown texture-contrast soils on alluvial fans from ranges, yellow-brown to yellow texture-contrast soils on the alluvium, usually with hard setting and bleached A-horizons. **Figure 6-1** to **Figure 6-3** illustrate the geology and soil landscapes relative to the proposal site.

Given the elevation of the land and distance from the coast, the proposal site is not likely to contain actual or potential acid sulfate soils.

6.2.2 Assessment of impact

The proposed works will involve site disturbance through excavations, vegetation (groundcover) removal, trenching, underboring, construction access and general construction activities associated with the construction of a powerline. These activities have the potential to impact on soil stability and erosion potential at immediately impacted sites for the pole locations. However, the extent of these impacts is likely to be minimal as works will be restricted to each pole location, limited disturbance for access, and pits for underboring. The proposed activity is expected to have a low impact on soils and geology in the area.

Mitigation measures proposed to manage erosion and sedimentation are outlined in **Section 6.2.3**. Water quality impacts are discussed in **Section 6.3.2**, air quality impacts are discussed in **Section 6.1.2**, and contamination impacts are discussed in **Section 6.8.2**.

6.2.3 Environmental mitigation measures

The following mitigation measures will be employed to manage erosion and sedimentation:

- Risks associated with sediment and erosion will be managed in accordance with The Blue Book – Managing Urban Stormwater: Soils and Construction (Landcom 2004) and
- Disturbed areas will be stabilised as soon as practicable following construction activities.

6.2.4 Conclusion

The proposal is not anticipated to have any adverse impacts on the soils and geology of the environment. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low. Further potential impacts to water quality are discussed in the following section.

6.3 Water Quality and Hydrology

6.3.1 Existing environment

The powerline is located approximately 400m to the southwest of the Molonglo River with the Jerrabomberra Creek bordering the project area to the west and south (approximately 750m in either direction). Landforms are further described in the Aboriginal Due Diligence report (**Appendix C**), as comprising gently undulating hilltops and long waning middle slopes. Water sources are only present in the form of two small drainage lines which feed southwards into Jerrabomberra Creek. **Figure 6-4** provides an illustration of waterways in the vicinity of the proposal site.

6.3.2 Assessment of impact

The following activities have the potential to impact on water quality during the construction and operation of the project:

- Earthworks, including bore excavations for footings and pits for underbore entry and exit points
- Access and vehicle movements (existing access will be utilised)
- Concreting works
- Fuel or oil leaks from construction and maintenance equipment.

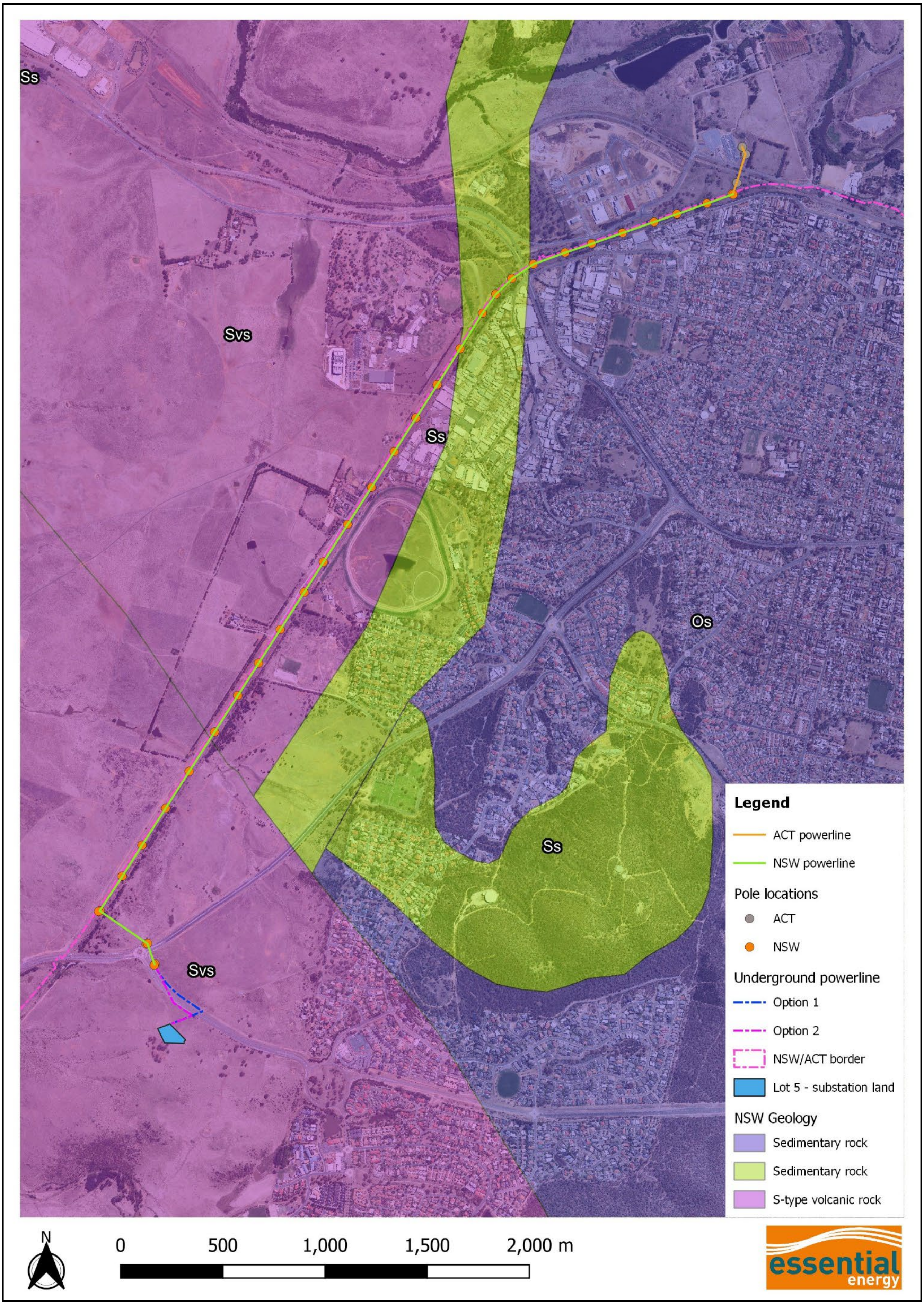


Figure 6-1: Geological features in the project area

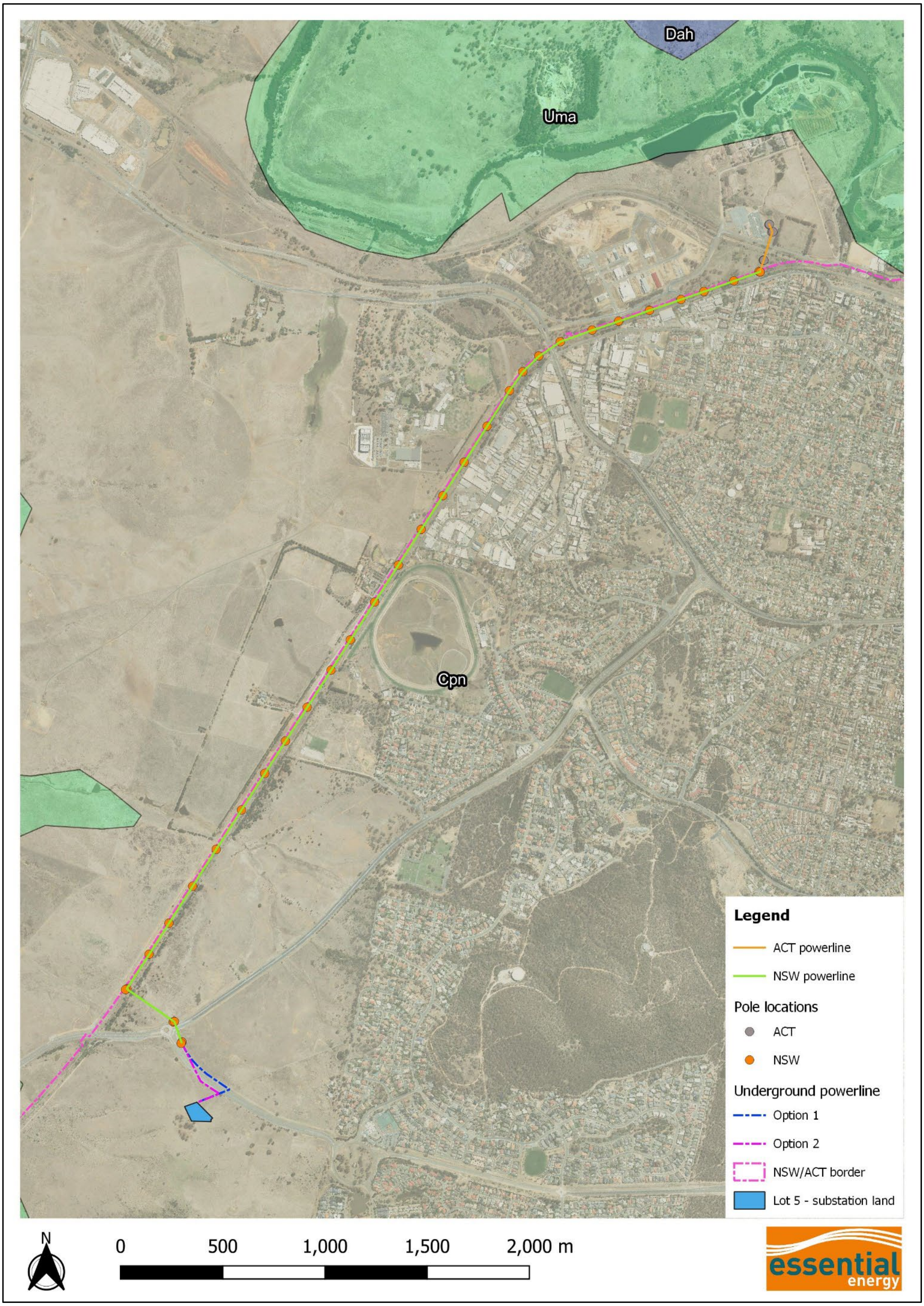


Figure 6-2: Mitchell landscape units across the project area

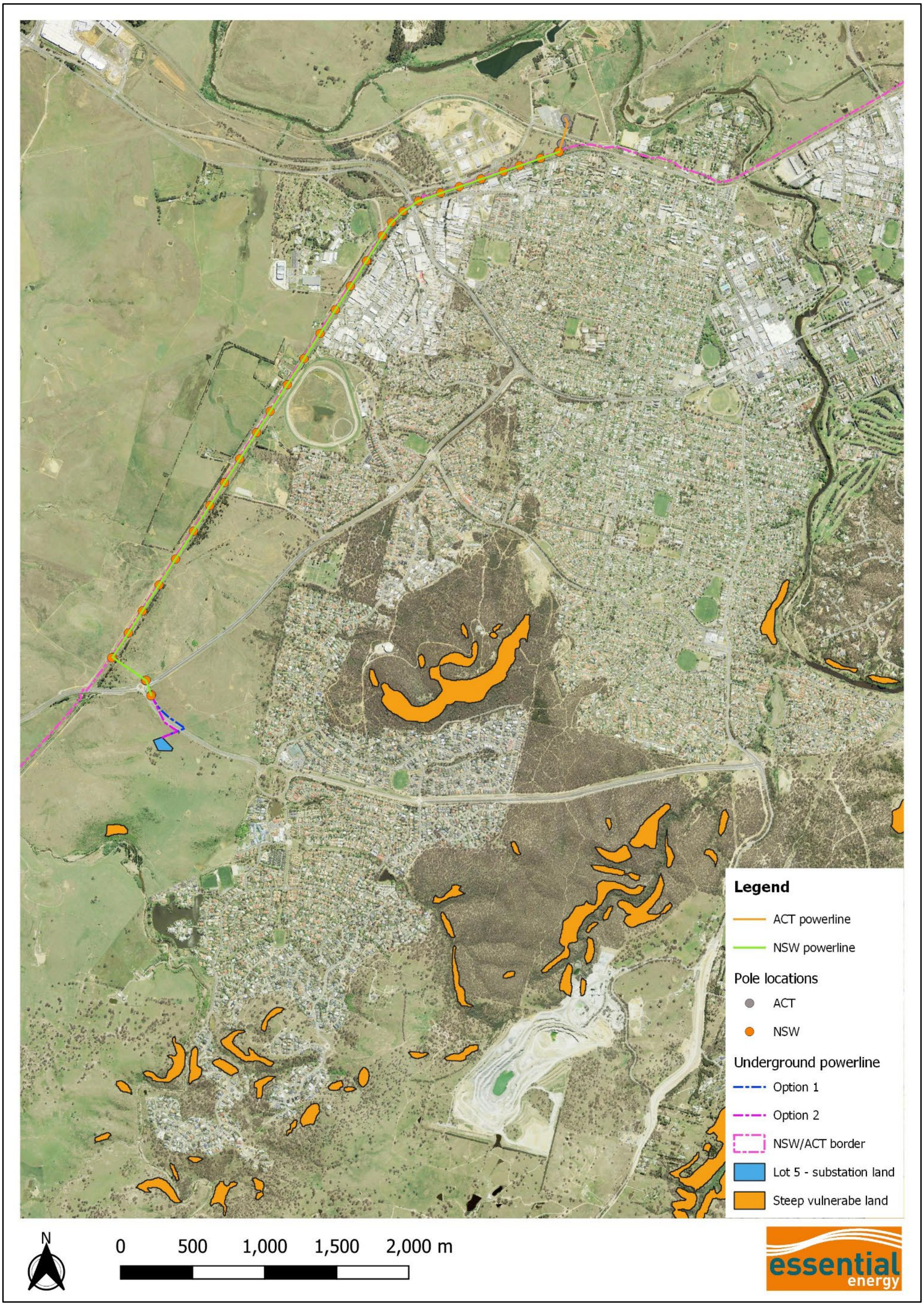


Figure 6-3: Vulnerable land in proximity to the project area

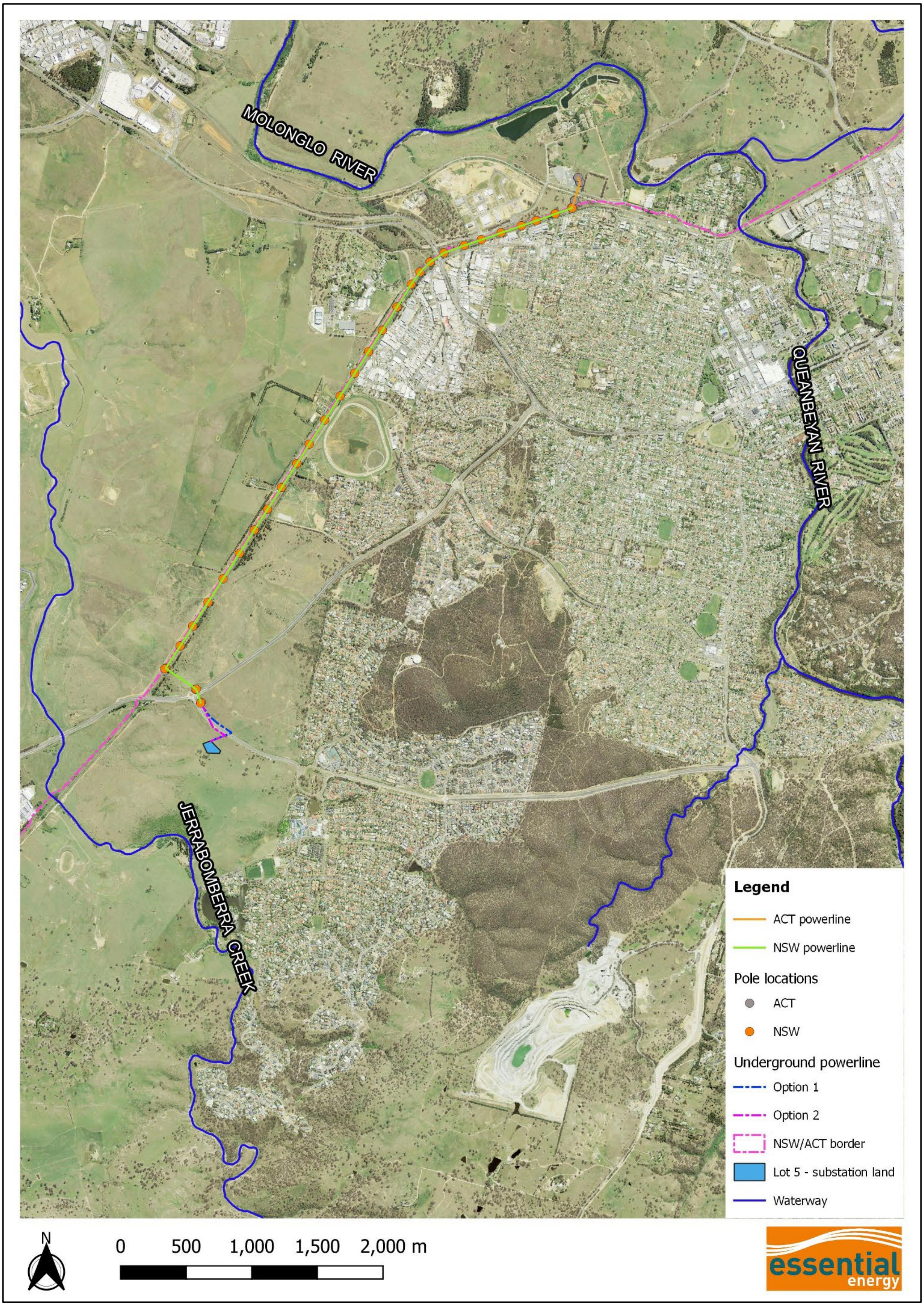


Figure 6-4: Waterways near the project area

Construction of the project will expose the natural ground surface and subsurface through boring/augering for the pole footings. Additional potential water quality risks include spillage of diesel or other chemicals during refuelling or maintenance activities on plant and equipment.

For the underground component along Tompsitt Drive, trenching, excavations and underboring will be required. Trenching can create and opportunity for water to pool during and after rainfall and underboring requires large entry and exit pits that can accumulate water. Any accumulated water in pits or trenches will be pumped out over grassed areas, with filter bags utilised where appropriate, or pumped into water tankers and removed from site. Preference will be given to pumping the water onto adjacent grassed areas, away from stormwater or natural drains.

These activities have the potential to affect the water quality in the area. In consideration of the small, isolated area of disturbance and location away from receiving waterways, any potential impacts to surface water flows are likely be negligible. Similarly, the proposal is not expected to have an impact on the Jerrabomberra Creek system.

Regarding groundwater, it is unlikely that excavation and trenching works will result in interaction with any aquifer.

As the construction of the proposed activities presents no impediments to surface water flows, it is expected that there would be no impact on local hydrological conditions.

6.3.3 Environmental mitigation measures

The following mitigation measures will be applied:

- Control measures will be implemented to manage risks associated with the handling of fuel through using spill trays when undertaking in field re-fuelling
- Management of disturbed areas in accordance with the requirements of the Blue Book to minimise potential impacts to waterways
- Discharge any accumulated water onto adjacent grassed areas within the road reserve (preferred option – reuse a beneficial resource), use filter bags or pump into a tanker and remove from site.

Access paths to utilise existing access tracks as far as reasonably practicable, with some new pathways possibly required to access particular pole locations.

6.3.4 Conclusion

The proposal is not anticipated to have any impact upon the water quality or hydrological conditions in the area. Any impacts that might occur would be short-term and minor, and would occur during construction and maintenance. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.4 Noise and Vibration

6.4.1 Existing environment

The proposal site is located in a predominantly rural environment, with some urban and commercial areas located nearby. The main noise influences on the existing environment would be road traffic noise from the surrounding road network, residential areas, the industrial estate, railway operations, and air traffic approaching or departing Canberra airport.

Parts of the alignment adjoin rural and conservation lands where a portion of the landscape can be characterised as a low noise environment. Notwithstanding the fact that those locations are under the Canberra airport flight path and located close to Lanyon Drive.

6.4.2 Assessment of impact

Construction noise

Noise impacts during construction may potentially disturb sensitive receivers in close proximity to the powerline alignment. The main sources of noise during construction would be equipment needed for site works, transportation of construction materials and equipment, construction of footings, installation of poles and conductors, and underboring. Any impacts from noise and vibration would be short-term, localised and transitory as the work site will continually move along the alignment.

The following activities are likely to be the main sources of construction noise impacts:

- Site preparation
- Vehicles and trucks transporting construction materials to and from the site
- Set up and movement of construction vehicles and equipment
- Boring or augering pole footings
- Conductor stringing and winching
- Underboring and excavation works along Tompsitt Drive (underground component).

For construction of the overhead powerline, excluding the underboring works, the activity will be low in intensity and transitory as works move along the alignment. Underboring works have greater potential to impact upon residents due to the location of underboring works in proximity to residential areas and the period of time it will take to complete the underbores.

Typically, an underbore rig will have an approximate noise level of 105dB(A). The closest sensitive receivers to the underbore siteare approximately 720m to the east. Based upon the land use type of the local area, a background noise level of 30dB(A) has conservatively been adopted.

The EPA Noise Policy for Industry (2017) identifies the assumed background noise levels for rural environments (rating background level – RBL) as 40dB(A) for the daytime. For standard construction hours, the management threshold limit is the noise affected RBL plus 10dB(A) resulting in a noise management level of 50dB(A).

To determine the potential sound power level or 'noise' from the underboring works at the nearest sensitive receiver the following formula can be applied as per the EPA 2009:

SPL=SWL-20log10r-8, where:

SPL is sound pressure level in dB(A),

SWL is sound power level (noise source) in dB(A),

r is the distance (m) from the source to the measuring point.

Based on this calculation, the estimated 105dB(A) noise from the underbore rig will be attenuated to a noise level of approximately 37dB(A) at the receiving properties 720m away (taking into account some attenuation from the adjoining grassland areas).

This figure is at least 13dB(A) under the day time noise management level for rural environments.

6.4.3 Environmental mitigation measures

In considering the remote nature of the majority of the powerline alignment, excluding the underbore, work hours will be between 7am and 6pm Monday to Friday with 8am to 1pm on Saturday. No work is proposed on Sundays and Public Holidays. On occasions works outside these hours may be undertaken where the following requirements are met:

- Neighbours (and other sensitive receivers) adjacent to the works, or the local council, or the NSW Environment Protection Authority (EPA), have been notified, and
- Where the works are required to take place in the vicinity of private access ways or driveways ,consultation with individual residents would be undertaken to advise residents of the planned timing of the works.

All plant and equipment will be operated and maintained in accordance with the manufacturer's specifications. Any noise complaint will be investigated with additional control measures put in place if required.

6.4.4 Conclusion

The proposal will have acoustic and vibration impacts during construction. The acoustic and vibration impacts during the construction phase will be medium term and moderate in some sections.

Given the mitigation measures outlined in this assessment, the impacts can be effectively managed, and the overall environmental risk is considered to be low to moderate.

6.5 Flora and Fauna

6.5.1 Existing environment

In considering the potential ecological values in proximity to the alignment a number of ecological investigations or reports have been prepared addressing various ecological values and potential impacts. Reports and assessments include the following and will be referenced throughout this chapter:

- Umwelt (2022) – *132kV Powerline Ecological Values Report – South Jerrabomberra Section*
- Fanning, D (2023) – *Proposed 132kV Powerline Queanbeyan to Environa – Ecological Issues and Assessment Report*
- Area (2023) – *132kV Powerline: Ecological Observation of/for Grassland Earless Dragon Potential Avian Predators, Golden Sun Moth, Pink-Tailed Worm Lizard Along the South Jerrabomberra Section*
- Hayward, B (2023) – *Avian Interaction with Powerlines and Potential Consequences*

The project alignment is situated within predominantly cleared land associated with agricultural related activities and the construction and operation of a railway line. Significant disturbance has been experienced along the alignment, which was a factor in considering this alignment for a powerline corridor, thereby minimising environmental impacts.

More recently, lands adjacent to the alignment have been converted to either public or private reserved land for conservation purposes. Comprising the Jerrabomberra East Grasslands Nature Reserve, the Queanbeyan Nature Reserve and Poplars North and Poplars South Biobank Agreement sites.

The powerline will extend across the Queanbeyan Nature Reserve, however, no physical assets will be located within the reserve land. Structures will be located at either end of the reserve boundary and aerial conductors strung between structures.

Plant Community Types

According to Umwelt 2022, field survey and desktop assessment identified the following four native vegetation communities covering 11.09 hectares (ha) in the project area:

- PCT 320: Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion
- PCT 654: Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion
- PCT 1289: Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion
- PCT 1330: Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion.

The remainder of the Project Area supported exotic vegetation, bare ground, or infrastructure.

PCT 320 and PCT 1289 meet diagnostic criteria for Natural Temperate Grassland of the South Eastern Highlands, a critically endangered ecological community (CEEC) listed under the EPBC Act.

PCT 654 and PCT 1330 meet diagnostic criteria for the White Box - Yellow Box - Blakely’s Red Gum Grassy Woodland and Derived Native Grassland critically endangered ecological communities listed under the BC Act and EPBC Act. All associated vegetation conforms to the BC Act CEEC.

According to Umwelt 2022, exotic vegetation is the most widely distributed vegetation type in the project area, comprising 10.18ha.

Distribution of BC Act and EPBC Act listed threatened ecological communities (TEC) in the project area is shown in **Figure 6-5** to **Figure 6-8**.

Figure 6-5: Distribution of listed TECs in the project area

Figure 6-6: Distribution of listed TECs in the project area

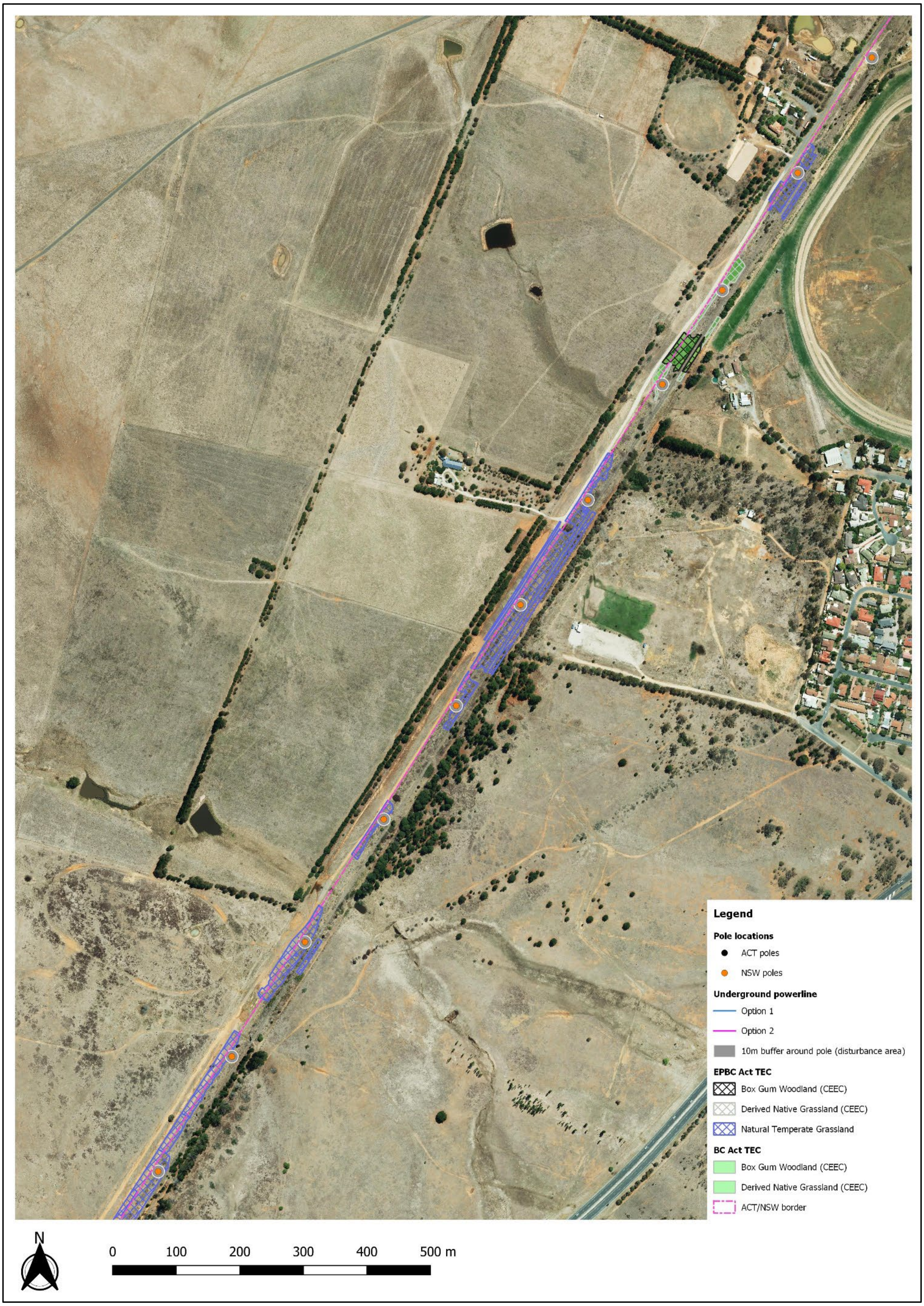


Figure 6-7: Distribution of listed TECs in the project area

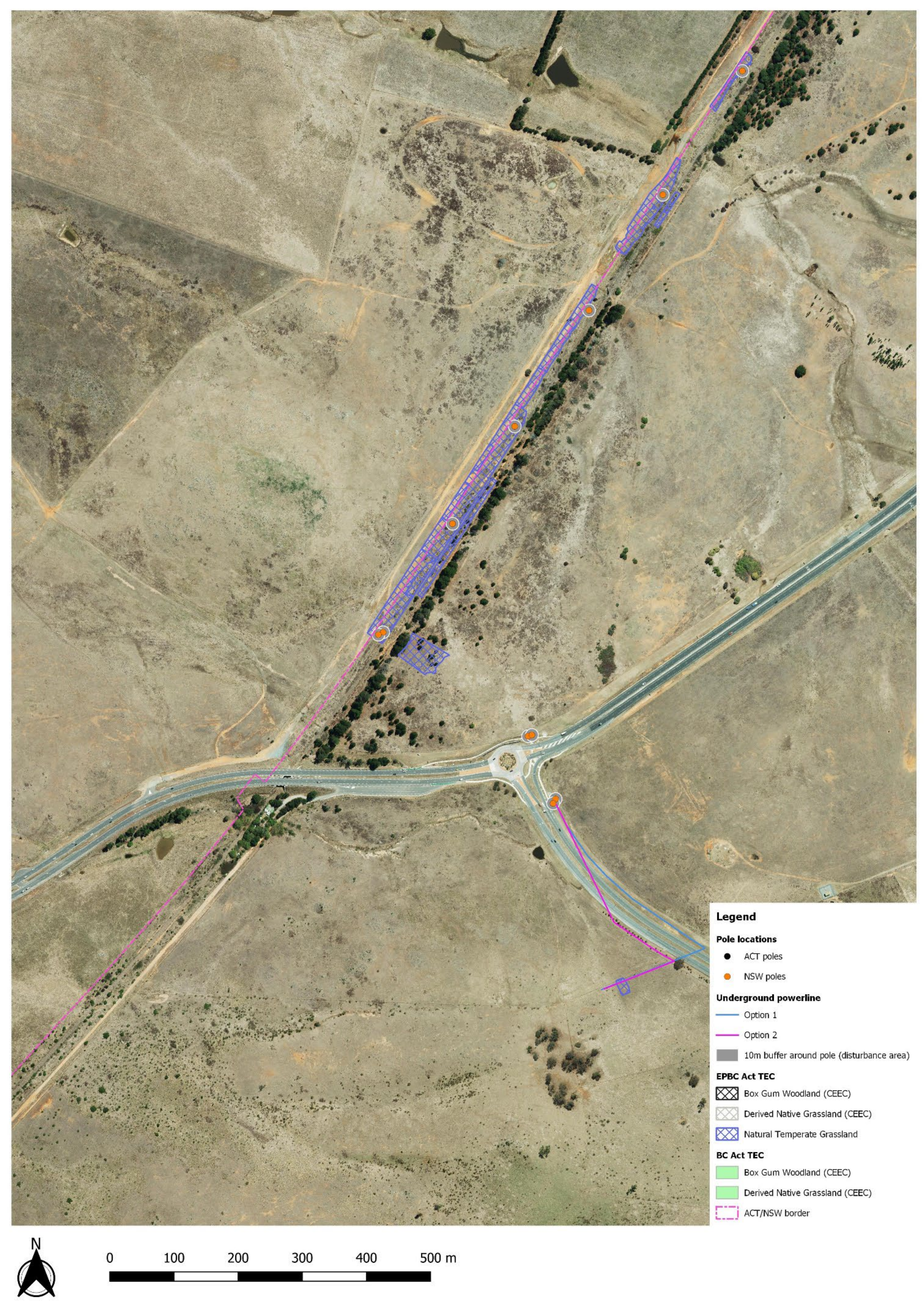


Figure 6-8: Distribution of listed TECs in the project area

Threatened flora species

Two threatened flora species were identified in project area during a survey conducted by Umwelt 2022 including:

- the Hoary Sunray (*Leucochrysum albicans* var. tricolor), listed under the EPBC Act (endangered) and
- Button Wrinklewort (*Rutidosis leptorhynchoids*), listed under both the EPBC Act and BC Act (endangered).

Both species had a high detectability due to the survey effort during September and the actual mapped extent of occupancy in the project area is shown in **Figure 6-9** to **Figure 6-12**.

Threatened fauna species

A total of 19 threatened fauna species comprising 12 bird species, one invertebrate, three mammal species and three reptile species have either been recorded in the project area or were assessed as having a moderate or higher likelihood of occurrence. Species-specific consideration of potential impacts was recommended, by Umwelt 2022, for the following species:

- Gang-gang Cockatoo (*Callocephalon fimbriatum*), listed as vulnerable under the BC Act and endangered under the EPBC Act
- Golden Sun Moth (*Synemon plana*), listed as endangered under the BC Act and vulnerable under the EPBC Act
- Grassland Earless Dragon (*Tympanocryptis pinguicolla / lineatata*) listed as critically endangered under the BC Act and endangered under the EPBC Act
- Pink-tailed Worm Lizard (*Aprasia parapulchella*) listed as vulnerable under both the BC Act and EPBC Act
- Striped Legless Lizard (*Delma impar*) listed as vulnerable under both the BC Act and EPBC Act.

Fanning 2023, however, did not accept the premise that vegetation along the alignment was of any real relevance for the Gang-gang Cockatoo. Furthermore, Fanning determined that for a highly noticeable species it was not recorded by either Umwelt (2022) or Area (2023) with potential habitat resources for this species being sparse and limited. Therefore, tests of significance were not completed for this species considering its low likelihood of utilising habitat within the project area.

Habitat for the three threatened reptiles, noted above, has been assessed as present in the project area. Native grasslands on both sides of the alignment are known to support habitat for the Grassland Earless Dragon and Striped Legless Lizard. According to Umwelt 2022, the Grassland Earless Dragon that occurs within the ACT and Queanbeyan has been provisionally listed as a critically endangered species on an emergency basis under the BC Act. Ongoing monitoring of the Grassland Earless Dragon by the ACT Government confirms the presence of the species in the locality of the powerline. A total of 6.95ha of habitat for Grassland Earless Dragon is present.

Habitat for the Pink-tailed Worm Lizard is more limited with the closet record of the species being located approximately 800m to the southwest of the project with the majority of records being located along the Jerrabomberra Creek corridor 2-4km to the south. A limited area (0.08ha) of suitable rocky habitat in good condition was identified to the south of the alignment, indicating that this species is likely to utilise the project area.

Striped Legless Lizard is a small lizard that inhabits natural temperate grasslands dominated by kangaroo grass, wallaby grass and spear grass, and is known to occur within the area. A total of 12.42ha of habitat for the Striped Legless Lizard is present in the project area.

Habitat for the Golden Sun Moth comprises the native grasslands and the derived native grasslands. A total of 8.11ha of golden sun moth habitat is present across multiple locations adjacent to the project area.

Threatened reptile habitat is shown in **Figure 6-13** to **Figure 6-16**, whilst Golden Sun Moth habitat across the project area is shown in **Figure 6-17** to **Figure 6-20**.

Figure 6-9: Distribution of threatened flora in the project area

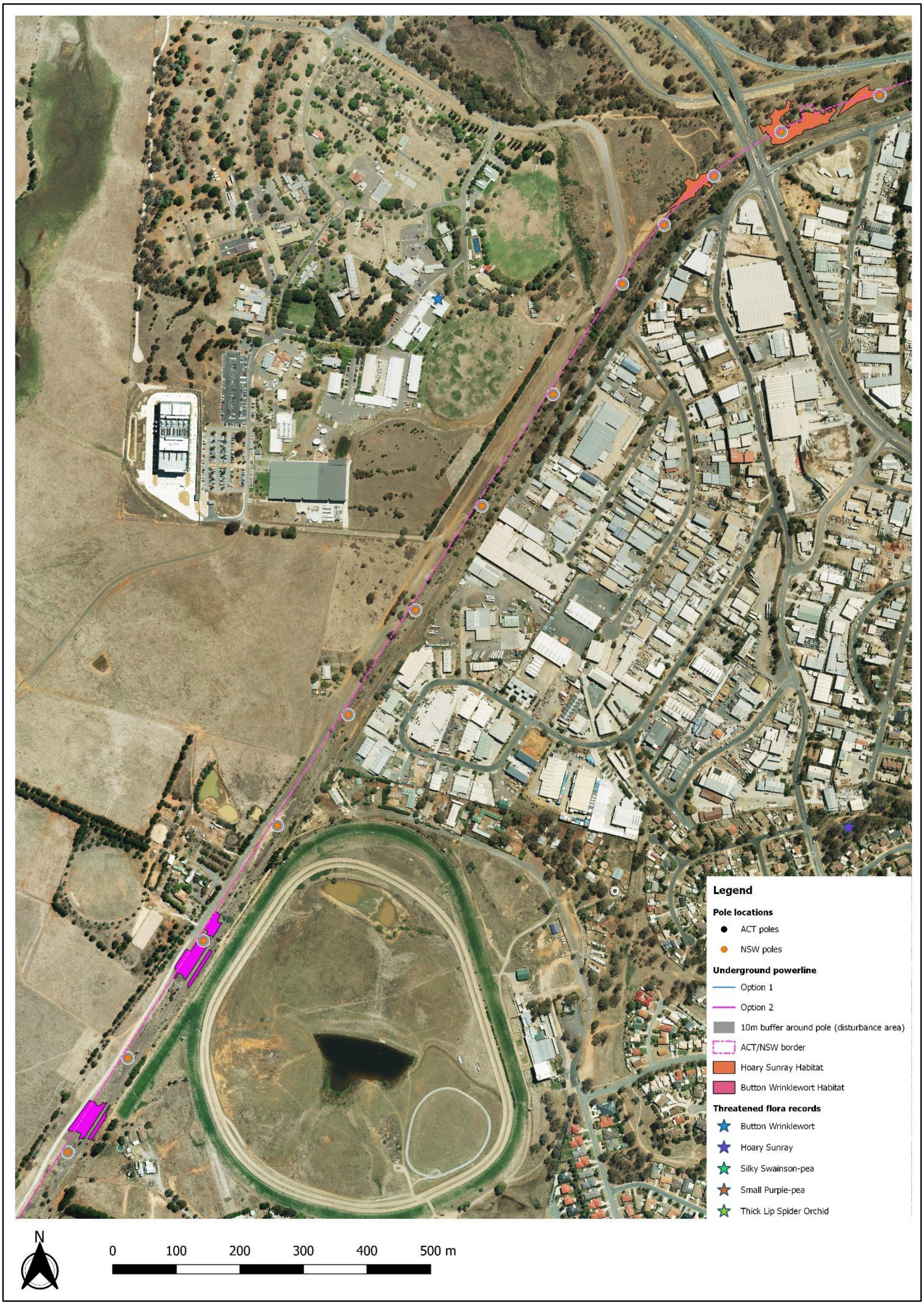


Figure 6-10: Distribution of threatened flora in the project area

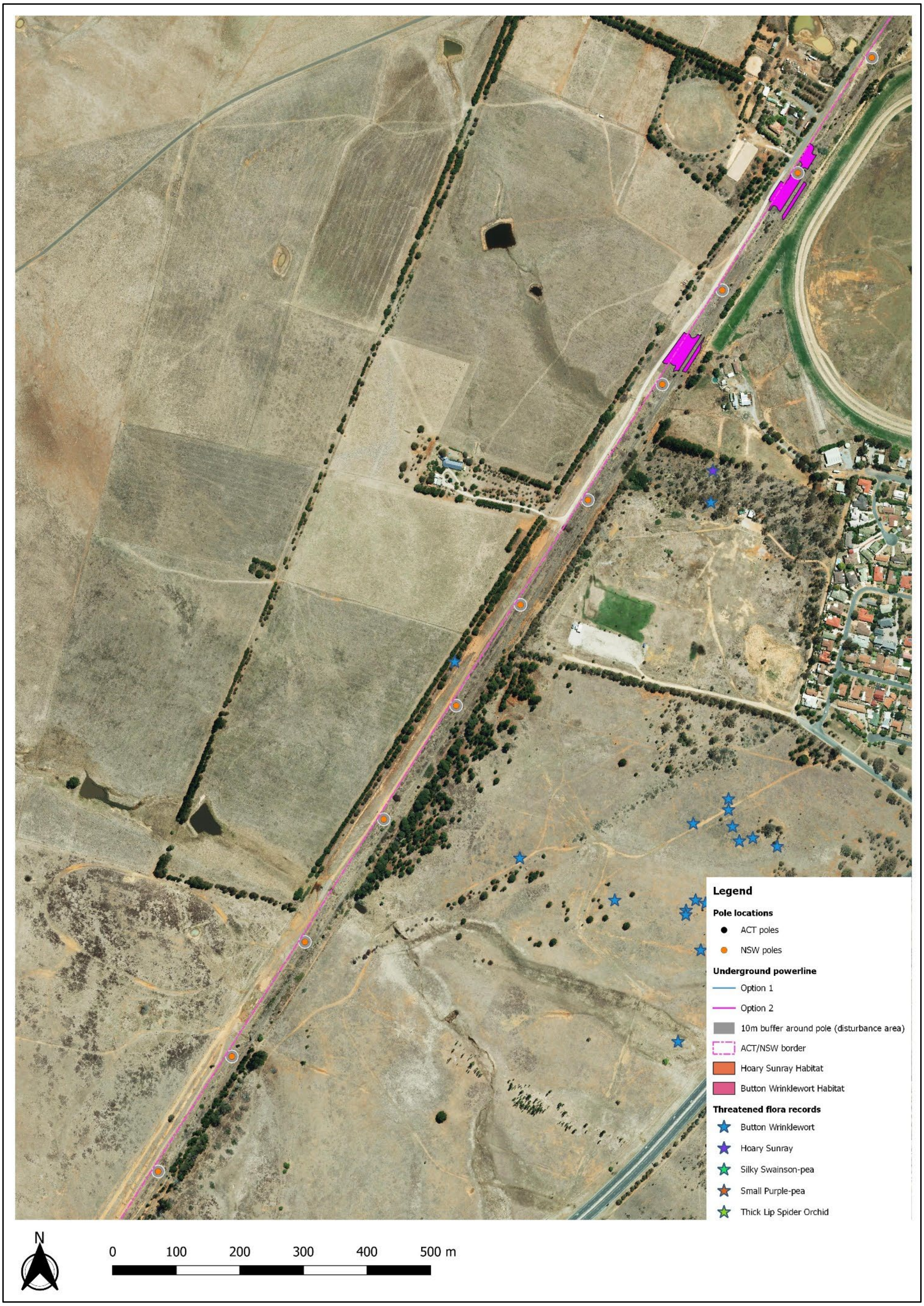


Figure 6-11: Distribution of threatened flora in the project area

Figure 6-12: Distribution of threatened flora in the project area

Figure 6-13: Distribution of threatened reptile habitat in the project area

Figure 6-14: Distribution of threatened reptile habitat in the project area

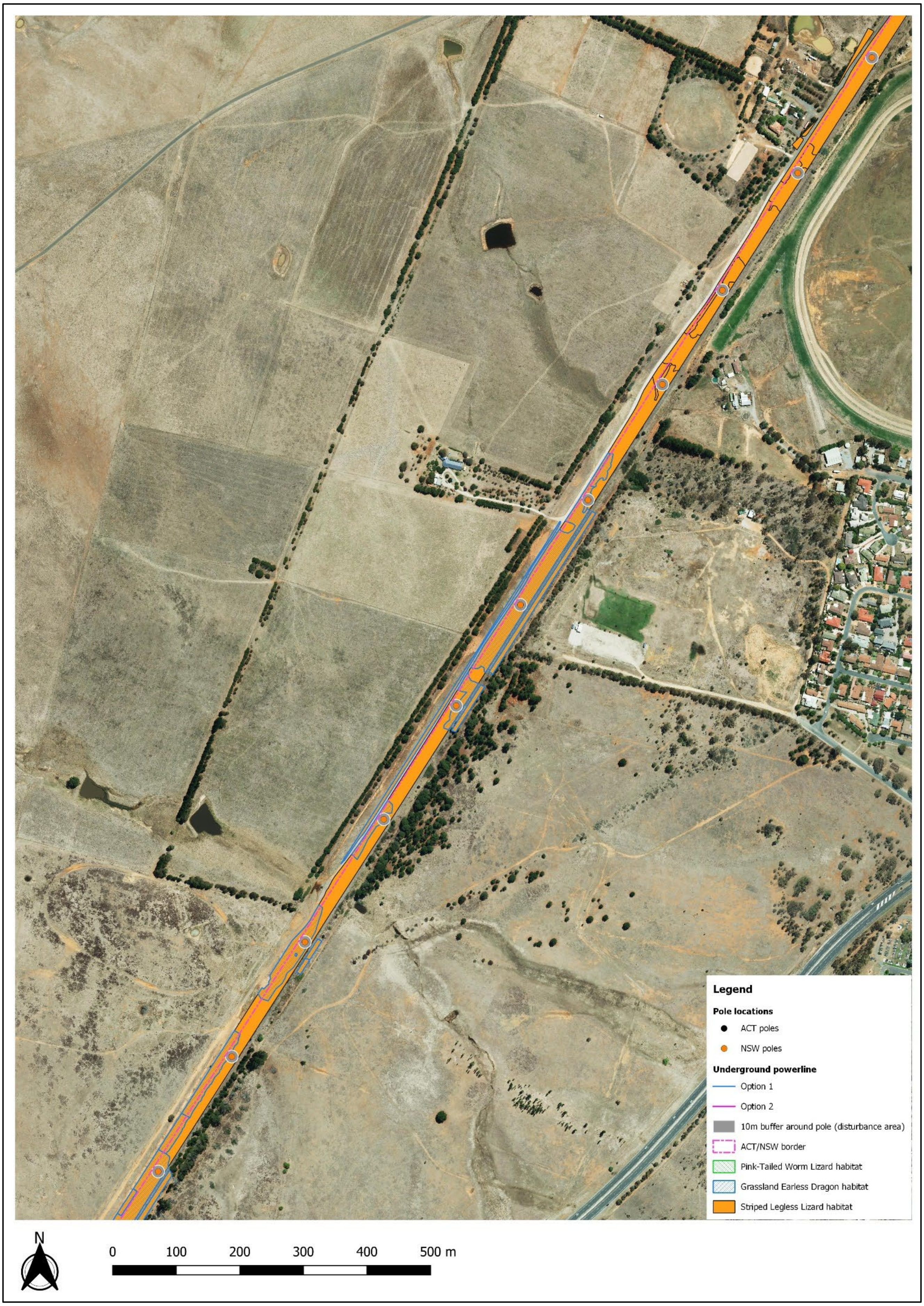


Figure 6-15: Distribution of threatened reptile habitat in the project area

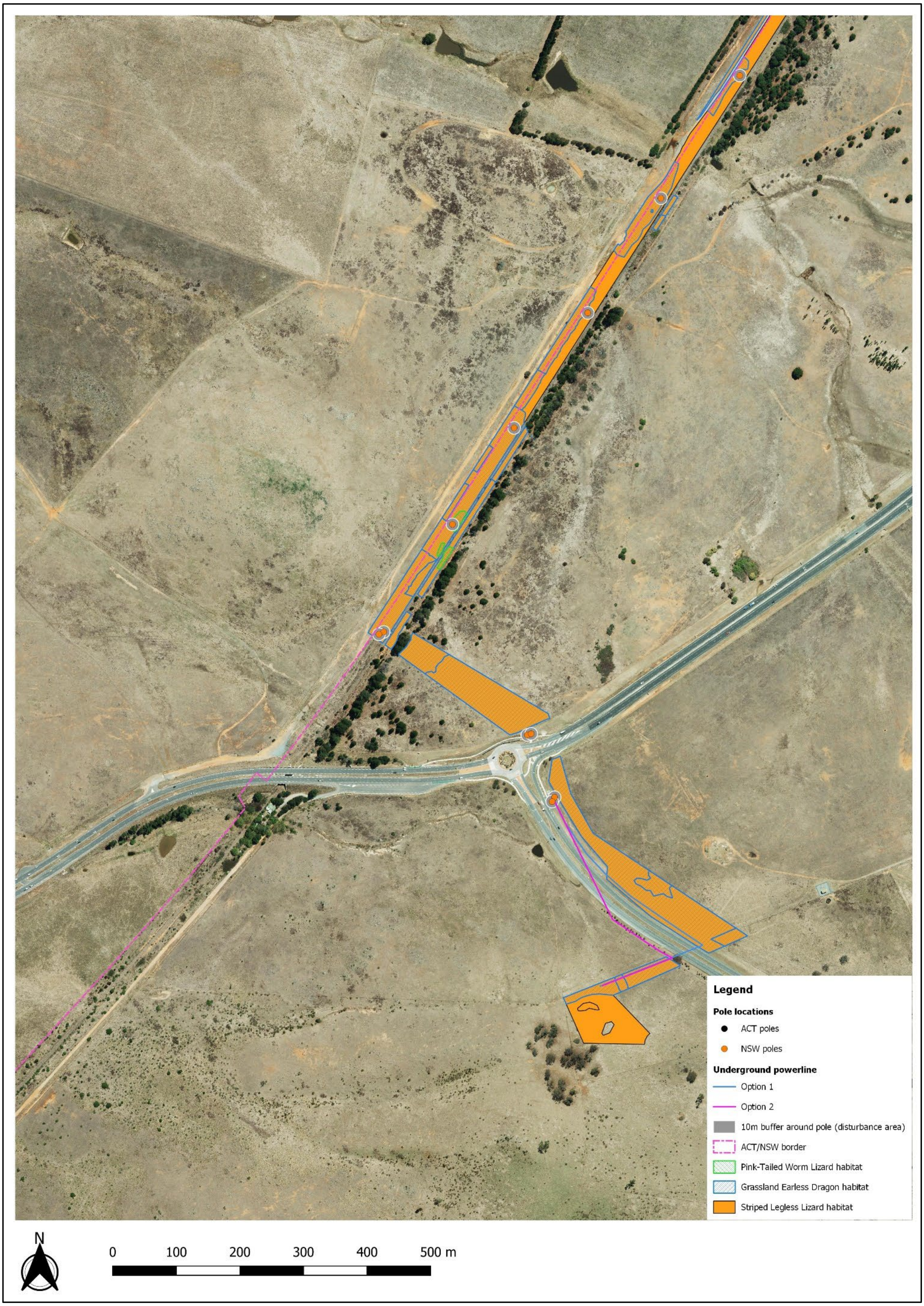


Figure 6-16: Distribution of threatened reptile habitat in the project area

Figure 6-17: Distribution of Golden Sun Moth habitat in the project area

Figure 6-18: Distribution of Golden Sun Moth habitat in the project area

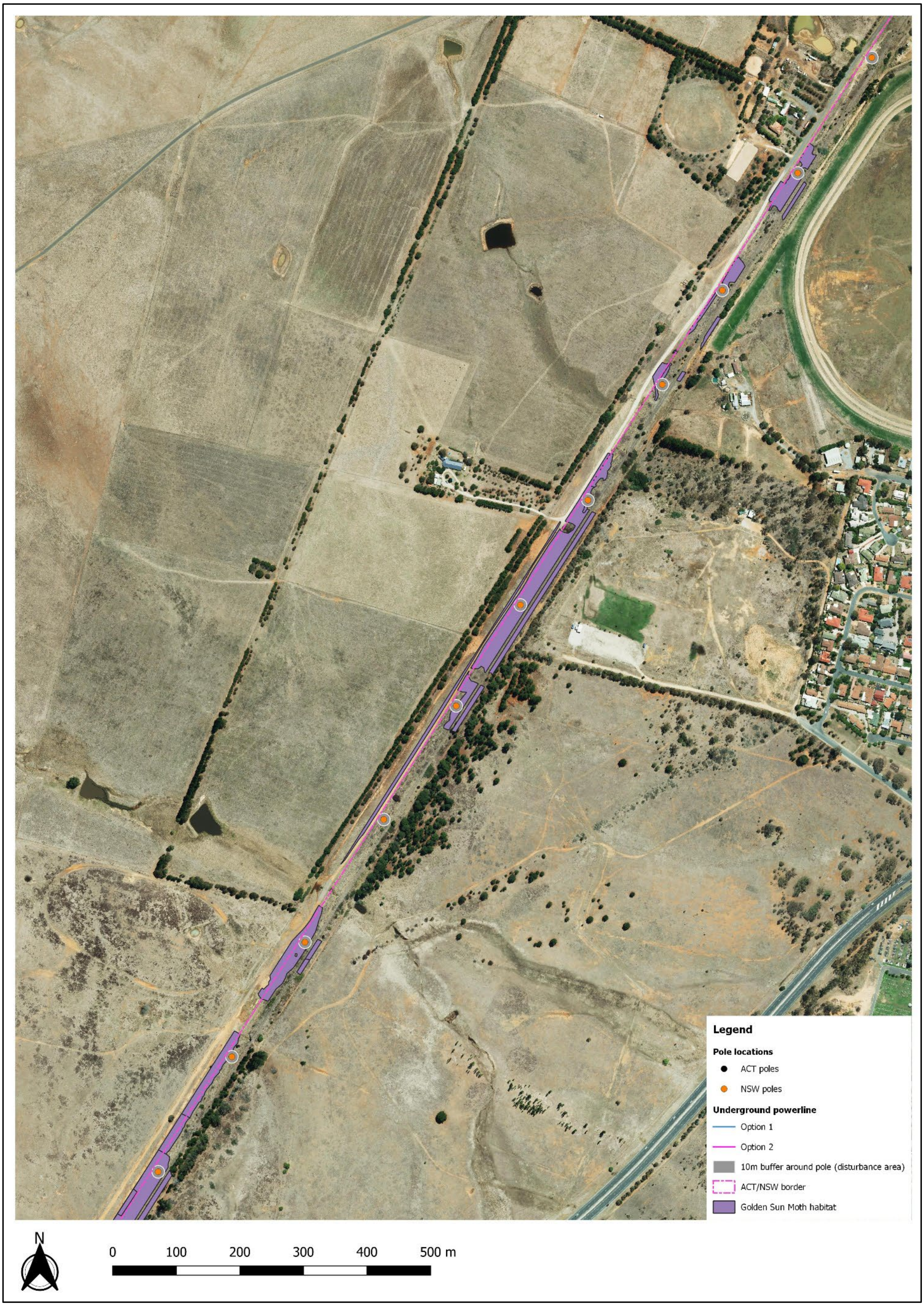


Figure 6-19: Distribution of Golden Sun Moth habitat in the project area

Figure 6-20: Distribution of Golden Sun Moth habitat in the project area

Threatened birds

Habitat for twelve threatened bird species has been assessed as present in the project area. All grassland and box gum woodland areas constitute foraging habitat for Spotted Harrier and Little Eagle, which are likely to occasionally forage over the project area as part of a much larger habitat range.

The nearest record of the Spotted Harrier is approximately 2km west of the project area and Jerrabomberra Creek. The Little Eagle inhabits open forests and woodlands across Australia and hunts over a large home range, feeding on birds, reptiles and mammals. No Little Eagles, or signs of their nests, were observed, however they are likely to use the airspace above the project area as they hunt.

Superb Parrots inhabit open forest and woodlands, and Box Gum Woodland within the project area would provide suitable habitat. The Superb Parrot is not known to regularly forage within the Queanbeyan/Jerrabomberra area, however, the project area does provide some habitat that individuals may occasionally forage in.

6.5.2 Assessment of impact

The decision to route the powerline alignment through a highly disturbed railway corridor has been made with a large focus on reducing the potential environmental impacts of the proposed activity. Nonetheless, some sensitive ecological values exist that require careful consideration. During the preparation of the environmental impact statement (EIS) for the ACT component of the powerline, the ACT Conservator of Flora and Fauna requested that the EIS consider the impacts the powerline may have on increasing predation on threatened reptiles. To address the potential concern, a detailed paper was prepared by Hayward 2023 addressing the potential risks that artificial structures, like the proposed powerline, would have on increasing predation efficiency, particularly with respect to threatened reptiles.

In the Hayward report, a range of literature was reviewed to ensure all factors are considered when assessing the potential impact of any development. A site inspection was also undertaken on 2 August 2022 on an existing Essential Energy 132kV powerline near Cooma, as well as the subject site, to review bird behaviour and their use of artificial and natural structures.

As detailed in the Hayward report, the proposed powerline is unlikely to increase predation efficiency or abundance on threatened reptiles in adjoining grassland areas. Success of prey methods, such as pouncing, is largely driven by perch height, which in low density environments requires a lower-level perch to detect prey either visually or audibly. Prey events identified within the literature occurred on smaller height poles with cross arms, with the literature confirming a diminishing rate of advantage the higher a perch becomes for many species. For other species that can predate at heights, soaring or hovering would be the preferred method due to the energy consumption required for zero velocity launches, and the limited survey area of perch hunting.

The proposed development will involve the erection of predominantly 22m high poles with horizontal insulators (insulators that connect directly to the pole). There will be no cross arm or other features that provide perching/roosting opportunities. The operation of the powerline will create a heat and electric field source, which has shown, in some circumstances, a repelling effect on birds. Hence the lack of birds typically observed to be occupying higher voltage powerlines on poles or conductors.

In considering bird characteristics and the design of the powerline, the proposed development is highly unlikely to increase bird predation efficiency or abundance. There is no evidence (either empirical or published) to suggest that the proposed powerline, in considering its design and operation, will provide an increase in perching opportunities. Particularly in low density landscapes where the prey (small lizards) is much smaller than the surrounding grass. In such circumstances, lower prey heights, and predators situated directly above the prey, are required for detectability. Indeed, where height is increased, the literature suggests there is a diminishing rate of success for prey attempts as the distance correlates directly with an increase in strike time.

The landscape in the immediate vicinity of the proposed powerline contains a large array of both natural and artificial structures, including the extensive Kangaroo exclusion fencing, planted Cypress Pines, and other railway infrastructure scattered throughout the adjoining grassland areas. Existing natural and artificial structures offer optimal heights for birds to predate from compared to a 22m high powerline.

The conclusions of the paper by Hayward were further explored and considered through a dedicated ecological observation report prepared by Area 2023. The Area report, after detailed field observation of birds in the locality, agreed with the findings of the Hayward report. The conclusion was that the Hayward paper correctly stated that a number of factors, and the influence they may have on natural predation processes, must be considered when assessing the potential impact of any development. For example, location, perch availability, powerline design/operation, and predator height preference.

A further ecological impact assessment was carried out based upon the field survey assessment from Umwelt 2022, by Fanning 2023. The purpose of this repot was to apply the potential impacts of the activity on the ecological values mapped and identified by Umwelt 2022. The Fanning report details out the potential impacts of the activity on habitat values identified in the Umwelt 2022 report, and as summarised in chapter 6.5.1 above. The proposed development will have direct and permanent impact across the life of the project, whilst some impacts will be of less intensity and short duration. Once construction has been completed, the powerline will have a relatively small footprint on the ground, being mainly limited to the pole locations.

Impacts will include the auguring of 1.2m to 1.5m diameter holes to a depth ranging from 3.8m to 10.5m. As most holes do not require significant depth (<6m), it is anticipated that most holes will be augured by a 20T excavator with an auguring attachment (Essential Energy has experienced the successful use of a 20T excavator drilling 1.5m to depths of 4m in a nearby area in similar ground conditions). Five locations involve depths greater than 6.8m whereby a drill rig is likely to be required.

For the purposes of the assessment, a disturbance footprint of 20m radius has been assumed at each pole location and the assessment of impact is based upon this area of disturbance. Actual disturbance is expected to be substantially less than the assumed disturbance in most circumstances. Limited vegetation clearing will be required along the alignment in discreet locations, predominantly involving opportunistic woody weeds and native vegetation that has recolonised the neglected rail corridor, which has not been adequately maintained since operations were suspended approximately 10 years ago.

Beyond the immediate vegetation clearing and trimming required in certain sections, predominantly between pole 7 and Canberra Avenue, the powerline project will involve only very limited removal of vegetation. Vegetation will be allowed to naturally rehabilitate between the pole structures enabling ground based ecological values to be retained. An important consideration in determining potential impacts as the majority of identified ecological values are ground-based and can co-exist with a powerline.

The Golden Sun Moth has recently had its conservation status downgraded from critically endangered to vulnerable. Assuming the species-specific significant impact guidelines still apply, the threshold limit for a significant impact is 0.5ha or 5,000m^2. Assuming a worst-case impact of 200m of Tompsitt Drive road reserve being impacted to 15m width for the trenching and underboring and a minimum of eight poles with a 20m radius of impact, the total worst possible impact would be 3,320m^2, less than the threshold in the impact guidelines. Furthermore, the Area 2023 report conducted Golden Sun Moth observations along Tompsitt Drive, and none were detected as using the habitat along that section. Post construction, the ecological values can return.

Fanning 2023 completed tests of significance for each threatened species, community or their habitat that is either known to occur within the project area or has a high likelihood of occurring under either the BC Act or EPBC Act,and concluded that the proposed powerline project would not likely impose a significant effect on any threatened species or ecological communities, or their habitats, under either the BC Act or EPBC Act.

6.5.3 Environmental mitigation measures

The following are recommended protection protocols to be undertaken during construction of the proposed activity:

- Where located in identified threatened fauna species habitat (or potential habitat), the disturbance footprints at each pole location will be inspected prior to the conduct of any works
- Any potential ‘No Go’ areas (not particularly likely given the disturb\ed nature of almost all of the powerline alignment) will be identified and communicated to contractors and Essential Energy staff.
- The pre-clearing translocation of lizards and/or rocks at relevant locations (likely to be required

only rarely – if at all)

- Vehicle movements between power poles (other than to the north of Uriarra Road) will be minimised, with priority given to the use of existing tracks and roads.

A site induction program to ensure that all construction, operation and maintenance staff and contractors are aware of the need to, and how to, avoid and protect vegetation outside of the construction footprint. Essential Energy Environmental Services (or appointee) will provide support during construction, including auditing of works and providing advice.

6.5.4 Conclusion

It is unlikely the proposal will have significant impacts on flora and fauna during construction and operational activities. In considering the potential impacts and ecological values. the environmental risk is considered to be low - moderate.

6.6 Aboriginal Heritage

6.6.1 Existing environment

The powerline is proposed to be constructed within a heavily disturbed disused railway corridor, where cutting and filling has taken place throughout the corridor to level out undulations. According to Past Traces 2022, landforms within the project area consist of gently undulating hillslopes and long waning middle slopes. Water sources are only present in the form of two small drainage lines which feed southwards into Jerrabomberra Creek. The 1st order drainage lines would have been intermittent and would have provided a water source only after recent rainfall.

The project area has been impacted by European settlement from the mid nineteenth century, particularly by the construction of the Bombala railway line and subsequent infrastructure placement along the rail corridor. The project area has been under continual grazing and pastoral regimes over a long period of time and has experienced the following:

- Vegetation and tree clearing
- Stock impacts
- Vehicle tracks
- Extensive impacts in areas of housing
- Ploughing of topsoils for improved pastures.

An Aboriginal Heritage Information Management System (AHIMS) search was undertaken 30 September 2021, and an updated search carried out on 24 March 2023 covering the project area. Only the one previously identified Aboriginal object (SJ1) recorded by Past Traces during the due diligence survey was identified in the project area with 50 sites identified within the broader search area. The recorded sites consisted of isolated artefacts, small artefacts and areas of potential archaeological deposit (PAD).

The Aboriginal Due Diligence report is attached as **Appendix C**, whilst the updated AHIMS search is attached as **Appendix D**. AHIMS results are presented in **Figure 6-21**, including site SJ1, identified during the survey and described below.

6.6.2 Assessment of impact

A field survey of the project area was undertaken across three days 28/29 October and 24 November 2022 to verify the findings of the desktop assessment. The survey covered both sides of the railway easement to a width of approximately 40m.

The aim of the investigation was to identify heritage objects or PADs. A single Aboriginal object (SJ1) was identified by the field survey within the railway corridor (refer to **Figure 6-22**). The object consists of an isolated find, a white quartz blade flake located along the western side (opposite side to the powerline) near Queanbeyan racecourse. The area is highly disturbed with a surface that has been scraped back. The site is not in situ and is in a disturbed context.

The project area has a high degree of disturbance within the rail corridor. In the paddocks to the south of the rail corridor, the soils appear to be thin and overlaying base clays and shale. Due to the lack of topsoils, this area is considered to hold low potential for unrecorded sites or subsurface deposits.

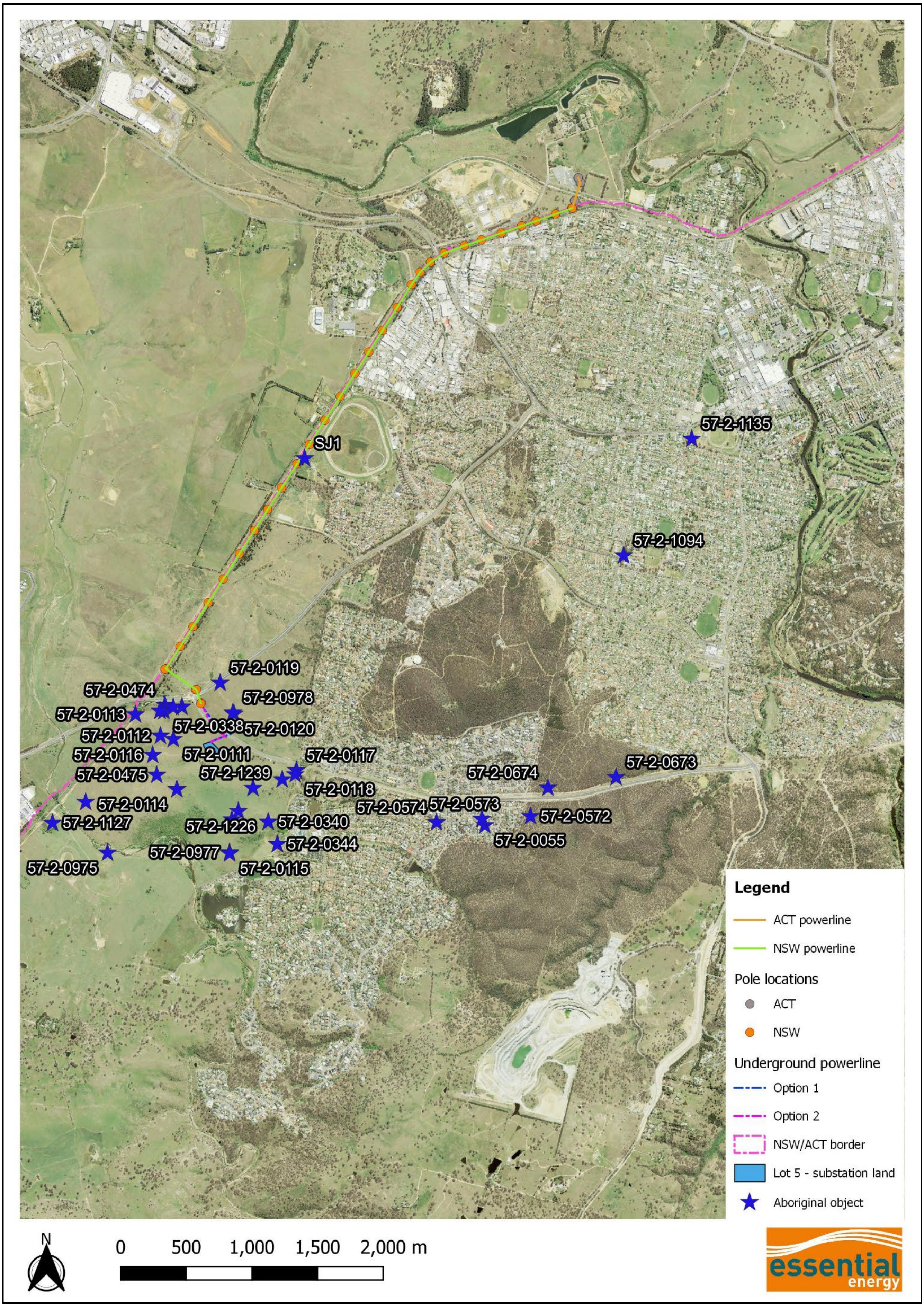


Figure 6-21: Distribution of recorded Aboriginal objects in the broader area

Figure 6-22: Location of isolated find (SJ1) in the survey area

The NPW Act requires that proponents follow a due diligence approach in regards to the protection of Aboriginal objects. There are three essential issues to consider when undertaking a due diligence assessment:

- The nature of the proposed activity (e.g. the extent of development impacts)
- Land condition and prior land uses (e.g. impacts to bushland or undisturbed ground, areas containing sandstone outcrops, rock shelters and overhangs, old growth trees, sand bodies, ground adjacent to creeks, rivers, lakes and swamps)
- Knowledge and available information (e.g. AHIMS database search, previous reports or studies relating to the site or in the area, and local knowledge, such as councils or Local Aboriginal Land Councils (LALC)).

An assessment against the due diligence requirements is provided in **Table 6-3**.

Table 6-1: Assessment against due diligence requirements

Step	Question	Response	Process
1	Are you disturbing the ground surface or culturally modified tree?	Yes ☑ No ☐	If Yes proceed to Step 2 If No AHIP not required proceed with caution
2	Check AHIMS – working near known Aboriginal sites? http://www.environment.nsw.gov.au/awssapp/login.aspx	Yes ☑ No ☐	If yes obtain site cards and proceed to Step 4 If No proceed to Step 3
3	Is the proposed activity on disturbed (e.g., ploughing, cleared vegetation, grazing) land? Check the land use layer	Yes ☑ No ☐	If Yes AHIP not required proceed with caution. If No proceed to step 4
4	Confirm the following: a) Does any other source of information indicate likely presence of Aboriginal heritage? (previous studies)? and/or b) Landscape features are likely to indicate presence of Aboriginal objects (e.g., within 200m of water, below or above a cliff face, located within a dune system, within 20m of or in a cave, rock shelter and is land not disturbed)? and/or c) Objects will, or are likely to be harmed?	Yes ☐ No ☑	If Yes to any or all questions further investigations or an AHIP is required If No AHIP not require proceed with caution

As an Aboriginal object was found within the survey area, an assessment of potential impacts needs to be undertaken to determine if impacts to that object can be avoided and whether there is potential to harm other objects. As Aboriginal object SJ1 is located on the western side of the railway corridor (opposite side to the powerline) and no construction traffic or equipment is required to traverse this area, impacts to that object can be avoided. As such, no further archaeological investigations are required.

Considering the highly disturbed nature of the work site, and the location of the activities away from any known Aboriginal sites, the proposal is not likely to impact Aboriginal heritage.

6.6.3 Environmental mitigation measures

In order to mitigate any potential impacts on Aboriginal heritage, the following mitigation measures will be employed:

- In the unlikely event that an Aboriginal heritage site or object is located during the construction phase of the project, works will cease in that area and a representative from Essential Energy's Environmental Services will be notified. Works with the potential to disturb the object would not resume until the object had been properly identified, and appropriate action taken
- If human remains are uncovered, works must immediately cease and the NSW Police

department and Essential Energy's Environmental Services team will be notified.

6.6.4 Conclusion

The proposal is not anticipated to have any impact upon Aboriginal heritage in the area. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.7 Non-Aboriginal Heritage

6.7.1 Existing environment

Non-Aboriginal heritage refers to any deposit, object or material evidence which relates to the settlement of New South Wales, not being Aboriginal settlement, and is of state or local heritage significance (Section 4 of the Heritage Act).

A desktop search of Australia's World Heritage Sites (Commonwealth DCCEEW, 2022b), National Heritage List (Commonwealth DCCEEW, 2022c), NSW State Heritage Inventory (Heritage NSW, 2022), and QPR LEP was conducted to determine the extent of non-Aboriginal heritage in the vicinity of the proposal.

There are a number of state heritage items within the Queanbeyan local area, including the Queanbeyan Railway Station Group and bridges associated with the operation of the railway. There are also a number of state heritage items scattered throughout Queanbeyan to the east of the project area. State heritage items in relation to the project are shown in **Figure 6-23**.

A number of local heritage items are also located within the Queanbeyan area, including in and around Crestwood close to where the powerline enters NSW, including the following (refer to **Figure 6-24**):

- Item I109 Remnant Cottage
- Item I110 House
- Item I173 House
- Item I174 House.

The powerline extends along a portion of the currently disused Queanbeyan to Bombala railway line. This railway branch, according the Historical Cultural Heritage Background Report Queanbeyan to Bombala Rail Line (attached as **Appendix E**), was completed on the 21 November 1921, with construction commencing during the 1880s with the objective of linking southern NSW townships to the Main South line.

The line was used for both passenger services and freight, with passengers able to travel from Sydney Central to Bombala. However regular steam operations ceased in 1962 and the 1970s saw a decline in rail services along the Bombala line with smaller junctions, platforms and stations beginning to close through the late 1960s and throughout the 1970s. August 1974 saw the last passenger train arrive in Bombala and the final goods service in March 1986.

6.7.2 Assessment of impact

The project is located approximately 310m to the west of the Queanbeyan Railway Station Group and as a consequence, this State Heritage item will not be impacted upon by the proposed powerline. No other State Heritage items will be impacted by the powerline.

Locally listed heritage items are located between 100m and 250m from the proposed powerline. These items consist of houses or a cottage and are not located within the alignment of the powerline. In considering the location of the powerline in the northern and western side of the railway corridor, the existing tree screen planting along Henderson Road will be maintained, shielding views of the powerline from these items. There are also existing electricity structures within the locality, meaning the proposed powerline will integrate with the existing urban amenity. Further information relating to potential visual impact is discussed in **Section 6.10**.

No impacts upon State or locally listed heritage items will occur as a consequence of the proposed activity.

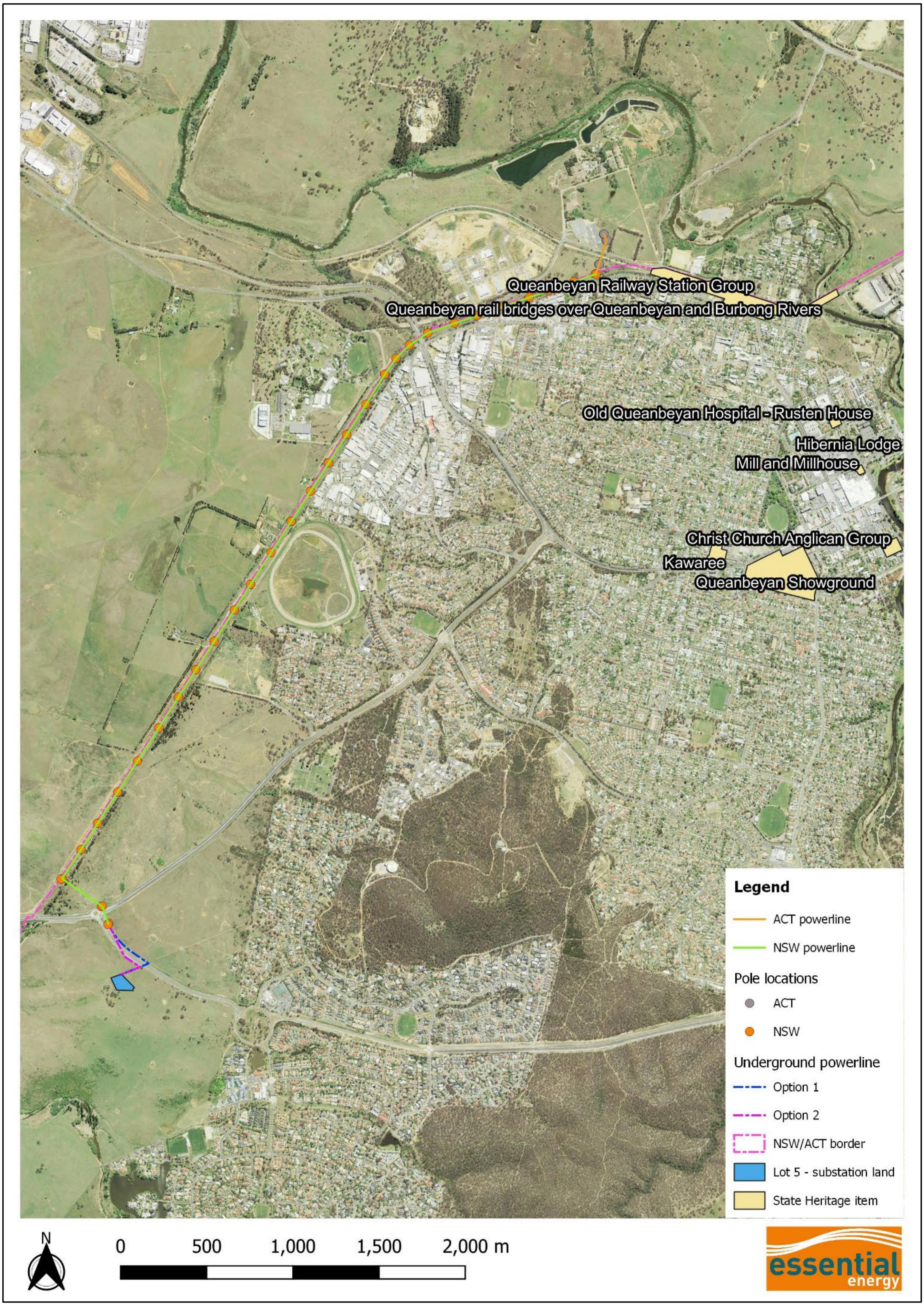


Figure 6-23: Distribution of State heritage items near the project

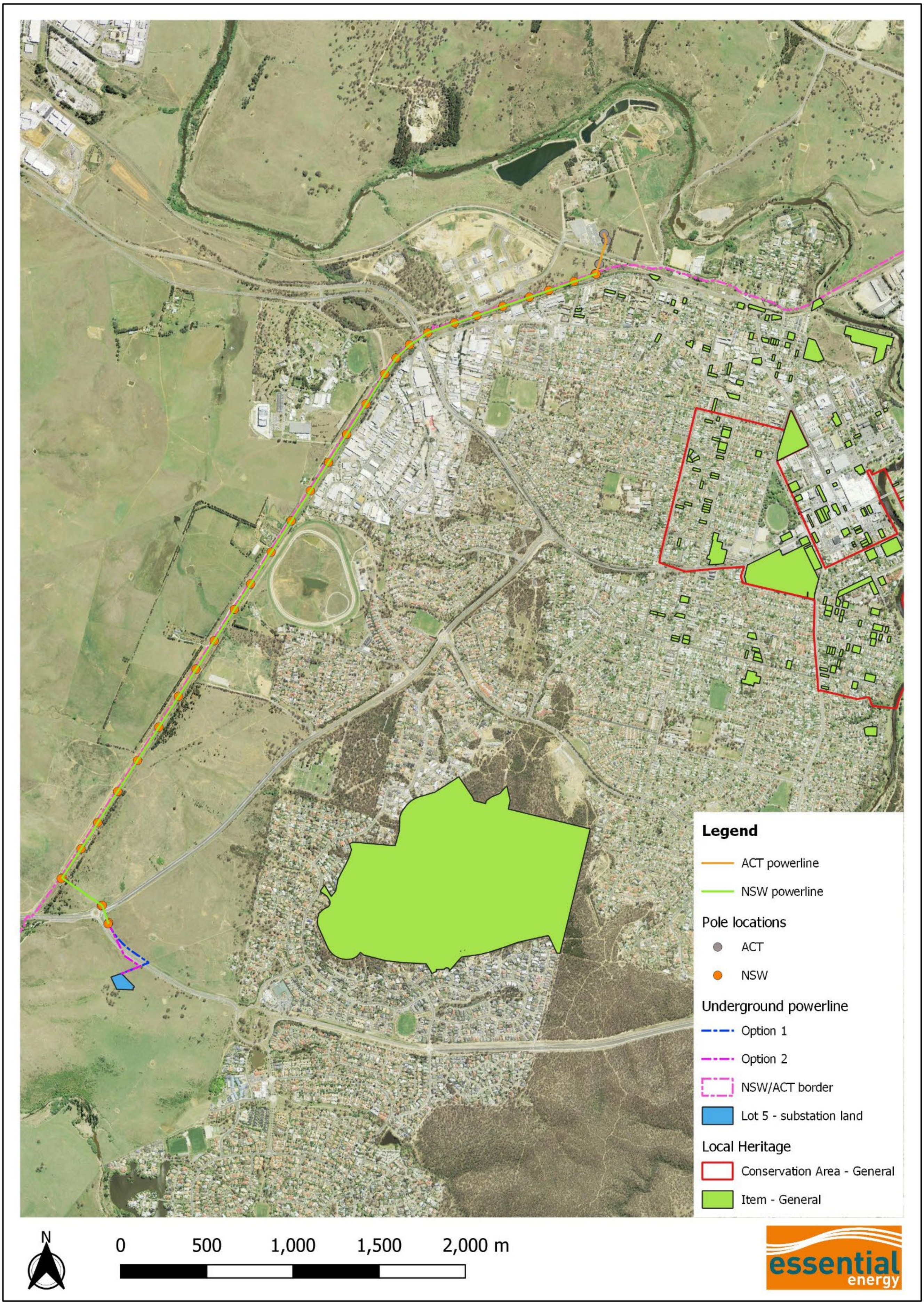


Figure 6-24: Distribution of local heritage items near the project

6.7.3 Environmental mitigation measures

The following mitigation measures would be applied:

- All construction work would be undertaken within the assessed areas of the proposal site only
- In the unlikely event that a previously unknown heritage site or object is located during construction of the proposal, works would cease immediately in that area and a representative from Essential Energy's Environmental Services would be notified. Works with the potential to disturb the object would not resume until the object had been properly identified, and appropriate action taken.

6.7.4 Conclusion

The proposal is unlikely to have a significant impact upon non-Aboriginal heritage in the area. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.8 Contamination

6.8.1 Existing environment

Current land uses within the study area may have resulted in the contamination of soils. Potential on-site sources of contamination include weed and pest spraying. The contaminants that may be encountered within the study area include insecticides, fungicides and herbicides

A search of the NSW EPA 'Contaminated Land – Record of Notices' (EPA, 2023a) and 'List of NSW Contaminated Sites Notified to EPA' (EPA, 2023b) did not identify any contaminated sites within the powerline alignment. Two former service stations within the Crestwood residential area had been notified to the EPA for contaminating potential, however, these sites are listed as regulation not being required. That is, not posing a significant risk of harm to human health or the environment. Refer to **Figure 6-25**.

A search of NSW Department of Primary Industries (DPI) Cattle Tick Dip Site Locator did not indicate any tick dip sites within or in the near vicinity of the proposal site.

6.8.2 Assessment of impact

There are no known records of contamination at, or within the near vicinity of, the proposal site. The site has undergone substantial ground disturbance activities from the construction of the railway corridor. The operation of a railway line could potentially increase the risk of contamination, however, there are no workshops or stations close by, meaning any rail-originated contamination would be limited to minor spills made by rolling stock.

Spillage of diesel, lubricating oils or other chemicals could occur during refuelling and/or maintenance of construction plant/equipment and vehicles, whilst leakage of fuels or oils could occur from poorly maintained construction plant/equipment and vehicles. Any on-site chemical spill or leak could adversely affect the water quality of surrounding waterways. The risk of chemical spills and leaks is expected to be minor, provided that adequate mitigation measures are implemented (see **Section 6.8.3**).

6.8.3 Environmental mitigation measures

The following mitigation measures will be adopted if and where required:

It is intended to reuse surplus spoil beneficially on site.

- In the event of encountering any suspected contamination in the work area, it will be separated and contained on site until it can be classified in accordance with the EPA (2014) Waste Classification Guidelines, and then disposed of at a facility that is lawfully able to accept the waste
- Control measures will be implemented to manage risks associated with the handling of fuel through using spill trays when undertaking in field re-fuelling
- Sediment and erosion control structures will be established and maintained in accordance with The Blue Book to minimise potential impacts on receiving watercourses.

6.8.4 Conclusion

The proposal is not anticipated to have any impact upon contamination in the area. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

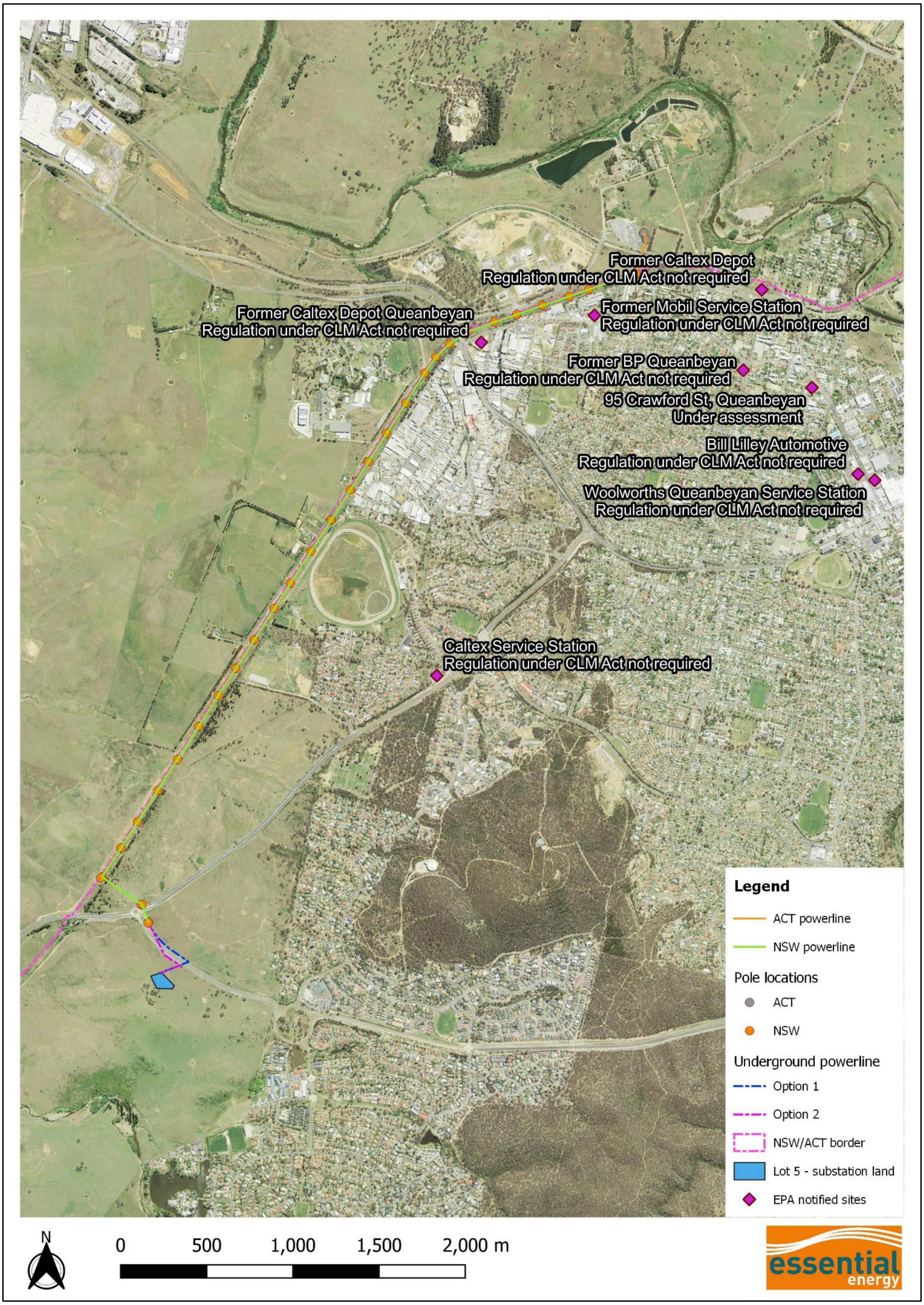


Figure 6-25: Sites notified to the EPA for contamination potential

6.9 Electric and Magnetic Fields

6.9.1 Existing environment

Electric and magnetic fields (EMF) are part of the natural environment and are present in the Earth's core and the atmosphere. EMF is also produced wherever electricity or electrical equipment are in use. Powerlines, electrical wiring, household appliances and electrical equipment all produce EMF.

The electric field is proportional to the voltage (which can be considered as the pressure with which electricity is pushed through the wires). The magnetic field is proportional to the current, that is, to the amount of electricity flowing through the wires. Both electric and magnetic fields are also dependent on the source geometry (i.e. conductor heights, cable depths, phase separations and so on). All fields decrease rapidly with distance from the source. Generally, the smaller the object or closer the conductors producing the field, the more rapidly the field would decrease with distance from the source. Essential Energy is aware of concerns in the community and some scientists regarding the possibility of adverse health effects from exposure to EMF.

All of the research has been extensively reviewed over the last 30 years by Australian and international inquiries and expert panels established for the purpose of trying to determine whether or not human exposure to EMF is related to adverse health effects.

There is scientific consensus that health effects have not been established, but that the possibility cannot be ruled out. Some scientists argue that there is a need for ongoing high quality scientific research in order to give better answers to the questions which have been raised. Others hold the view that no further research is required and that EMF should not be regarded as a risk to health.

It is well accepted by scientists that no study considered in isolation would provide a meaningful answer to the question of whether or not EMF can contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. Over many years, governments and regulatory agencies around the world have commissioned independent scientific review panels to provide such an overall assessment. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), as part of the Health and Ageing Portfolio, is a Federal Government agency charged with responsibility for protecting the health and safety of people, and the environment, from EMF.

ARPANSA advises that:

> "On balance, the scientific evidence does not indicate that exposure to 50 Hz EMFs found around the home, the office or near power lines is a hazard to human health."
>
> "… the majority of scientists and Australian radiation health authorities in particular, do not regard chronic exposure to 50 Hz electric and magnetic fields at the levels commonly found in the environment as a proven health risk. Moreover, the evidence we have is inconclusive and does not allow health authorities to decide whether there is a specific magnetic field level above which chronic exposure is dangerous or compromises human health."

"At the present time there is no evidence that exposure to electric fields is a health hazard (excluding of course electric shock)."

There are currently no Australian standards regulating exposure to these fields. The National Health and Medical Research Council has issued interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields. These guidelines are aimed at preventing immediate health effects resulting from exposure to these fields. The recommended magnetic field exposure limit for members of the public (24 hour exposure) is 0.1 millitesla (1,000 mG - milligauss) and for occupational exposure (whole working day) is 0.5 millitesla (5,000 mG).

Essential Energy operates its powerlines, substations and other electrical infrastructure well within these interim guideline limits.

Essential Energy's policy involves providing balanced and accurate information, operating our electrical power system prudently within Australian health guidelines, and closely monitoring scientific research on the EMF health issue.

6.9.2 Assessment of impact

The proposed new 132kV dual circuit powerline incorporates prudent avoidance measures into the design of the alignment with the route selected on the basis of avoiding areas of proximity to residential areas. The design of the proposal has minimised the magnetic field as far as technically reasonable and within the context of "…[doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk [to health]", consistent with Gibbs Inquiry (1991).

Essential Energy completed EMF modelling for the proposed powerline. EMF levels associated with a particular powerline vary from time to time and from place to place depending upon a variety of factors, principally the load in the powerline and ground clearance. Accordingly, when undertaking calculations in the context of EMF assessments it is necessary to make conservative assumptions about these variables to provide a conservative indication of the long-term average fields which might be associated with a section of the line.

Typically when performing magnetic field calculations, a relatively high loading condition (85^{th} percentile) is used in conjunction with a ground clearance which corresponds to the low point in a low span. As such the resulting field estimates can often appear high when compared to actual measurements taken along the powerline.

In undertaking the EMF modelling a number of conservative and worst-case scenario inputs were factored into the model. The model assumed the highest proposed feeder current rating, highest proposed feeder temperature and, as the powerline is dual circuit, opposing phase orientation set for these calculations.

Under these conditions the highest possible EMF level recorded in the model was 3.3μT or 33mG directly beneath span pole 32 to pole 33 (centreline). In addition to the conservative powerline input parameters, the elevated topography between these poles brings the ground closer to the line in this span, leading to a higher value than other spans. Refer to **Appendix F** for EMF model results.

The figures above related specifically to levels directly under the powerline. EMF levels drop relative to the distance from the electrical circuit creating the field (the conductors). Under the worst-case scenario conditions, EMF levels at 20m from the centreline are similar to the ranges expected from typical household electrical appliances. Refer to the ENA Guideline included as **Appendix G**.

The centreline of the powerline is a minimum 35m from the nearest sensitive receivers being the medium density housing near Uriarra Road, Crestwood. In particular, the units that have an outdoor courtyard towards the footpath that extends along the eastern side of the railway corridor. At a distance of 35m from the powerline, EMF contributions at these locations would be negligible.

Given the above, it is expected that any EMF generated by the proposed powerline will fall well below the interim guidelines for continuous public exposure (24 hours per day) of 1,000mG.

Given the distance to sensitive residential receivers, it is unlikely the new powerline will expose sensitive receivers to EMF.

6.9.3 Conclusion

The proposal will comply with all relevant national and international guidelines. The resulting magnetic fields from the powerline will be within the range of fields expected from electricity infrastructure in the area. The overall environmental risk is considered to be low.

6.10 Visual and Aesthetics

6.10.1 Approach

The following visual amenity assessment approach was applied to evaluate the potential visual impacts associated with the project. It is based on a professionally recognised system developed by the United States Forest Service (1974), and similar methods adopted by the Forestry Commission of Tasmania (1983) and the NSW Department of Planning (1980).

The approach used in this assessment is as follows:

- The existing visual environment of the site is described (in terms of landscape character, scenic quality, visual and landscape sensitivity and major view points)
- A brief description is made of the proposed visual changes, and
- An impact assessment is then undertaken, assessing both the changes to the site itself, and any impacts to views from surrounding areas.

The visual impact of the proposed activity has been determined though the interaction of visual modification and visual sensitivity. These are discussed in more detail in the following sections. The 'visual impact matrix', illustrated in **Table 6-4**, is used to determine the potential visual impact of the proposed activity by combining a ranking of high, medium and low for both visual modification and visual sensitivity.

Table 6-2: Visual impact matrix

		Visual Sensitivity		
		High	Medium	Low
Visual Modification	High	High Impact	High Impact	Moderate Impact
	Medium	High Impact	Moderate Impact	Minor Impact
	Low	Moderate Impact	Minor Impact	Minor Impact

6.10.2 Visual modification

Visual modification expresses the visual interaction between the proposal and the existing visual environment. It is the visual contrast between pre and post-development, and is a combination of the appearance of the development (size, form, colour, texture), absorptive capacity of the landscape setting, and the distance from which the development is viewed. Visual modification is expressed here as high, medium or low.

High modification

A high degree of visual modification would result if the proposed developments are a major element and contrast strongly with the existing landscape. The contrast is likely to occur if there is little or no natural screening or integration created by vegetation, or if there is an open plain. For example, powerlines passing over vegetated ridge tops also usually represent a high visual modification, particularly if it is a new powerline passing through otherwise undisturbed vegetated terrain and the viewer is parallel to the line.

Medium visual modification

A medium degree of visual modification would result if the proposed developments are visible and contrast with the landscape but are integrated to some degree. This would happen if the surrounding vegetation and/or topography provide some measure of visual screening, backgrounding or other form of visual integration of the development with its setting. An example of a medium visual modification is an urbanised streetscape with existing powerlines and/or established trees on the roadside.

Low visual modification

A low degree of visual modification occurs if there is minimal visual contrast and a high level of integration of size, form, colour or texture between the development and the environment. This would occur if there is a high degree of visual integration of the development into the existing landscape or a low level of visual modification of the existing visual setting is achieved. A low visual modification may reflect a situation where the development may be noticeable, but it does not markedly contrast with the existing landscape, as is the case with upgrading existing powerlines.

Throughout the study area, the degree of visual modification is highly dependent on the distance the viewer is from a new development. As the distance from the new development to the viewing location increases, the development becomes less prominent, and therefore its visual modification is less.

Visual modification is also affected by the angle at which a new development is viewed. In general, the visual modification when viewing the new development at right angles is less than when viewing in parallel, depending on the distance from the new development.

6.10.3 Visual sensitivity

Visual sensitivity is a measure of how critically a change to the existing landscape would be viewed from various viewpoints. This is dependent on a number of viewer characteristics, such as the number of viewers affected, land use, existing vegetation patterns, distance of the development from viewers, and the visibility of the development from critical viewing locations.

High visual sensitivity

Occupiers of residential properties with long viewing periods adjacent or within close proximity to the proposal. High sensitive areas can also apply to users of outdoor recreational areas, including reserved land or nature recreation such as walking, swimming, fishing or trail riding. This is particularly the case where their attention is focussed, in part, on the landscape and amenity that is being affected by the proposed development.

Medium sensitivity

Medium sensitivity would apply to circumstances in which viewers have intermittent exposure, such as outdoor workers and outdoor recreation users, however, for the recreational user, attention is focussed predominantly on the activity they are viewing, such as a sporting event, rather than the proposed development. In addition, medium sensitivity would also apply to occupiers of residential properties with long viewing periods at a distance from or partially screened from the proposed development or project area.

Low sensitivity

Low sensitive viewers include predominantly those groups that have a short term view of the proposed development. This would be limited to mainly road users, trains or transport routes that are passing through or adjacent to the study area. Low sensitivity would also apply where viewers are adequately screened from the proposed development so that their viewing periods are limited to short periods.

6.10.4 Existing visual environment (landscape description)

The powerline alignment is situated within a largely disturbed corridor associated with the construction and historical operation of the Bombala railway line. Adjoining portions of the powerline alignment include cleared land, disturbed land from the installation of other utilities, infrastructure, conservation lands, residential areas and industrial areas.

The closest sensitive receivers are those that reside in the suburb of Crestwood and vehicles traveling along key roads, for example, Uriarra Road, Norse Road, Canberra Avenue, Lanyon Drive and Tompsitt Drive.

6.10.5 Visual changes

The powerline will become a permanent change in the visual landscape, however, there are a number of existing electricity assets within the immediately vicinity including powerlines in the ACT and NSW. The railway corridor was selected on the basis of providing an alignment that minimises impacts upon sensitive receivers. Design elements include the location of the powerline on the northern and western side of the railway corridor, thereby, maximising the distance to residents in Crestwood and maintaining the planted tree screen along Henderson Road.

Once the alignment enters NSW, the powerline extends in a west-southwesterly direction with agricultural land buffering the powerline to the west in the ACT. There is some potential for residents within the medium-density housing complex near Uriarra Road to have some views of the poles, however, their visual outlook is limited by small outdoor areas and high fences. As the powerline alignment extends westward from Uriarra Road, existing overhead electricity infrastructure is present running parallel with Norse Road on the ACT side, and the railway on the NSW side. The powerline crosses from the ACT into NSW near the intersection with Kendall Avenue and Stephens Road. Overhead electricity infrastructure is again present for a small section along Woods Lane servicing the residents along this section of the ACT as well as HMAS Harmon.

From the locked gate along Woods Lane, the powerline will result in a new visual change to the landscape from this section, across Queanbeyan Nature Reserve, and over the intersection of Lanyon Drive with Tompsitt Drive. At this point, the powerline will convert to an underground configuration where it will proceed via one of two route options into the substation site.

In considering the permanency of a change to the visual landscape and the integration of the powerline along some sections of the alignment, the powerline is expected to have a medium visual change.

6.10.6 Visual sensitivity

Construction of the powerline will take place across a number of different land use types including rural, infrastructure, and conservation. There are limited opportunities for long-term viewing vantage points to the powerline from nearby sensitive receivers. Most view of the powerline will be from opportunistic viewing from occupants of vehicles and people undertaking recreational activities. For example:

- Vehicles traveling along Henderson Road will have obscured views
- People using the walking track between Henderson Road and Uriarra Road
- Vehicles travelling along the following roads:
  - Norse Road in the ACT
  - Uriarra Road
  - Canberra Avenue (crossing of railway corridor)
  - Woods Lane (until the locked gate – just to the south of Queanbeyan Racecourse)
  - Lanyon Drive and
  - Tompsitt Drive
- Walking along walkways where views of the powerline can be seen
- People utilising the conservation lands in the ACT and NSW.

The powerline will have some viewing vantage points from residents within the Crestwood suburb, with the medium-density housing complex near Uriarra Road having the greatest potential due to their orientation. However, the medium-density complex units have high fences and small courtyards with viewing towards the north and the powerline. In considering the visual outlook, views would be largely limited to poles themselves and not the powerline in its entirety.

Taking a conservative approach, visual sensitivity is anticipated to be medium.

6.10.7 Summary of potential impacts

Visual modification has been assessed as being medium over the longer term, whilst visual sensitivity is considered to be medium. In accordance with the visual impact matrix, the proposed activity is likely to result in a moderate visual impact.

Whilst the proposed development has been determined to have a moderate impact, powerlines by their nature are considered to be low impact due to their size, scope and intensity. This is because power poles, although high in height, are spaced sporadically along an alignment. Powerlines, and in particular, the poles, do not block significant amounts of sunlight, and generally do not significantly impede views, nor do they impact upon privacy.

Furthermore, powerlines are an essential service provision that benefits the broader Australian population and the economy. As such, powerlines, like other utilities, are generally permissible within all planning zones and are a reasonable and necessary development.

6.11 Waste

6.11.1 Assessment of impact

Waste material generated from the proposal would generally comprise the following:

- General construction waste including but not limited to cardboard, paper, wood, mesh, steel, concrete, and other damaged or excess construction materials
- General refuse generated by personnel including putrescible wastes, food scraps, packaging and other domestic wastes
- Drilling mud from underboring
- Surplus excavated soil material from excavation, pole footings and trenching works.

Any surplus soil that cannot be reused on site will be assessed against the virgin excavated natural material (VENM) criteria or any relevant waste exemption order, or classified and disposed of at a facility lawfully able to accept the waste.

Drilling operations for the underbores will result in the creation of liquid wastes. The material will either be taken and lawfully disposed of directly as liquid waste, or allowed to dry and be tested against the drilling mud EPA waste exemption order and/or waste classification tested.

The proposed activity is not expected to result in the creation of excessive materials for disposal, with opportunities to utilise surplus material on site or through waste reclamation and exemption orders.

6.11.2 Environmental mitigation measures

The following mitigation measures will be employed to minimise and manage impacts to waste:

- All waste material will be reused, recycled, or disposed of at a facility lawfully capable of receiving the waste
- Drilling mud to be taken directly to a facility capable of receiving liquid waste, or held in storage to dry and then be tested against the EPA waste exemption order for drilling mud or tested in accordance with the waste classification guidelines.

6.11.3 Conclusion

The proposal is not anticipated to generate a large quantity of waste. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.12 Bushfire

6.12.1 Existing environment

The proposed powerline alignment south of the Queanbeyan West industrial estate is located within the land mapped as Category 3 bushfire prone land. The alignment to the north of this point is not mapped within bushfire prone land, potentially reflecting the more developed land uses, for example, urban roads, HMAS Harmon and developments to the north of Norse Road in the ACT. Refer to **Figure 6-26** for an overview of bushfire prone land relative to the proposed activity.

According to the NSW Rural Fire Service – Guide for Bush Fire Prone Land Mapping (November 2015), vegetation category 3 is considered to be medium bush fire risk vegetation, being higher than category 2, but lower than category 1. Vegetation mapped this way includes grasslands, which is the predominant vegetation cover across the powerline alignment.

6.12.2 Environmental impact assessment

The proposal comprises the construction of a new powerline on what is currently rural, infrastructure and conservation land, with grass cover as the predominate vegetation type.

In considering the various construction activities, the following potential fire ignition sources have been identified in **Table 6-5**.

Table 6-3: Potential construction bush fire risk activities

Activity risk	Description of works
On-site hot works (if required)	Metal grinding, cutting and welding have the potential to create uncontrolled sparks
Catalytic converter-fitted vehicle exhaust system	Catalytic converters run extremely hot and can ignite tall flammable grass
Discarded cigarette butts from smokers	Littering of cigarette butts can provide an ignition source of flammable vegetation.

The Victorian Government held a Royal Commission into the 2009 Victorian Bushfires (State of Victoria 2010) that found five of the 15 fires the Commission reviewed were associated with electricity asset failures. A focus of the Commission's findings was on the ageing nature of the electricity assets and how they were at the distribution level, with specific reference to the 22kV network. The proposed new powerline forming part of the scope of works of this REF is on the high voltage or sub-transmission network, being a 132kV dual circuit powerline. It will also represent a new asset, in contrast to the ageing assets identified to pose a greater risk by the Victorian Government Commission.

Higher voltage powerlines provide higher bush fire mitigation due to their height, materials, design and monitoring/safety systems. Furthermore, stricter vegetation controls are enforced for vegetation in and around higher voltage powerline to reduce fire risks. Whilst they are do not pose a zero risk, they are substantially lower than that for distribution networks and a well-maintained powerline, or one within a low density vegetation area, is unlikely to ignite fires.

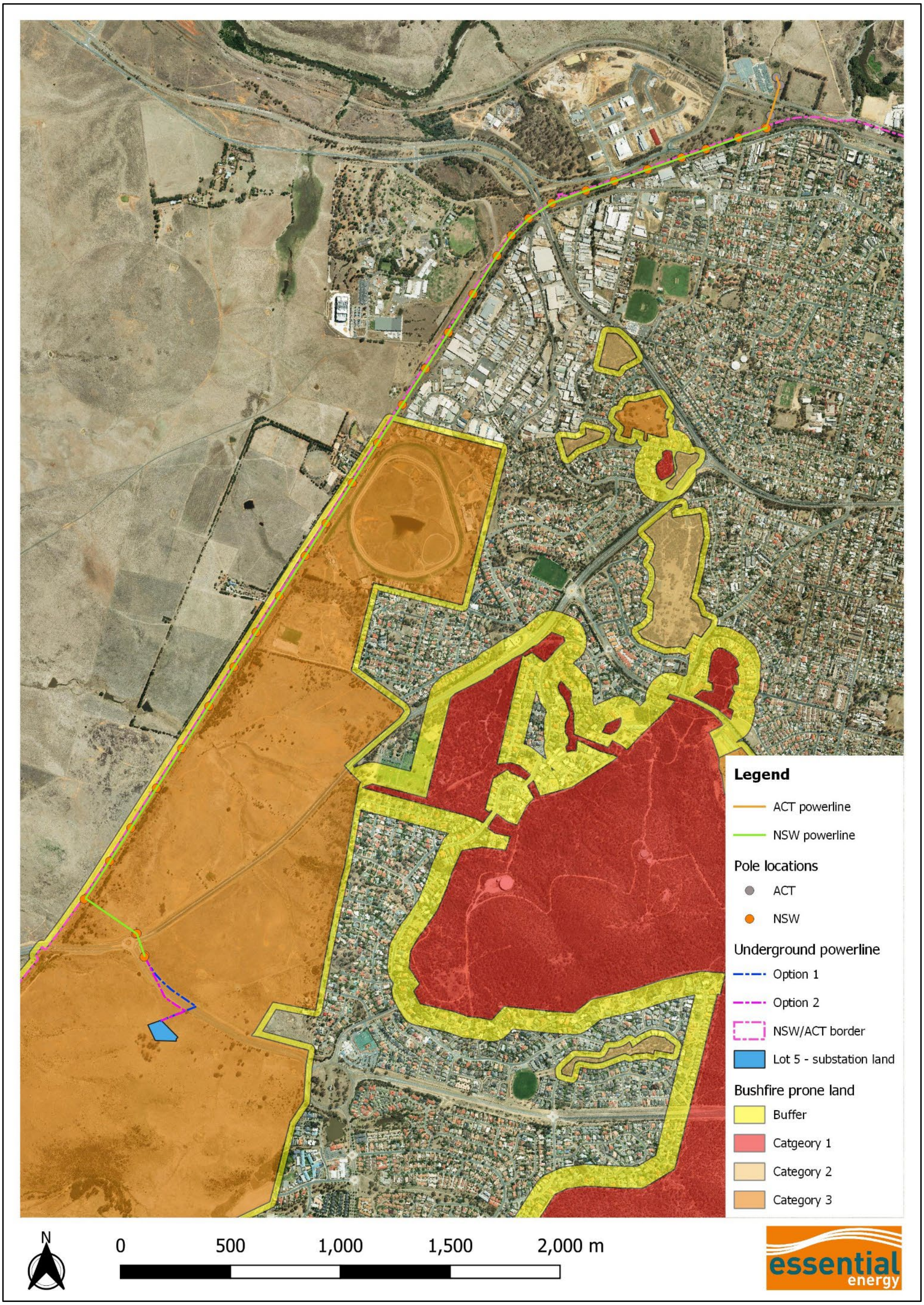


Figure 6-26: Mapped bushfire prone land in the broader area

6.12.3 Environmental mitigation measures

For construction-related bush fire risk activities, the following mitigation will be implemented:

- Where any hot work is required, a permitting, approval or job safety assessment should be performed to consider the risk of uncontrolled sparks during activities, and potential to ignite fires. Such activities are also to be restricted or prohibited during declared total fire bans
- Vehicles to use dedicated identified access pathways. Particular consideration required for lower height vehicles during high bush fire danger periods
- Smoking to only occur in designated smoking areas with sufficient facilities in place to appropriately dispose of ash and butts.

Ongoing vegetation maintenance would occur to ensure safe clearance distances are maintained along the powerline alignment.

6.12.4 Conclusion

The proposal is not anticipated to generate significant bush fire risk. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.13 Traffic and Access

6.13.1 Existing environment

The proposal area is located within a variable landscape that is predominantly rural on the edge of a major city. Consequently, although a rural outlook exists for parts of the alignment, traffic can be heavy during peak periods in proximity to the alignment. In particular, on Uriarra Road, Canberra Avenue, Norse Road, Lanyon Drive and Tomspitt Drive.

Access to enter the railway corridor will be required from some of these roads, including Woods Lane.

6.13.2 Environmental impact assessment

Access into the railway corridor and other sections of the powerline is anticipated to be via existing roads and access tracks. Norse Road/Uriarra Road will provide access for the NSW section from these roads back towards the ACT border. The road reserve between Uriarra Road and Canberra Avenue, where existing overhead powerlines exist, will provide the access points into the rail corridor. From Canberra Avenue, Woods Lane will provide access to the north towards Canberra Avenue and south towards the Queanbeyan Nature Reserve.

Traffic control will be required on Canberra Avenue and Uriarra Road for the stringing of conductors. This activity can be completed outside of peak times when traffic is not as busy. Similarly, Lanyon Drive will be required to be crossed and will require traffic control during stringing operations.

During construction, there will be a slight increase in vehicular movements as materials are transported to site. Designated laydown areas along the alignment will be identified on the NSW side of the border and used as a staging point for delivering materials to their location. Primarily, these materials will be poles, conductor, optical ground wire (OPGW), insulators and other materials.

During operation, the proposal would only be accessed irregularly by maintenance personnel. The proposal would not strain the capacity of the road system.

6.13.3 Environmental mitigation measures

The following mitigation measures will be employed:

- A traffic management plan (TMP) for the construction phase will be prepared. The TMP would outline requirements for the safe and continued use of local transport corridors during construction.

6.13.4 Conclusion

The proposal will have traffic and access impacts during construction and maintenance operations. The impacts will be short-term and minor. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.14 Land Use

6.14.1 Existing environment

The proposal is located predominantly within a disused railway corridor that is zoned, according to the QPR LEP, as SP2 Infrastructure. Other land use zones that the powerline extends across includes the Queanbeyan Nature Reserve, zoned as Conservation, the Tompsitt Drive and Lanyon Drive road reserves, and the Poplar Innovation Precinct, zoned as B7 – Business Park.

6.14.2 Assessment of impact

The proposed powerline will extend across a diversity of land uses along an alignment that has been designed with the specific intention of minimising impacts on those land uses and sensitive receivers. The location of the powerline within the railway corridor has been selected in a manner to enable the recommencement of rail operations. In addition, the poles have been located to not only enable recommencement, but to also provide sufficient distance to allow for the duplication of the railway, thereby factoring future potential railway options into the design.

Where the powerline extends across Queanbeyan Nature Reserve, this has been designed to span across the reserve with no physical assets located on the ground, only the suspended conductor traversing above the reserve. This design has been developed at the request of the National Parks and Wildlife Service with the specific aim of reducing vehicle usage across the reserve for ongoing inspections and maintenance.

Once in the road reserve of Tompsitt Drive, the powerline will convert to underground configuration and enter into Lot 5 of the PIP via Lot 6. A 10m easement will facilitate and restrict activities on the underground powerline across Lot 6, and has been designed in consultation with the purchaser of Lot 6, who have considered the powerline in their own design plans.

6.14.3 Environmental mitigation measures

The following measures should be adhered to during the construction phase of the proposed activity:

- Consultation about the proposed works and schedule will be undertaken directly with landowners
- The site should be left in a tidy condition at the conclusion of construction activities.

6.14.4 Conclusion

Any impacts on land use are likely to be minor and enable the continuation of current land uses with limited to no long-term impacts or impediments. Given the nature of existing land uses, the overall environmental risk is considered to be low.

6.15 Social and Economic

6.15.1 Existing environment

Electricity is an essential service in the human environment, by virtue of enhancing productivity, comfort, safety, health and the economy. The benefits of a secure and reliable electricity supply are evident in every aspect of our lives. Construction and operation of the 132kV dual circuit powerline will support the broader SJHVSP, in particular supporting the development of the SJDP, and ensure safe and reliable electricity supply to the broader South Jerrabomberra area.

Queanbeyan-Pelerang council has adopted a number of strategic plans relating to housing and employment lands. South Jerrabomberra features prominently in the plans, recognising the importance of the SJDP to council for providing affordable housing and employment opportunities.

The South Jerrabomberra Structure Plan 2013 and Residential and Economic Strategy 2015-2031 identify South Jerrabomberra as providing approximately 2,500 new dwellings, as well as approximately 130ha dedicated to employment lands. The purpose of the SJHVSP is to provide sufficient supply to meet the current and forecast demand for electricity within this region. The SJHVSP has been designed to enable future augmentations should demand exceed current projections.

The PIP is referred to in the *Towards 2040 Queanbeyan-Palerang Regional Council Local Strategic Planning Statement* (QPRC, July 2020) and supports Planning Policy 10 and 11 of that Statement. The proposal site, in particular the broader PIP, supports Goal 1 (A connected and prosperous economy), and Goal 3 (Healthy connected communities) of the *South East and Tablelands Regional Plan 2036.*

6.15.2 Environmental impact assessment

An improvement to the electricity supply network provides many benefits to the broader community through a secure and reliable electricity supply.

In the absence of further augmentation to the high voltage supply network, there is an increased risk of supply interruptions, and it is unlikely that any further development could proceed. This would detrimentally impact on economic and social development of the region, and potentially prove to be disruptive to existing commercial enterprises and to residences throughout the local area.

The proposal is unlikely to affect community resources; this may include the use of community infrastructure roads, water, and waste management services. The proposal is unlikely to cause substantial change or disruption to the community through loss of neighbourhood cohesion, access to facilities, community identity, or cultural character.

6.15.3 Environmental mitigation measures

The following mitigation measures will be employed to manage and minimise potential negative social and economic impacts:

- Management of construction traffic in the vicinity of construction works, including communication with local residents and road users
- Signs and barriers would be erected around construction work sites, where appropriate, to minimise the possibility of personnel injuries and prevent placing the public at risk.

6.15.4 Conclusion

Construction will be temporary in nature, and apart from some changes to the visual amenity, long-term impacts are not expected.

The social impact would be short-term and minor, however, the proposal will have longer term positive economic impacts. Given the mitigation measures outlined in this assessment, the overall environmental risk is considered to be low.

6.16 Cumulative Impacts

Cumulative impacts may be experienced due to the interaction of elements within the proposal, or with other existing or proposed developments within the locality. The new 132/11kV ZS will be located within an approved six lot subdivision as part of Stage 1 of the PIP, which is in itself part of the much broader SJDP. Poplars Pty Ltd has obtained approval under Part 4 of the EP&A Act for disturbance of all areas within Stage 1 of the PIP. Essential Energy understands that as part of the subdivision works, Poplars Pty Ltd has purchased and retired all necessary biodiversity offset credits. As such, any potential cumulative impacts to threatened species, populations and ecological communities from the construction, operation and maintenance of the ZS will be negligible to nil, and not likely to result in a significant impact.

Similarly, given the relatively small disturbance footprint and the localised extent of potential impacts during construction and operational phases, the potential cumulative impact to other environmental factors during construction and operation of the ZS has been minimised to the greatest extent possible, and would not be significant. Any residual, minor impacts identified in this section of the REF, can be mitigated and managed through the range of measures outlined in this section and summarised in **Table 6-5**.

6.17 Summary of Environmental Mitigation Measures

The environmental mitigation measures outlined in this document would be incorporated into the Project Construction Environmental Management Plan (CEMP). These safeguards would minimise any potential adverse impacts arising from the proposed works on the surrounding environment. The mitigation measures are summarised in **Table 6-6**.

Table 6-4: Summary of Environmental Mitigation Measures

Aspect	Environmental Mitigation Measures	Timing
General	• All environmental mitigation measures must be incorporated within the Construction Environmental Management Plan (CEMP), or relevant works plan as applicable for the proposed works.	Pre-works.
General	• Environmental awareness training must be provided to all field personnel, contractors and subcontractors.	Pre-works and during works as required.
Consultation	• Considerable public engagement has already occurred during the project planning and pre-work stages, including, letterbox drop of project information newsletter to 2250 residences in the ACT and NSW; project information made available on Essential Energy's website; establishment of a free call line and email address; community briefings and engagement with community-based organisations • In addition specific stakeholder engagement has occurred via Ministerial and MP briefings; one on one meetings with the NSW Government (BCT, DPE, TfNSW, and Department of Regional NSW), e-mails and other direct correspondence with impacted landholders • Ongoing engagement and updates on project progression will continue via the Essential Energy Engagement website, and with affected stakeholders, where required.	Project planning and re-works. Project planning and re-works. During works.
Licences, Permits, Approvals and Notifications	• Notification to the local council in accordance with clause section 45 of the *Electricity Supply Act 1995*.	40 days prior to works commencing. This notification has been sent.
Air Quality	• Any potential dust-borne materials transported to and from the activity site will be covered at all times during transportation • Any temporary stockpiles of surplus excavated material will be managed effectively. Potential reasonable and feasible options include covering or wetting down materials during dry and windy conditions • All vehicles and machinery will be well maintained according to manufacturer requirements to ensure emissions are kept within acceptable limits.	During works.
Geology and Soil	• Risks associated with sediment and erosion will be managed in accordance with The Blue Book – Managing Urban Stormwater: Soils and Construction (Landcom 2004) and • Disturbed areas will be stabilised as soon as practicable following construction activities.	During works.
Water Quality	• Control measures will be implemented to manage risks associated with the handling of fuel through	During works.

Aspect	Environmental Mitigation Measures	Timing
and Hydrology	using spill trays when undertaking in field re-fuelling • Management of disturbed areas in accordance with the requirements of the Blue Book to minimise potential impacts to waterways • Discharge any accumulated water onto adjacent grassed areas within the road reserve (preferred option – reuse a beneficial resource), use filter bags or pump into a tanker and remove from site.	
Noise and Vibration	• On occasions works outside specified hours may be undertaken where the following requirements are met: - Neighbours (and other sensitive receivers) adjacent to the works or the local council or the NSW Environment Protection Authority (EPA) have been notified and - Where the works are required to take place in the vicinity of private access ways or driveways ,consultation with individual residents would be undertaken to advise residents of the planned timing of the works.	During works.
Flora and Fauna	• Where located in identified threatened fauna species habitat (or potential habitat), the disturbance footprints at each pole location will be inspected prior to the conduct of any works • Any potential 'No Go' areas (not particularly likely given the disturb\ed nature of almost all of the powerline alignment) will be identified and communicated to contractors and Essential Energy staff • The pre- clearing translocation of lizards and/or rocks at relevant locations (likely to be required only rarely – if at all). • Vehicle movements between power poles (other than to the north of Uriarra Road) will be minimised; with priority given to the use of existing tracks and roads.	Pre-works, during works and post works.
Aboriginal Heritage	• In the unlikely event that an Aboriginal heritage site or object is located during the construction phase of the project, works will cease in that area and a representative from Essential Energy's Environmental Services will be notified. Works with the potential to disturb the object would not resume until the object had been properly identified, and appropriate action taken • If human remains are uncovered, works must immediately cease and the NSW Police department and Essential Energy's Environmental Services team will be notified.	During works.

Aspect	Environmental Mitigation Measures	Timing
Non-Aboriginal Heritage	• All construction work would be undertaken within the assessed areas of the proposal site only • In the unlikely event that a previously unknown heritage site or object is located during construction of the proposal, works would cease immediately in that area and a representative from Essential Energy's Environmental Services would be notified. Works with the potential to disturb the object would not resume until the object had been properly identified, and appropriate action taken.	During works.
Contamination	• In the event of encountering any suspected contamination in the work area, it will be separated and contained on site until it can be classified in accordance with the EPA (2014) Waste Classification Guidelines, and then disposed of at a facility that is lawfully able to accept the waste • Control measures will be implemented to manage risks associated with the handling of fuel through using spill trays when undertaking in field re-fuelling • Sediment and erosion control structures will be established and maintained in accordance with The Blue Book to minimise potential impacts on receiving watercourses.	During works.
Waste	• All waste material will be reused, recycled, or disposed of at a facility lawfully capable of receiving the waste • Drilling mud to be taken directly to a facility capable of receiving liquid waste, or held in storage to dry and then be tested against the EPA waste exemption order for drilling mud or tested in accordance with the waste classification guidelines.	During works.
Bushfire	• Where any hot work is required, a permitting, approval or job safety assessment performed the consider the risk of uncontrolled sparks during activities and potential to ignites fires. Such activities to be restricted or prohibited during declared total fire bans • Vehicles to use dedicated identified access pathways. Particular consideration required for lower height vehicles during high bush fire danger periods • Smoking to only occur in designated smoking areas with sufficient facilities in place to appropriate dispose of ash and butts.	During works.
Traffic and Access	• A traffic management plan (TMP) for the construction phase will be prepared. The TMP would outline requirements for the safe and continued use of local transport corridors during construction.	Pre-works and during works.
Land Use	• Consultation about the proposed works and schedule will be undertaken directly with landowners • The site should be left in a tidy condition at the conclusion of construction activities.	Pre-works, during works and post-works.
Social and Economic	• Management of construction traffic in the vicinity of construction works, including communication with local residents and road users	Pre-works and during works.

Aspect	Environmental Mitigation Measures	Timing
	• Signs and barriers would be erected around construction work sites, where appropriate, to minimise the possibility of personnel injuries and prevent placing the public at risk.	

7. Ecologically Sustainable Development

Ecologically sustainable development (ESD) is an attempt to provide the best outcomes for the human and natural environments both now and into the indefinite future. One of the most often cited definitions of sustainability is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". Sustainability relates to the continuity of economic, technical, social, institutional and environmental aspects of human society, as well as the non-human environment.

The existing environment has been described throughout **Section 6** of this REF for the various aspects of the natural environment assessed as part of this proposed activity.

The proposal has been assessed against the following four principles of ESD listed in the *Protection of the Environment Administration Act 1991.*

The four principles of ESD are:

- The precautionary principle: section 6(2)(a)(i)(ii)
- The principle of inter-generational equity: section 6(2)(b)
- The principle of biological diversity and ecological integrity: section 6(2)(c)
- The principle of improved valuation of environmental resources: section 6(2)(d)(i)(ii)(iii).

An assessment of the proposal against the principles is provided below.

7.1 Precautionary Principle

The precautionary principle states that:

'If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, public and private decisions should be guided by:

1) *careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
2) *an assessment of the risk weighted consequence of various options.'*

For the precautionary principle to be applicable, two pre-conditions must be satisfied; "*first it is not necessary that serious or irreversible environmental damage has actually occurred – it is the threat of such damage that is required. Secondly, the environmental damage threatened must attain the threshold of being serious or irreversible*"[4].

If there is no threat of serious or irreversible environmental damage, there is no basis upon which the precautionary principle can apply.

Environmental investigations, including detailed ecological and Aboriginal and non-Aboriginal heritage assessments, have been undertaken during the preparation of this REF to ensure that the potential environmental impacts are understood with a high degree of certainty. The spatial scale of impacts would be local and isolated to the immediate construction area. Therefore, it can be concluded that this proposal will not result in a threat of serious or irreversible damage.

Mitigation measures have also been proposed in this REF to minimise the identified potential impacts of the project. A Construction Environmental Management Plan (CEMP) will be developed and implemented as a precautionary measure, and no mitigation measures have been deferred due to a lack of scientific certainty. The proposal is therefore consistent with the precautionary principle.

7.2 Principle of Inter-Generational Equity

The principle of inter-generational equity states that:

'The present generation should ensure that the health, diversity and productivity of the environment

[4] Telstra Corporation Limited v Hornsby Shire Council [2006] NSWLEC 133, Preston CJ at 129

are maintained or enhanced for the benefit of future generations.'

To the extent possible, all environmental impacts and appropriate mitigation measures have been identified. The proposal would not harm the health, diversity and productivity of the environment to such an extent that future generations would not be able to benefit.

The proposal is therefore consistent with the principle of inter-generational equity.

7.3 Principle of Biological Diversity and Ecological Integrity

The principle of biological diversity and ecological integrity states that:

'Conservation of biological diversity and ecological integrity should be a fundamental consideration.'

Comprehensive and detailed ecological assessments, including an original study on Avian Interactions with Powerlines and work by two ecological consultants incorporating literature reviews and field-based observations of locally-occurring bird species, provide a scientifically credible basis on which to draw conclusions on potential biodiversity impacts.

Through this methodological and rigorous approach, the conservation of biological diversity and ecological integrity has been a fundamental consideration. A currently highly disturbed and disused railway corridor was selected on the basis of minimising potential environmental impacts and maximising distance to sensitive receivers.

The specialist reports relating to ecology determined that the proposed activity would not result in a significant impact upon biological diversity and ecological integrity. Impacts upon ecological integrity are described in **Section 6.5**.

7.4 Improved Valuation of Environmental Resources

The principle of improved valuation of environmental resources states that:

'Environmental factors should be included in the valuation of assets and services such as:

- Polluter pays – that is, those who generate pollution and waste should bear the cost of containment, avoidance and abatement
- The users of goods and services should pay prices based on the full life cycle of costs of providing those goods and services, including the use of natural resources and assets and the ultimate disposal of any waste
- Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms that enable those best placed to maximise benefits or minimise cost to develop their own solutions and responses to environmental problems.'

The proposal has been designed taking into consideration the least possible impact on the environment. All costs associated with the containment, avoidance and abatement of pollution have been factored into the design of this proposal. The proposal will have the positive benefit of supporting the broader SJHVSP, creating regional economic opportunities and job growth in the area.

8. Construction Environmental Management Plan

8.1 Introduction

A Construction Environmental Management Plan (CEMP) outlines the environmental objectives of a project, the environmental mitigation measures to be implemented, the timing of implementation, responsibilities for implementation and management, and a review process to determine the effectiveness of the strategies.

The construction contractor(s) would be required to develop a project-specific CEMP that addresses the scope of works to be undertaken. The CEMP would detail how the works would be undertaken to comply with all environmental laws, Essential Energy's environmental policy, and the environmental mitigation measures described in this REF.

The key objectives of the CEMP would include:

- Ensuring that the works are carried out in accordance with legislative requirements and relevant non-statutory policies
- Ensuring that the works are carried out in accordance with the requirements detailed in this REF, including all requirements outlined in any relevant approvals, permits or licences and the mitigation measures described in **Section 6**
- Ensuring that employees engaged to undertake the works comply with the conditions detailed in the CEMP
- Identifying management responsibilities and reporting requirements to demonstrate compliance with the CEMP.

It is also noted that the CEMP would be a working document and may be amended over the course of the project.

If a particular activity falls outside the scope of the REF and CEMP, and it would increase the environmental impact, the activity is not permitted to continue without an appropriate environmental assessment under the EP&A Act.

8.2 Implementation of the CEMP

The CEMP would be a working document and would be amended should strategies initially implemented be found to be inadequate to manage environmental impacts. The CEMP would typically:

- Establish environmental goals and objectives
- Detail the conditions of approval
- List actions, timing and responsibilities for implementation that arise from the mitigation measures recommended in this REF
- Detail statutory requirements
- Provide a framework for reporting on relevant matters on an ongoing basis
- Detail training requirements for personnel in environmental awareness and best practice environmental management systems
- Outline emergency procedures, including contact names and corrective actions
- Detail process surveillance and auditing procedures
- List complaint handling procedures
- Detail quality assurance procedures.

8.2.1 Auditing schedule of the CEMP

Auditing of the proposal would be undertaken to establish whether the contractor is conducting activities in accordance with their current environmental management plans and whether the management plans are providing an effective tool to control adverse environmental impacts.

The following activities are proposed to achieve the audit's purpose:

- Review the on-site implementation of the contractor's CEMP
- Review the documentation process to determine if planned works have received endorsement to proceed
- Monitor the compliance of construction activities with the project determination and environmental legislation
- Review the outcomes of any previous audit(s) and determine if there has been any change in the environmental performance of the construction contractor
- Identify opportunities to improve on-site environmental management practices.

The benefits of conducting the environmental audit are to allow:

- Feedback on the CEMP implementation process to assist both the contractor and project manager to improve the future preparation of site environmental management documentation
- Improve the planning of construction projects through documentation and impact assessment to ensure best environmental management practices are implemented on site
- Improve environmental management processes on site.

9. Environmental Checklist

In accordance with section 5.5 of the EP&A Act and clause 171 of the EP&A Reg, Essential Energy, when assessing the environmental impact of an activity on the environment, must consider the factors identified in **Table 9-1** and **Table 9-2** below.

Table 9-1: Section 5.5 requirements

Requirement	Section Reference
For the purpose of attaining the objects of this Act relating to the protection and enhancement of the environment, a determining authority in its consideration of an activity shall, notwithstanding any other provisions of this Act or the provisions of any other Act or of any instrument made under this or any other Act, examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity.	Section 2, 6, 7 and 8
Without limiting the above, a determining authority shall consider the effect of an activity on any wilderness area (within the meaning of the *Wilderness Act 1987*) in the locality in which the activity is intended to be carried on	N/A – there are no wilderness areas within or close to the activity area

Table 9-2: Clause 171 checklist

171 Factor	Section Reference
The environmental impact on a community *The works are located in a predominantly disturbed railway corridor, notwithstanding also being located in proximity or across land dedicated to the conservation of biological diversity. Impacts on the community have been considered by this REF. These include noise, dust, biodiversity, social, visual impacts and EMF.*	Sections 6.1, 6.2, 6.3, 6.4, 6.6, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.13 6.14, 6.15 and 6.16.
The transformation of a locality *The powerline extends along an approximately 6km long alignment with variability in adjacent land uses along that alignment. In certain locations there will be a high degree of integration, whilst in others, a new feature will be added into the landscape where similar structures do not currently exist.* *The route of the powerline has been selected based on a number of matters, including an alignment that avoids close interactions with people and causing land use conflicts. The use of a heavily disturbed and disused railway corridor provides an opportunity to place the powerline away from people, whilst also taking into account any future railway operations. To that end, the powerline has been designed to not only facilitate the re-commencement of the railway line, but also any future duplication of the railway.*	Sections 2.2, 4.2, 6.10, 6.14 and 6.15
The environmental impact on the ecosystems of the locality *The proposed powerline has been designed and located within a heavily disturbed railway corridor to reduce potential ecosystem impacts. A number of studies have been prepared to specifically address potential impacts on biodiversity, providing a scientifically credible basis for assessing the degree of potential impacts the powerline may imposeon ecosystems.*	Sections 6.5 and 7.
Reduction of the aesthetic, recreational, scientific, or other environmental quality or value of a locality *The proposed activity will result in the introduction of a physical feature within a landscape that does not currently exist, however in certain sections, it will be integrated to a degree. The powerline has been designed to avoid areas of potential recreational and other environmental qualities so as to reduce the impacts to as low as reasonably necessary to facilitate the activity.*	Sections 2.2, 4.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.9, 6.10, 6.14, 6.15 and 6.16

171 Factor	Section Reference
The effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations. *No sites of Aboriginal heritage will be impacted by the proposal. A review of non-Aboriginal heritage databases, registers and LEPs indicated no sites of world, national, state, or local heritage were located at or within close proximity to the proposed powerline alignment.*	Sections 6.6, 6.7.
The impact on the habitat of protected fauna (within the meaning of the *Biodiversity Conservation Act, 2016*). *The proposed powerline alignment extends along a predominantly disturbed railway corridor. Nonetheless, sections of the alignment do contain ecological values, including habitat for protected fauna. The alignment is predominantly comprised of grassland vegetation, with the powerline having limited impacts at the pole locations. The majority of the current biodiversity values will remain post-construction.*	Section 6.5
The endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air. *The proposed powerline alignment extends along a predominantly disturbed railway corridor. Nonetheless, sections of the alignment do contain ecological values, including threatened ecological communities, species and their habitats. The existence of these species has been considered in the design of the powerline through individual pole locations and the alignment.* *Impacts to a listed threatened ecological community (TEC) will occur for a small section of the works toward the northeast of Uriarra Road. However, whilst vegetation clearing will occur, that disturbance will be predominantly to weeds or other exotic species, with the ground species triggering the criteria for a TEC, being largely conserved.* *For the preparation of the environmental impact statement (EIS) for the ACT component, the Flora and Fauna Conservator requested that the impact of the powerline on avian predation and abundance be considered with particular regard to threatened reptiles. In response to this requirement, a detailed paper on avian interactions with powerline was prepared as part of the EIS. This was further built upon for the NSW environmental assessment, including the ecological assessment report, that included site-specific observations of bird predation and behaviour.* *Through this methodical, rigorous approach and scientifically credible scenario, it was concluded that the proposed powerline will not lead to an increase in predation efficiency or predator abundance.*	Section 6.5
Long-term effects on the environment. *Long-term adverse environmental effects are not anticipated.*	Sections 6 and 7
Degradation of the quality of the environment. *This risk is considered low with the implementation of soil and water management measures included in this REF.*	Sections 6.1, 6.2, 6.3, 6.4, 6.5 and 6.8.
Risk to the safety of the environment. *There is potential risk to the environment from spillage of materials during construction of the proposal. Implementation of the mitigation measures contained in Section 6 of this REF will ensure that potential environmental risks are minimised.*	Sections 6.1, 6.2, 6.3, 6.8, 6.11, 6.12, 6.13, 6.14 and 7.
Reduction in the range of beneficial uses of the environment. *No long-term reduction in the range of beneficial uses of the environment is anticipated as a result of the proposal.*	Section 6 and 7
Pollution of the environment. *Risk of pollution to the environment is considered low and can be managed with implementation of mitigation measures provided in this REF.*	Section 6

171 Factor	**Section Reference**
Environmental problems associated with the disposal of waste *Waste generated as a result of the proposed works will be minor. All wastes that is generated as a result of the project and requiring offsite disposal will be taken to a facility lawfully capable of receiving that waste.*	Section 6.11
Increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply. *The proposal is unlikely to increase demands upon rare natural resources.*	Section 6
The cumulative environmental effect with other existing or likely future activities *The proposed powerline forms a component of the broader SJHVSP that also includes the construction of a zone substation, which will increase capacity and reliability to the South Jerrabomberra precinct. The proposed activity will also facilitate an increase in electricity supply capacity to service predicted load increases associated with the SJDP.* *Developments within the SJDP are subject to planning and assessment approvals, including rezonings, subdivisions and individual developments. Current approved developments have had their biodiversity impacts offset through the improvement of biodiversity values, purchase of credits, or the conservation of private lands.* *Given the relatively small disturbance footprint and the localised extent of potential impacts during construction and operational phases, the potential cumulative impacts to other environmental factors during construction and operation of the powerline and substation have been minimised to the greatest extent possible, and would not be significant. Any residual, minor impacts identified in this REF can be mitigated and managed through the range of measures outlined in Section 6, and summarised in Table 6-6.*	Section 6.16
The impact on coastal processes and coastal hazards, including those under projected climate change conditions? *The proposal is not located on the coast.*	Section 1 and 6.
Applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1. *The Poplars Innovation Precinct (PIP), of which the proposal site forms a part, is referred to in the Towards 2040 Queanbeyan-Palerang Regional Council Local Strategic Planning Statement (QPRC, July 2020) and supports Planning Policies 10 and 11 of that Statement. The PIP also supports Goal 1 (A connected and prosperous economy), and Goal 3 (Healthy connected communities) of the South East and Tablelands Regional Plan 2036.* *In addition, Queanbeyan council has adopted a number of strategic plans relating to housing and employment lands. South Jerrabomberra features prominently in the plans, recognising the importance of the SJDP to council for providing affordable housing and employment opportunities.* *The South Jerrabomberra Structure Plan 2013 and Residential and Economic Strategy 2015-2031 identify South Jerrabomberra as providing approximately 2,500 new dwellings as well as approximately 130ha dedicated to employment lands. The purpose of the SJHVSP is to provide sufficient supply to meet the current and forecast demand for electricity within this region. The substation, and associated high voltage powerline, are required to enable the development to occur. The SJHVSP has been designed to enable future augmentations should demand exceed current projections.*	Section 6.13, 6.14, 6.15, 6.16
Other relevant environmental factors. *No other relevant environmental factors have been identified during the preparation of this REF*	N/A

10. Conclusion

This REF has been prepared to assess the environmental impacts associated with the construction, operation and maintenance of the new South Jerrabomberra 132kV powerline project. Essential Energy is a determining authority as defined in the EP&A Act. As such, the activity does not require consent under Part 4 of the EP&A Act. The activity has been assessed under Part 5, Division 5.1 of the EP&A Act.

The proposal would enable the upgrade of the local electricity network to both support the SJDP and increase overall network capacity, placing Essential Energy in a better position to meet customers' current future electricity needs.

The proposal complies with the provisions of section 5.5 of the EP&A Act and clause 171 of the EP&A Reg as shown in **Section 9**.

The proposal and its associated environmental impacts are unlikely to have a significant impact on the environment. The proposed new 132kV dual circuit powerline would support the SJDP, and strengthen Essential Energy's electricity network in the broader area, maximising the social and economic benefits, whilst minimising any adverse environmental impacts.

11. References

Department of Planning and Environment – Guidelines for Division 5.1 assessments, June 2022.

Department of Environment, Climate Change and Water (DECCW), 2010a, Mitchell Landscapes NSW OEH v3 2011. Bioregional Assessment Source Dataset.

DECCW, 2010b, Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales, DECCW, 13 September 2010.

Commonwealth DCCEEW, 2022b, Australia's World Heritage List, https://www.dcceew.gov.au/parks-heritage/heritage/places/world-heritage-list, Accessed 14 December 2022.

Commonwealth DCCEEW, 2022c, Australia's National Heritage List, https://www.dcceew.gov.au/parks-heritage/heritage/places/national-heritage-list, Accessed 14 December 2022.

Environmental Protection Authority (EPA), 2014, Waste Classification Guidelines, Sydney, NSW EPA, November 2014.

EPA, 2023a, Contaminated land - record of notices, https://app.epa.nsw.gov.au/prclmapp/searchregister.aspx, Accessed 14 December 2022.

EPA, 2023b, List of NSW contaminated sites notified to EPA, https://www.epa.nsw.gov.au/your-environment/contaminated-land/notified-and-regulated-contaminated-land/list-of-notified-sites, Accessed 14 December 2022.

Essential Energy, 2023, Review of Environmental Factors South Jerrabomberra Zone Substation, Essential Energy, May 2023.

Heritage NSW, 2022, State Heritage Inventory, https://www.environment.nsw.gov.au/topics/heritage/search-heritage-databases/state-heritage-inventory, Accessed 14 December 2022.

Forestry Commission of Tasmania, 1983, Visual Management System.

Landcom 2004, Managing Urban Stormwater: Soils and Construction, 4th edition.

Queanbeyan-Palerang Regional Local Environmental Plan 2022.

United States Department of Agriculture Forest Service, 1974, National Forest Landscape Management, Volume 2.

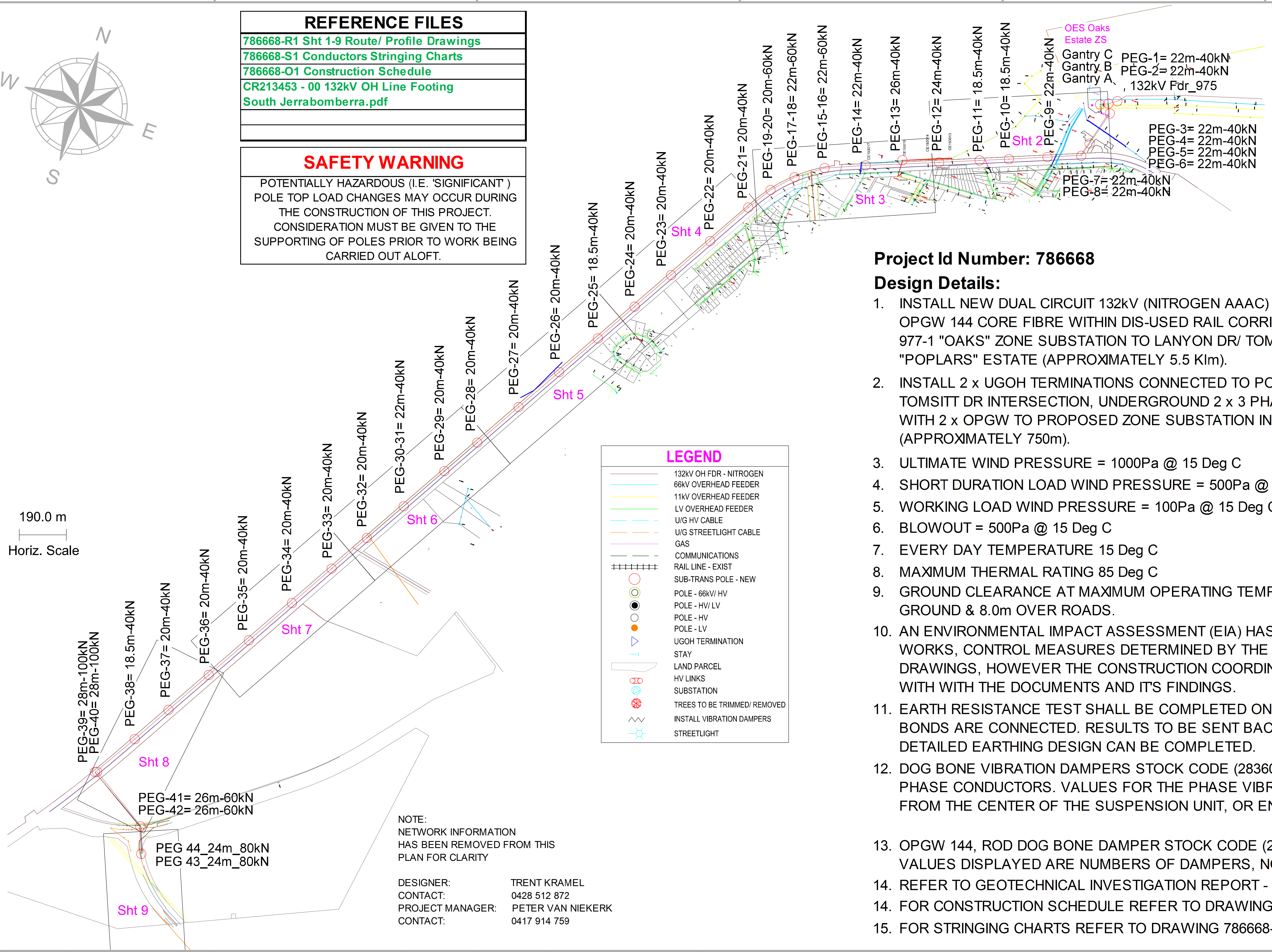
Appendix A – Design plans

REFERENCE FILES

- 786668-R1 Sht 1-9 Route/ Profile Drawings
- 786668-S1 Conductors Stringing Charts
- 786668-O1 Construction Schedule
- CR213453 - 00 132kV OH Line Footing South Jerrabomberra.pdf

SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.



LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

NOTE:
NETWORK INFORMATION HAS BEEN REMOVED FROM THIS PLAN FOR CLARITY

DESIGNER:	TRENT KRAMEL
CONTACT:	0428 512 872
PROJECT MANAGER:	PETER VAN NIEKERK
CONTACT:	0417 914 759

Project Id Number: 786668

Design Details:

1. INSTALL NEW DUAL CIRCUIT 132kV (NITROGEN AAAC) CONDUCTORS AND DUAL OPGW 144 CORE FIBRE WITHIN DIS-USED RAIL CORRIDOR FROM EXISTING FEEDER 977-1 "OAKS" ZONE SUBSTATION TO LANYON DR/ TOMSITT DR INTERSECTION, "POPLARS" ESTATE (APPROXIMATELY 5.5 Klm).
2. INSTALL 2 x UGOH TERMINATIONS CONNECTED TO POLES FROM LANYON DR/ TOMSITT DR INTERSECTION, UNDERGROUND 2 x 3 PHASE 630mm² cU 1C CABLES WITH 2 x OPGW TO PROPOSED ZONE SUBSTATION IN "POPLARS" ESTATE (APPROXIMATELY 750m).
3. ULTIMATE WIND PRESSURE = 1000Pa @ 15 Deg C
4. SHORT DURATION LOAD WIND PRESSURE = 500Pa @ 15 Deg C
5. WORKING LOAD WIND PRESSURE = 100Pa @ 15 Deg C
6. BLOWOUT = 500Pa @ 15 Deg C
7. EVERY DAY TEMPERATURE 15 Deg C
8. MAXIMUM THERMAL RATING 85 Deg C
9. GROUND CLEARANCE AT MAXIMUM OPERATING TEMPERATURE = 7.3m OVER GROUND & 8.0m OVER ROADS.
10. AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) HAS BEEN WRITTEN FOR THESE WORKS, CONTROL MEASURES DETERMINED BY THE EIA ARE SUMARISED ON THE DRAWINGS, HOWEVER THE CONSTRUCTION COORDINATOR SHOULD BE FAMILIAR WITH WITH THE DOCUMENTS AND IT'S FINDINGS.
11. EARTH RESISTANCE TEST SHALL BE COMPLETED ON EVERY POLE BEFORE OPGW BONDS ARE CONNECTED. RESULTS TO BE SENT BACK TO THE DESIGNER SO DETAILED EARTHING DESIGN CAN BE COMPLETED.
12. DOG BONE VIBRATION DAMPERS STOCK CODE (283608) ARE TO BE INSTALLED ON PHASE CONDUCTORS. VALUES FOR THE PHASE VIBRATION DAMPERS ARE IN "mm" FROM THE CENTER OF THE SUSPENSION UNIT, OR END OF COMPRESION DEADEND.
13. OPGW 144, ROD DOG BONE DAMPER STOCK CODE (283596) ARE TO BE INSTALLED. VALUES DISPLAYED ARE NUMBERS OF DAMPERS, NOT DISTANCE.
14. REFER TO GEOTECHNICAL INVESTIGATION REPORT - TBA
14. FOR CONSTRUCTION SCHEDULE REFER TO DRAWING 786668-O1
15. FOR STRINGING CHARTS REFER TO DRAWING 786668-S1

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

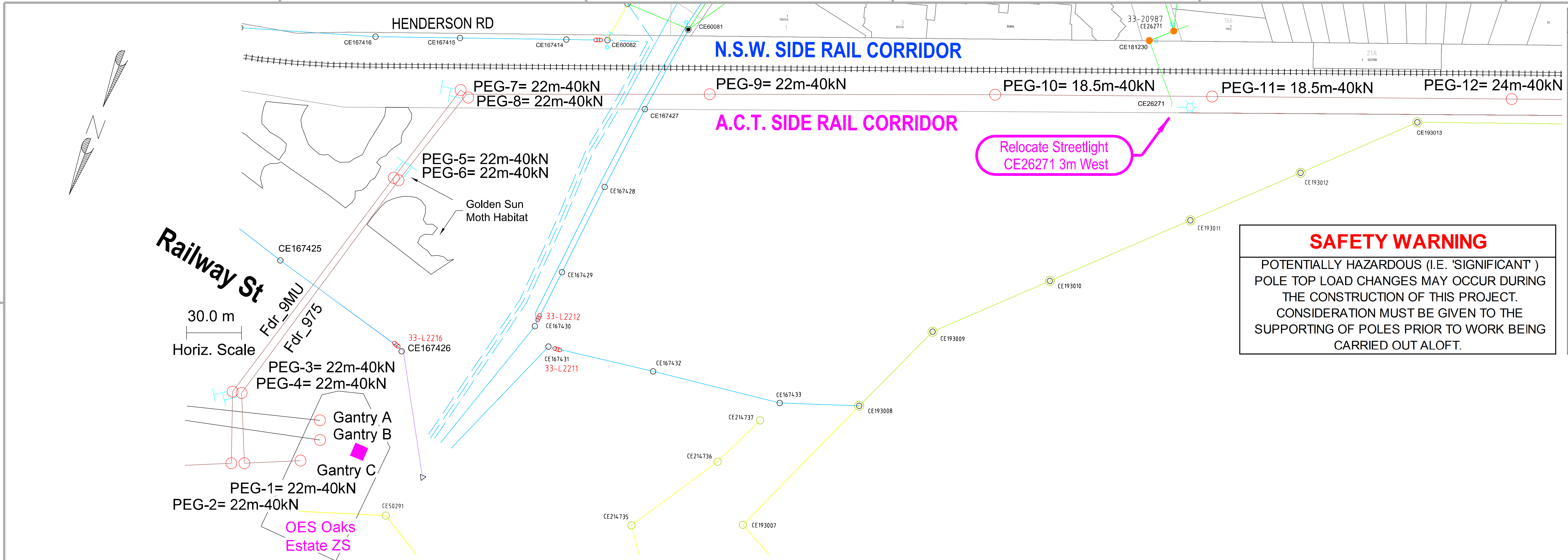
TRANSMISSION LINES

975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA QUEANBEYAN PRELIMINARY DRAWING

essential energy

SCALE	SIZE	DRAWING NUMBER	SHT	VER
N.T.S.	SIZE	786668-R1	1/9	A



SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

Peg No.	Pole No.	Ahead Span	Line Deviation ANGLE	EASTING	NORTHING	132/66kV Structure Details						Underbuild Details		Stay Details					OPGW/ OHEW Details		OPGW Junction Box Location	Foundation Details				Vibration Dampers / Conductor				Status	Revision	Comments
						Pole Top Construction CEOM	Structure Type	Manufacturer	Length (m)	Strength (kN)	Depth in ground (m)	Construction	Attachment Below Pole Top (m)	No.	Assembly CEOM	Slope Angle	Orientation	Attachments Below Pole Top (m)	Drawing CEOM	Quantity		Auger size (m)	Stay Anchor CEOM	Footing Depth (m)	Footing Type	OPGW (see Note 11) Back Span	OPGW (see Note 11) Ahead span	Phase (see note 10) Back Span	Phase (see note 10) Ahead span			
Gantry C		30.6	0.0	701503.67	6087007.38	Replace 132kV strain insulators 3 x item 261962	D	Steel	Existing Steel Gantry Frame			N/A	N/A	N/A	N/A	N/A	N/A	N/A	Existing			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Replace existing 132kV strain insulators
1		38.3	90.5	701531.26	6087020.71	22m Single Circuit Strain Pole - CEOM7402.54	D	Steel - BPM	22	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7406.19 - Assy 13	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Dificult Access - Steel Pole Required
-	CE227401	37.6	43.0	701564.62	6087043.86	Replace 132kV strain insulators 3 x item 261962	D	Steel	22	44	Exist	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Refer Googong Project	-	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Dificult Access - Steel Pole Required
2		40.5	84.2	701533.56	6087022.68	22m Single Circuit Strain Pole - CEOM7402.54	D	Steel - BPM	22	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Dificult Access - Steel Pole Required
3		144.3	38.6	701547.66	6086986.07	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.03	50	175	5.00 7.00	7406.19 - Assy 6	1	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Dificult Access - Steel Pole Required
4		146.0	42.5	701552.84	6086987.11	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.03	50	175	5.00 7.00	7406.19 - Assy 6	1	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	Dificult Access - Steel Pole Required
5		131.7	2.0	701514.48	6086845.68	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.02	50	0	6.00	7406.19 - Assy 6	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
6		135.9	0.1	701517.40	6086845.52	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.02	50	0	6.00	7406.19 - Assy 6	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
7		131.7	51.6	701497.19	6086789.29	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.03	50	175	5.00 7.00	7406.19 - Assy 6	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
8		135.9	87.2	701502.66	6086787.17	22m Single Circuit Strain Pole - CEOM7402.53	D	Steel - BPM	22	40	TBA	N/A	N/A	1	7405.03	50	170	5.00 7.00	7406.19 - Assy 6	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
9		155.7	0.1	701376.79	6086735.98	22m Single Circuit Intermediate Vertical Pole - CEOM7402.51	S	Steel - BPM	22	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7406 -Assy 6 & 7 7406.19 - Assy 1	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
10		118.4	0.4	701233.50	6086675.16	18.5m Single Circuit Intermediate Vertical Pole - CEOM7402.51	S	Steel - BPM	18.5	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7406 -Assy 6 & 7 7406.19 - Assy 1	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
11		163.4	0.0	701124.25	6086629.64	18.5m Single Circuit Intermediate Vertical Pole - CEOM7402.51	S	Steel - BPM	18.5	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7406 -Assy 6 & 7 7406.19 - Assy 1	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	
12		160.1	0.1	700973.44	6086566.79	24m Single Circuit Intermediate Vertical Pole - CEOM7402.51	S	Steel - BPM	24	40	TBA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7406 -Assy 6 & 7 7406.19 - Assy 1	1	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	For Construction	A	

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

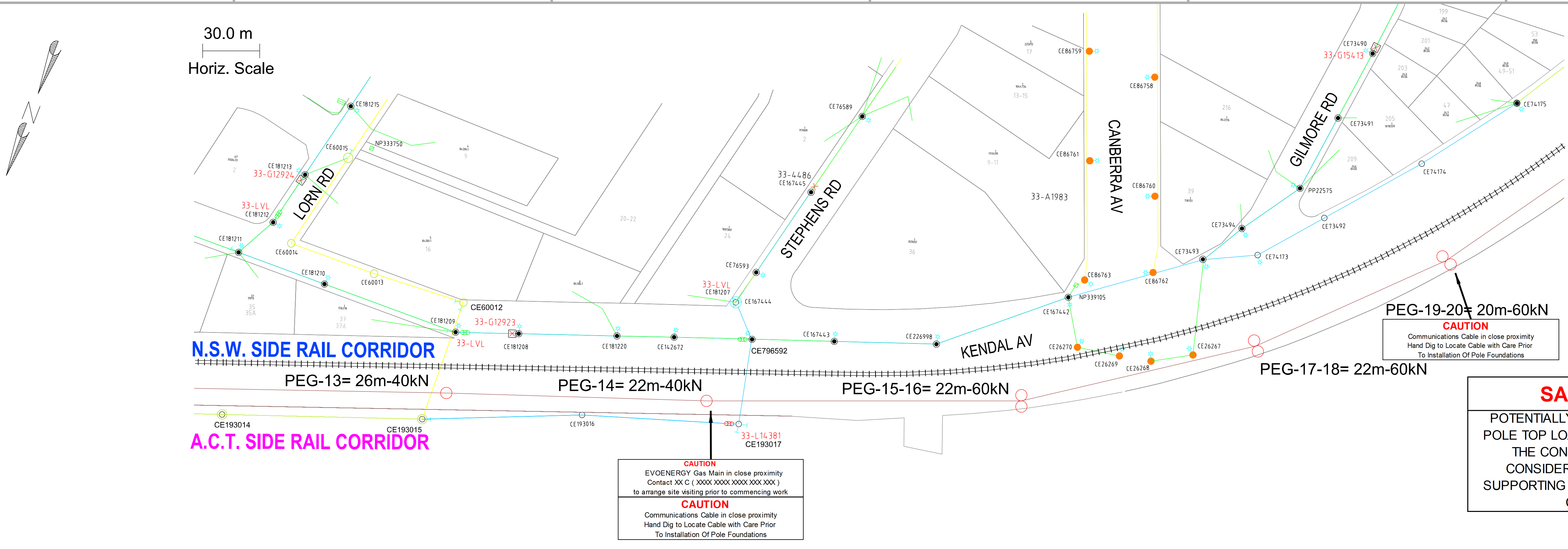
TRANSMISSION LINES

975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	2/9	A



LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES

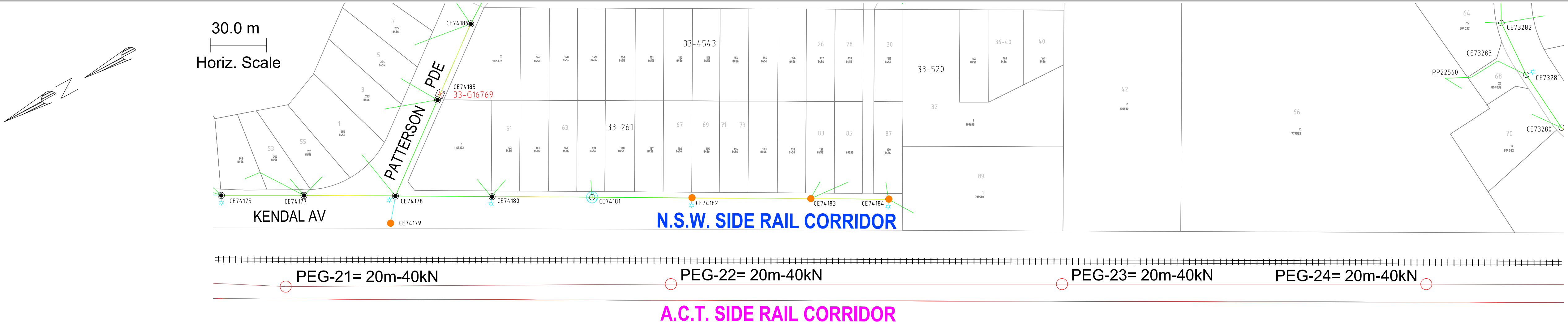
975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

essential energy

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	3/9	A



LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES

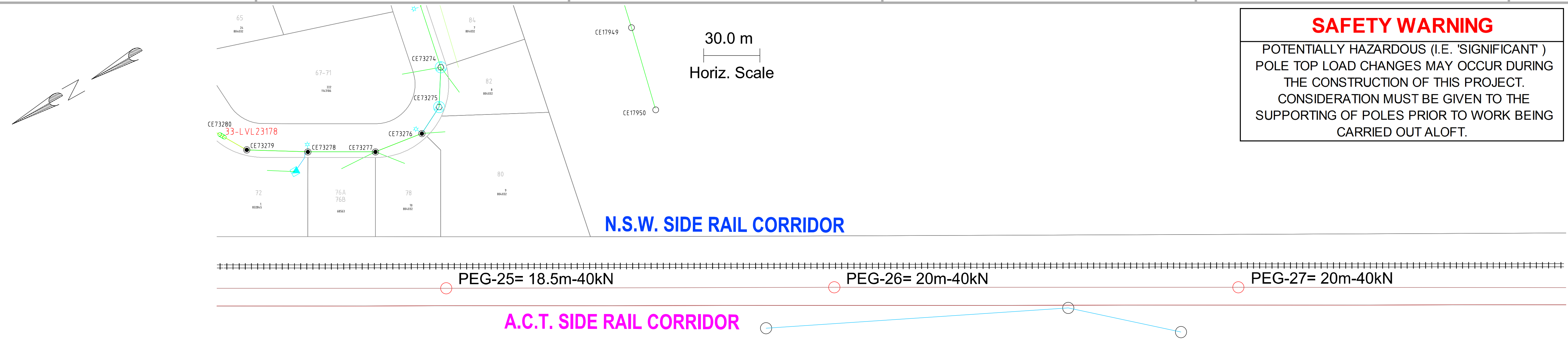
975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	4/9	A

essential energy



SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES

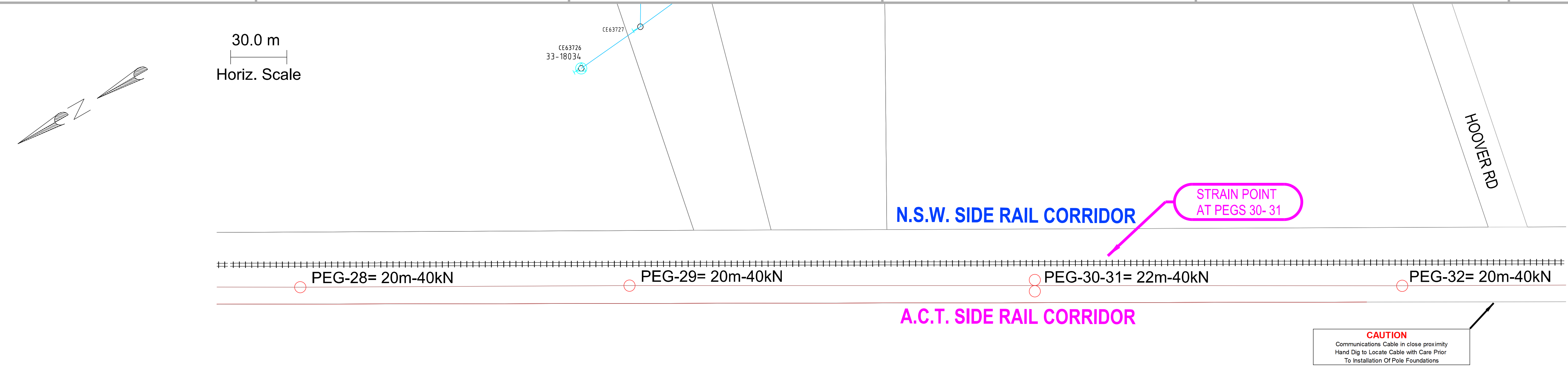
975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	5/9	A

essential energy



LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

SAFETY WARNING

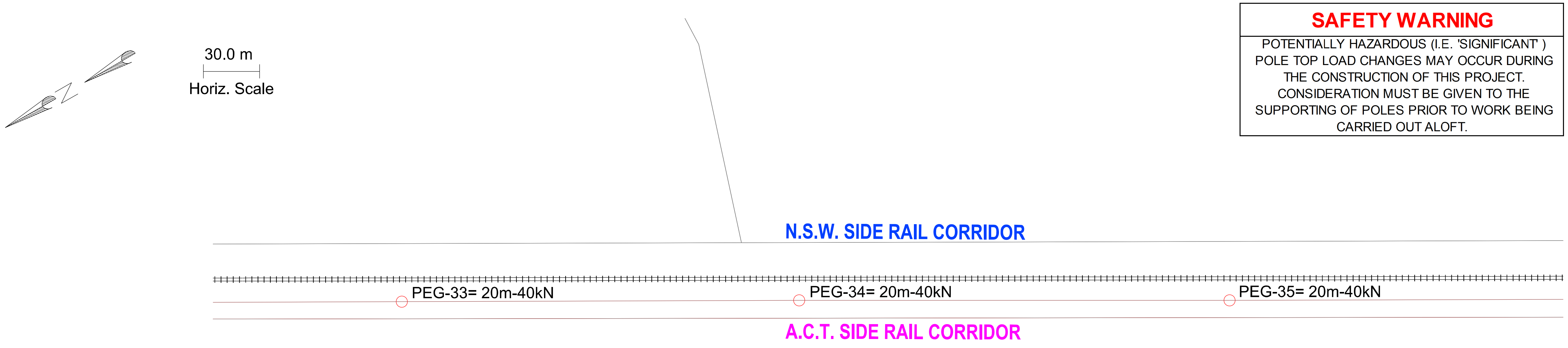
POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES
975 & 9MU Queanbeyan - Suth Jerrabomberra
SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	6/9	A



SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES

975 & 9MU Queanbeyan - Suth Jerrabomberra

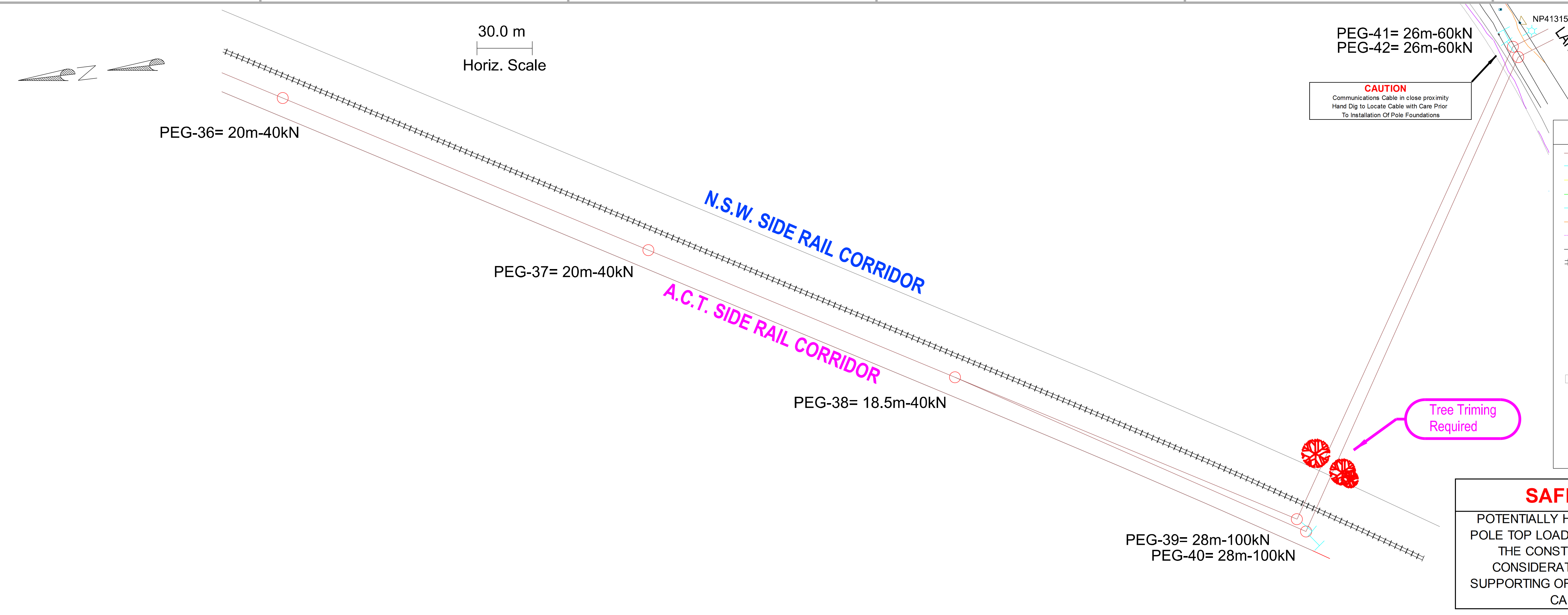
SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

essential energy

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	7/9	A

CAD File: 786668_South Jerra Bomberra.dgn Printed: 28/09/2022 2:00:05 PM Printed By: tkramel



LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

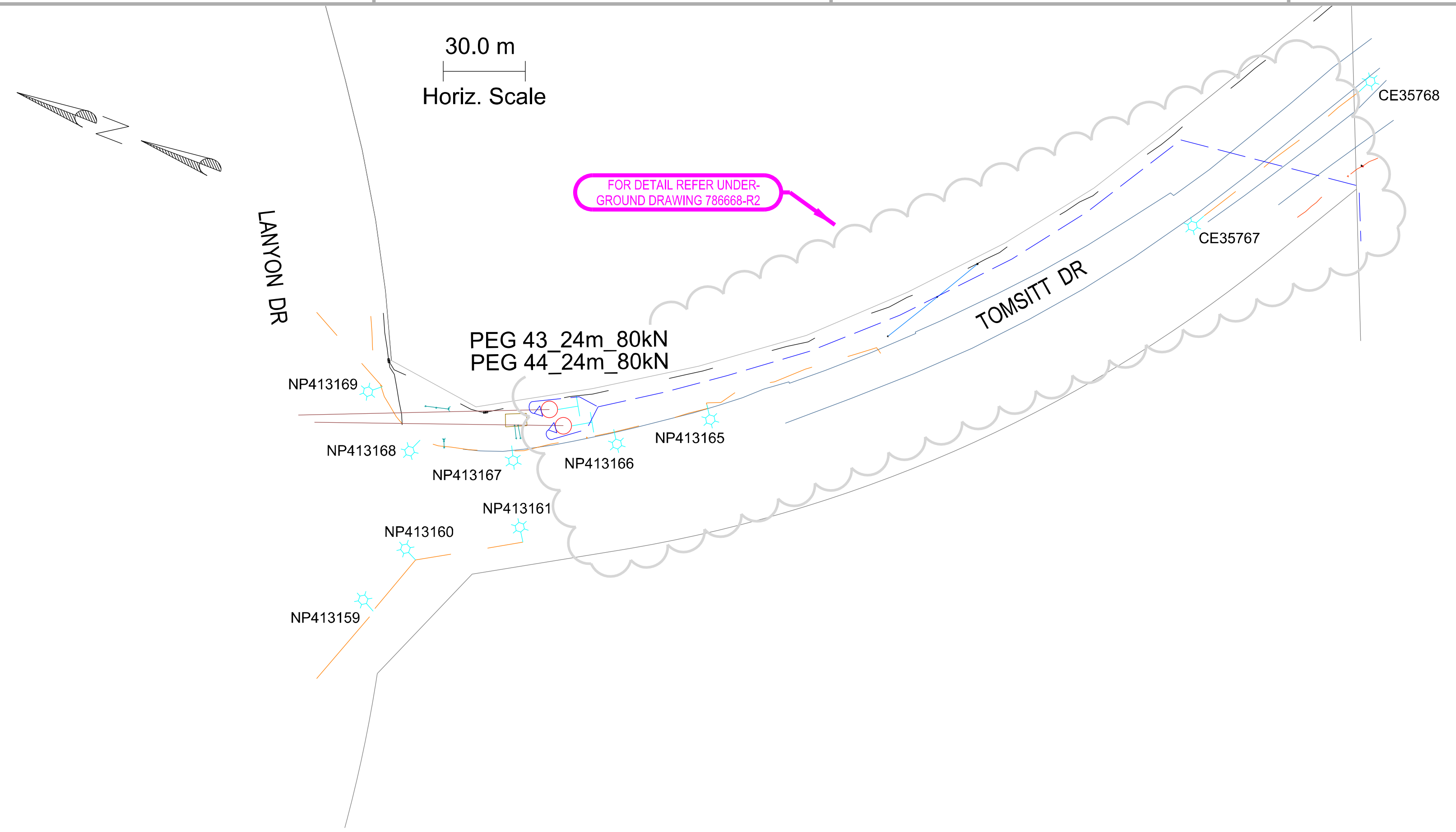
TRANSMISSION LINES

975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	8/9	A



SAFETY WARNING

POTENTIALLY HAZARDOUS (I.E. 'SIGNIFICANT') POLE TOP LOAD CHANGES MAY OCCUR DURING THE CONSTRUCTION OF THIS PROJECT. CONSIDERATION MUST BE GIVEN TO THE SUPPORTING OF POLES PRIOR TO WORK BEING CARRIED OUT ALOFT.

LEGEND

- 132kV OH FDR - NITROGEN
- 66kV OVERHEAD FEEDER
- 11kV OVERHEAD FEEDER
- LV OVERHEAD FEEDER
- U/G HV CABLE
- U/G STREETLIGHT CABLE
- GAS
- COMMUNICATIONS
- RAIL LINE - EXIST
- SUB-TRANS POLE - NEW
- POLE - 66kV/ HV
- POLE - HV/ LV
- POLE - HV
- POLE - LV
- UGOH TERMINATION
- STAY
- LAND PARCEL
- HV LINKS
- SUBSTATION
- TREES TO BE TRIMMED/ REMOVED
- INSTALL VIBRATION DAMPERS
- STREETLIGHT

VER	DATE	PURPOSE	REMARKS	DESIGNED	DRAWN	REVIEWED	APPROVED
A	01/09/2022	PRELIMINARY	PRELIMINARY DESIGN ONLY	T. KRAMEL	T. KRAMEL	TBA	TBA

TRANSMISSION LINES

975 & 9MU Queanbeyan - Suth Jerrabomberra

SOUTH JERRABOMBERA
QUEANBEYAN
PRELIMINARY DRAWING

SCALE : N.T.S.
SIZE : SIZE

DRAWING NUMBER	SHT	VER
786668-R1	9/9	A

GENERAL

G1. THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH SPECIFICATIONS AND OTHER CONSULTANT'S DRAWINGS.
G2. ALL DISCREPANCIES SHALL BE REFERRED TO THE SUPERINTENDENT AND RESOLVED BEFORE PROCEEDING WITH THE WORK.
G3. ALL DIMENSIONS SHOWN SHALL BE VERIFIED BY THE BUILDER ON SITE. THESE STRUCTURAL DRAWINGS SHALL NOT BE SCALED FOR DIMENSIONS. THE RL's SHOWN ON THESE DRAWINGS ARE APPROXIMATE AND ARE FOR THE SOLE PURPOSE OF ASSISTING THE STRUCTURAL DOCUMENTATION. THEY ARE NOT TO BE USED FOR CONSTRUCTION PURPOSES. REFER TO ESSENTIAL ENERGY DOCUMENTATION FOR ALL SETOUT AND ALL RL DOCUMENTATION.
G4. ALL WORKMANSHIP, TESTING, MATERIALS AND SUPERVISION ARE TO BE IN ACCORDANCE WITH THESE SPECIFICATIONS, THE WORK HEALTH AND SAFETY ACT 2011. ENFORCED BY THE WORKCOVER AUTHORITY AND CURRENT RELEVANT AUSTRALIAN STANDARDS.
G5. PROPRIETARY ITEMS SPECIFIED SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S WRITTEN RECOMMENDATIONS. DO NOT VARY SPECIFIED PROPRIETARY PRODUCTS WITHOUT WRITTEN APPROVAL FROM THE ENGINEER.
G6. THESE DRAWINGS AND ISSUED WRITTEN INSTRUCTIONS DURING THE COURSE OF THE CONTRACT DEPICT THE COMPLETE STRUCTURE. THEY DO NOT DESCRIBE A WORK METHOD. THE ARRANGEMENT, DESIGN AND INSTALLATION OF TEMPORARY WORKS REMAINS THE RESPONSIBILITY OF THE CONTRACTOR.
G7. THE DETERMINATION OF A SAFE WORK METHOD REMAINS THE RESPONSIBILITY OF THE CONTRACTOR. ANY ELEMENT WHICH POSES AN UNACCEPTABLE LEVEL OF SAFETY RISK TO CONSTRUCT SHALL BE REFERRED TO THE STRUCTURAL ENGINEER. TEMPORARY BRACING AND SUPPORT OF STRUCTURE IS THE RESPONSIBILITY OF THE CONTRACTOR AND SHALL BE MAINTAINED DURING ALL STAGES OF CONSTRUCTION.
G8. NOTES ON ANY DRAWING APPLY TO ALL DRAWINGS IN THE SET UNLESS NOTED OTHERWISE
G9. THE BUILDER SHALL PROVIDE CERTIFICATION ON ANY DESIGN AND CONSTRUCT COMPONENT BY A CHARTERED PROFESSIONAL ENGINEER (NPER).
G10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE LOCATION OF ALL SERVICES IN THE VICINITY OF THE WORKS. ANY SERVICES SHOWN ARE PROVIDED FOR INFORMATION ONLY. THE CONTRACTOR SHALL CONFIRM THE LOCATION OF ALL SERVICES PRIOR TO COMMENCING AND SHALL BE RESPONSIBLE FOR THE REPAIR OF ANY DAMAGE CAUSED TO SERVICES, AS WELL AS ANY LOSS INCURRED AS A RESULT OF THE DAMAGE TO ANY SERVICE.
G11. THE STRUCTURAL COMPONENTS DETAILED ON THESE STRUCTURAL DRAWINGS ARE JOB SPECIFIC AND HAVE BEEN DESIGNED IN ACCORDANCE WITH THE RELEVANT AUSTRALIAN STANDARDS AND BUILDING CODE OF AUSTRALIA FOR THE FOLLOWING FIRE RATINGS, WIND LOADS, FLOOR USAGE AND EARTHQUAKE LOADS.
FOOTING LOADS:
- ALL DESIGN LOADS PROVIDED BY ESSENTIAL ENERGY

G12. THE METHOD OF CONSTRUCTION AND THE MAINTENANCE OF SAFETY DURING CONSTRUCTION IS THE RESPONSIBILITY OF THE BUILDER. IF ANY STRUCTURAL ELEMENT PRESENTS DIFFICULTY IN RESPECT TO SAFETY THE MATTER SHALL BE REFERRED TO NORTHROP CONSULTING ENGINEERS FOR RESOLUTION BEFORE PROCEEDING WITH THE WORK.
G13. NO CHANGES IN ANY STRUCTURAL ELEMENT SHALL BE MADE WITHOUT WRITTEN APPROVAL FROM NORTHROP CONSULTING ENGINEERS. IF THERE IS A DISCREPANCY THEN FOR TENDER PURPOSES ALLOW FOR THE MOST EXPENSIVE OPTION. NORTHROP CONSULTING ENGINEERS SHALL BE CONTACTED TO CONFIRM PRIOR TO CONSTRUCTION.
G14. CONSTRUCTION USING THESE DRAWINGS SHALL NOT COMMENCE UNTIL ALL NECESSARY APPROVALS ARE PROVIDED AND ONLY IF THE DRAWINGS ARE DESIGNATED "ISSUED FOR CONSTRUCTION".
G15. NORTHROP CONSULTING ENGINEERS ACCEPTS NO RESPONSIBILITY FOR ANY WORK NOT INSPECTED OR NOT APPROVED BY NORTHROP CONSULTING ENGINEERS DURING CONSTRUCTION.

CONSTRUCTION PHASE SERVICES - WITNESS POINTS

WP1. OBTAIN NORTHROP CONSULTING ENGINEERS WRITTEN INSTRUCTION AT THE FOLLOWING HOLD POINTS:
- PREPARATION OF FOUNDING MATERIAL, INCLUDING PIER BORE HOLES.
- NORTHROP TO INSPECT REINFORCEMENT PRIOR TO PLACEMENT IN TO BORE HOLES
- REINFORCEMENT PRIOR TO PLACEMENT OF CONCRETE

WP2. PROVIDE MINIMUM 48 HOURS NOTICE FOR ANY REQUIRED INSPECTIONS.

FOUNDATIONS

F1. ASSUMED ALLOWABLE BEARING CAPACITY:
- BORED PIERS = 1000kPa END BEARING, 200 KPA SOIL COHESION FOR SPECIFIED EMBEDMENT IN ROCK
- PILE CAPS = 150kPa

F2. A GEOTECHNICAL REPORT HAS BEEN CARRIED OUT, REFER TO REPORT PREPARED BY ACT GEOTECHNCIAL ENGINEERS THIS REPORT IS FOR INFORMATION ONLY, IT IS NOT A COMPLETE DESCRIPTION OF CONDITIONS AT OR BELOW GROUND LEVEL.
F3. THE CONTRACTOR SHALL ALLOW TO ENGAGE A QUALIFIED (NPER) GEOTECHNICAL ENGINEER TO APPROVE THE FOUNDATION MATERIAL. OBTAIN GEOTECHNICAL ENGINEERS APPROVAL AND SUBMIT CERTIFICATE IN WRITING TO NORTHROP CONSULTING ENGINEERS PRIOR TO CONCRETING FOUNDATIONS.
F4 ENSURE STABILITY OF ADJACENT BUILDINGS AND PATHS IS MAINTAINED DURING ALL STAGES OF CONSTRUCTION.
F5. DO NOT ALLOW EXCAVATED MATERIAL TO BE STOCKPILED WITHIN 1500mm OF FOOTING TRENCHES OR PITS. NO EARTH OR DETRITUS IS TO FALL INTO THE FOOTING TRENCHES BEFORE OR DURING CONCRETE PLACEMENT.
F6. PILES & FOOTINGS SHALL BE CENTRALLY LOCATED UNDER POWER POLE COLUMNS UNLESS NOTED OTHERWISE ON THE STRUCTURAL DRAWINGS.
F7. FOOTINGS SHALL BE EXCAVATED TO THE DETAILED DEPTH AND WIDTH. FOOTINGS SHALL BE INSPECTED AND FILLED WITH CONCRETE AS SOON AS POSSIBLE TO AVOID EITHER SOFTENING OF THE FOUNDATION MATERIAL OR DRYING OUT BY EXPOSURE.
F8. THE BASE OF ALL PIER HOLES SHALL BE FREE OF WATER AND CLEANED OF LOOSE MATERIAL OR DEBRIS PRIOR TO PLACEMENT OF CONCRETE. ALLOW TO PROVIDE TEMPORARY LINERS AS DEEMED NECESSARY.

CONCRETE

C1. CARRY OUT ALL CONCRETE WORK IN ACCORDANCE WITH AS3600-2018 AND NATSPEC CONCRETE STANDARDS.
C2. CONCRETE PROPERTIES AND COVER TO REINFORCING :

COVER TO REINFORCEMENT

ELEMENT	CONCRETE STRENGTH f'c (MPa)	MAXIMUM 56 DAY DRY SHRINKAGE	COVER (mm)
BORED PIERS	40	1000 um	75 MIN TO SUITE SPECIFIED PCD
PILE CAPS	40	1000 um	50

MAXIMUM AGGREGATE SIZE = 20mm U.N.O.
SLUMP DURING PLACING = 80mm ±10mm
EXPOSURE CLASSIFICATION =B2 (EXTERNAL CONCRETE ELEMENTS)
ALL CONCRETE TO BE PLACED USING TREME
NO ADMIXTURES SHALL BE USED IN THE CONCRETE MIX UNLESS APPROVED BY NORTHROP CONSULTING ENGINEERS IN WRITING.

C3. CONCRETE PROPERTIES FOR PILES SHALL BE VARIED FROM NORMAL CLASS AS FOLLOWS :
- MINIMUM CEMENT CONTENT 250kg/m^3
- MAXIMUM 56 DAY SHRINKAGE STRAIN = AS NOMINATED ABOVE

C4. FORMWORK FINISH CLASSIFICATION TO AS3610.1-2010 :

ELEMENT	CLASS
- INGROUND FOOTINGS	5

C5. SURFACE FINISHES :
- PILE CAPS STEEL TROWEL

C6. ALL PILES TO BE INSTALLED IN ACCORDANCE WITH THE CONCRETE INSTITUTE OF AUSTRALIA "RECOMMENDED PRACTICE: TREMIE CONCRETE FOR DEEP FOUNDATIONS" WHEN PLACING CONCRETE ENSURE THAT THE MAXIMUM FREE FALL HEIGHT DOES NOT EXCEED 3M
C7. COMPACT ALL CONCRETE, INCLUDING FOOTINGS USING MECHANICAL VIBRATORS.
C8. PLACE CONCRETE CONTINUOUSLY BETWEEN CONSTRUCTION JOINTS SHOWN ON PLAN. DO NOT BREAK OR INTERRUPT SUCCESSIVE POURS SUCH THAT COLD JOINTS OCCUR.
C9. CONCRETE PROFILES :
- SIZES OF CONCRETE ELEMENTS DO NOT INCLUDE THICKNESS OF APPLIED FINISHES.
- NO HOLES, CHASES OR EMBEDMENT OF PIPES OTHER THAN SHOWN IN THE STRUCTURAL DRAWINGS SHALL BE MADE IN CONCRETE MEMBERS WITHOUT THE PRIOR WRITTEN APPROVAL OF NORTHROP CONSULTING ENGINEERS.

C10. REINFORCEMENT QUALITY AND NOTATION :

REINFORCEMENT NOTATION

SYMBOL	BAR TYPE	STRENGTH GRADE (MPa)	DUCTILITY CLASS	TO COMPLY WITH AUSTRALIAN STANDARD
N	HOT ROLLED DEFORMED RIB BAR	500	NORMAL	AS/NZS 4671-2001

ALL REINFORCING BARS SHALL BE GRADE D500N TO AS/NZS 4671-2001 AND ALL MESH SHALL BE GRADE 500L TO AS/NZS 4671-2001. UNLESS NOTED OTHERWISE CLASS L REINFORCEMENT SHALL NOT BE USED.
REINFORCEMENT LABELS :

N12-300 — SPACING (mm); BAR SIZE (mm); TYPE OF REINFORCEMENT
3/N20 — BAR SIZE (mm); TYPE OF REINFORCEMENT; NUMBER OF BARS

C11. REINFORCEMENT IS REPRESENTED DIAGRAMMATICALLY, AND NOT NECESSARILY IN TRUE PROJECTION. BARS SHOWN ARE INDICATIVE ONLY AND LENGTHS MAY VARY. BEAM ELEVATIONS TAKE PRECEDENCE OVER SECTIONS. SLAB PLANS TAKE PRECEDENCE OVER SECTIONS. REFER TO SECTIONS FOR EXTRA BARS THAT MAY BE REQUIRED.
C12. USE ONLY PLASTIC OR CONCRETE CHAIRS AT EXTERNAL SURFACES.
C13. SITE BENDING OF REINFORCEMENT BARS SHALL BE DONE WITHOUT HEATING USING A RE-BENDING TOOL. THE BARS SHALL BE RE-BENT AGAINST A FLAT SURFACE OR A PIN WITH A DIAMETER NOT LESS THAN THE MINIMUM PIN SIZE PRESCRIBED IN AS3600-2018.
C14. SPLICES IN REINFORCEMENT SHALL BE MADE ONLY IN POSITIONS SHOWN ON THE STRUCTURAL DRAWINGS OR IN POSITIONS OTHERWISE APPROVED IN WRITING BY NORTHROP CONSULTING ENGINEERS. LAPS SHALL NOT BE LESS THAN THE DEVELOPMENT LENGTH FOR EACH BAR AND IN ACCORDANCE WITH AS3600-2009 SECTION 13.
C15. WELDING OF REINFORCEMENT SHALL NOT BE PERMITTED UNLESS SHOWN ON THE STRUCTURAL DRAWINGS OR APPROVED BY NORTHROP CONSULTING ENGINEERS.
C16. AT EXTERNALLY EXPOSED SURFACES NO METALLIC ITEMS INCLUDING FORM BOLTS, FORM SPACERS, METALLIC BAR CHAIRS AND TIE-WIRE ARE TO BE PLACED IN THE COVER ZONE.
C17. ALL REINFORCEMENT, ANCHOR BOLTS AND OTHER CONCRETE INSERTS SHALL BE WELL SECURED IN POSITION AND INSPECTED BY NORTHROP CONSULTING ENGINEERS PRIOR TO PLACING CONCRETE.
C18. HOLD DOWN BOLTS & PILE REINFROCEMENT SHALL BE HOT DIPPED GALVANISED.
C19. ALL CONCRETE MIXES SHALL BE DESIGNED BY A RECOGNISED TESTING LAB AND SUBMITTED FOR REVIEW BY NORTHROP CONSULTING ENGINEERS.
C20. ALL COMPRESSIVE STRENGTH TEST REPORTS SHALL BE SUBMITTED TO NORTHROP CONSULTING ENGINEERS FOR REVIEW.
C21. PROJECT CONTROL TESTING SHALL BE CARRIED OUT ON ALL CONCRETE IN ACCORDANCE WITH AS1379-2007. TEST CYLINDERS ARE TO BE KEPT ON SITE.
C22. FOR ELAPSED TIME BETWEEN THE WETTING OF THE MIX AND THE DISCHARGE OF THE MIX, REFER TO CONCRETE - ELAPSED DELIVERY TIMES NOTE.

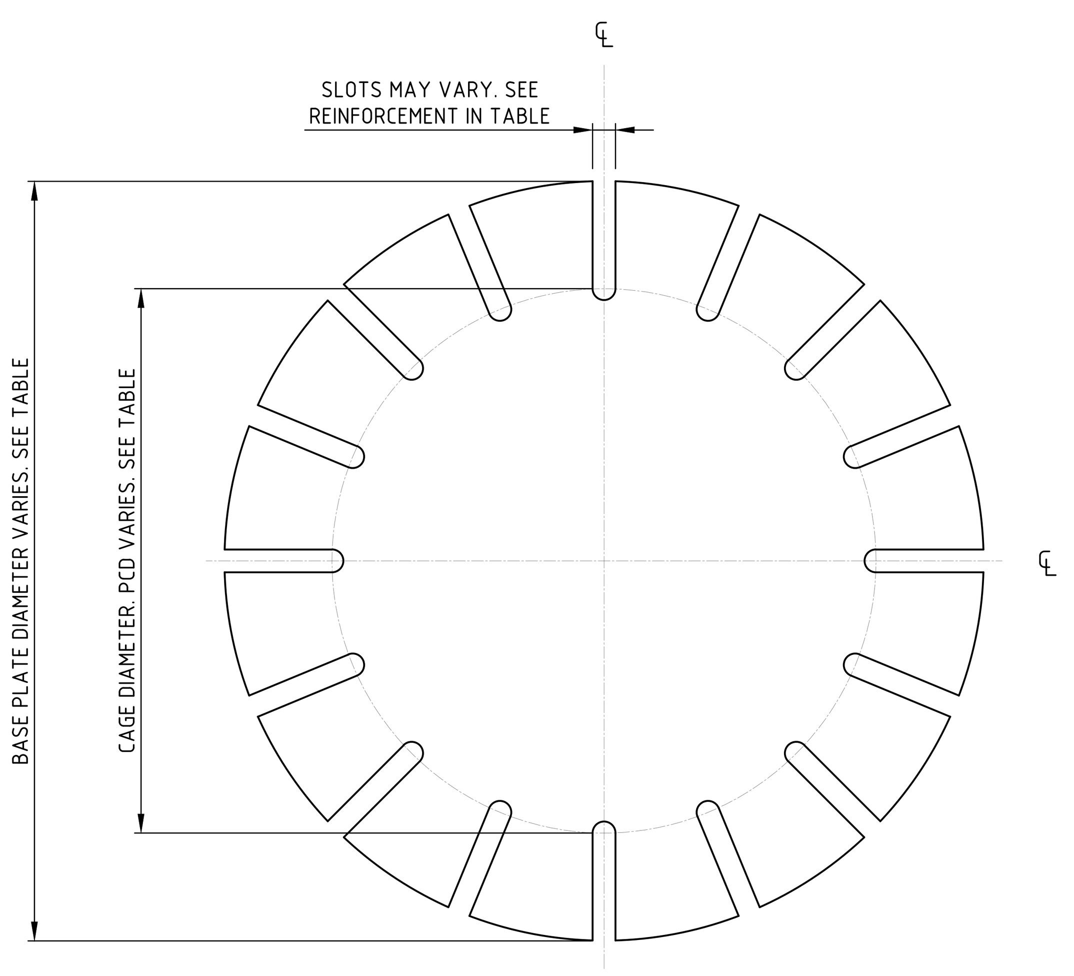
CONCRETE - ELAPSED DELIVERY TIMES

CE1. ELAPSED TIME BETWEEN THE WETTING OF THE MIX AND THE DISCHARGE OF THE MIX AT THE SITE MUST NOT EXCEED THE CRITERIA IN THE ELAPSED DELIVERY TIMETABLE BELOW

ELAPSED DELIVERY TIME TABLE

CONCRETE TEMPERATURE AT TIME OF DISCHARGE (°C)	MAXIMUM ELAPSED TIME (HOURS)
< 24	2.00
24 to 27	1.50
27 to 30	1.00
30 to 32	0.75
32 to 35	0.50

IF THE ELAPSED TIME IS LONGER THAN THE CORRESPONDING TIME IN THE TABLE ABOVE, OR THE TEMPERATURE IS GREATER THAN 35°C, EITHER NORTHROP CONSULTING ENGINEERS OR THE CONCRETE MIX DESIGN ENGINEER ARE TO BE CONTACTED TO CONFIRM WHETHER PLACEMENT IS TO PROCEED OR IF THE POUR IS TO BE STOPPED. IF THE POUR IS STOPPED, PRIOR TO ANY FURTHER CONCRETE PLACEMENT NORTHROP CONSULTING ENGINEERS ARE TO BE CONTACTED TO INSPECT THE WORKS AND DETERMINE WHAT, IF ANY, RECTIFICATION WORKS ARE REQUIRED.



TYPICAL BASE PLATE DETAIL
REFER TO STRUCTURAL PILE DATA SHEET
FOR REINFORCEMENT

STRUCTURAL DATA

PILE PROXIMITY	PILE STYLE	PEG NUMBER	DESIGN BASE BENDING MOMENT	DESIGN BASE SHEAR LOAD	FOOTING TYPE	BATTER PROXIMITY	PILE DIA	ESTIMATED DEPTH TO ROCK	REQUIRED ROCK EMBEDMENT	ESTIMATED TOTAL PILE DEPTH	REINFORCEMENT
3.0m REFER PLAN	SINGLE PILE	PEG-1= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m	5.80M	6.80M	16M30 @ 860 PCD
3.0m REFER PLAN	SINGLE PILE	PEG-2= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m	5.80M	6.80M	16M30 @ 860 PCD
5.28 REFER PLAN	SINGLE PILE	PEG-3= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m	4.30M	5.30M	16M30 @ 860 PCD
5.28 REFER PLAN	SINGLE PILE	PEG-4= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m	4.30M	5.30M	16M30 @ 860 PCD
3.0m REFER PLAN	SINGLE PILE	PEG-5= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m ESTIMATE	5.80M	7.30M	16M30 @ 860 PCD
3.0m REFER PLAN	SINGLE PILE	PEG-6= 22m-40kN	942 kNm	55 kN	TYPE 1A	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m ESTIMATE	5.80M	7.30M	16M30 @ 860 PCD
5.86 REFER PLAN	SINGLE PILE	PEG-7= 22m-40kN	942 kNm	55 kN	TYPE 1	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m ESTIMATE	3.30M	4.80M	16M30 @ 860 PCD
5.86 REFER PLAN	SINGLE PILE	PEG-8= 22m-40kN	942 kNm	55 kN	TYPE 1	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m ESTIMATE	3.30M	4.80M	16M30 @ 860 PCD
n/a	SINGLE PILE	PEG-9= 22m-40kN	942 kNm	55 kN	TYPE 1	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m ESTIMATE	3.30M	4.80M	16M30 @ 860 PCD
n/a	SINGLE PILE	PEG-10= 18.5m-40kN	820 kNm	54 kN	TYPE 2	SEE SECTION	1200 mm DIA	1.50m ESTIMATE	4.00M	5.50M	16M30 @ 790 PCD
n/a	SINGLE PILE	PEG-11= 18.5m-40kN	820 kNm	54 kN	TYPE 2	SEE SECTION	1200 mm DIA	1.50m	7.00M	8.50M	16M30 @ 790 PCD
n/a	SINGLE PILE	PEG-12= 24m-40kN	1004 kNm	54 kN	TYPE 3	NO IMPACT ANTICIPATED	1200 mm DIA	1.75m ESTIMATE	3.75M	5.50M	16M30 @ 900 PCD
n/a	SINGLE PILE	PEG-13= 26m-40kN	1127 kNm	57 kN	TYPE 4	NO IMPACT ANTICIPATED	1200 mm DIA	2.00m	4.00M	6.00M	16M30 @ 930 PCD
n/a	SINGLE PILE	PEG-14= 22m-40kN	942 kNm	55 kN	TYPE 1	NO IMPACT ANTICIPATED	1200 mm DIA	2.00m ESTIMATE	3.30M	5.30M	16M30 @ 860 PCD
3.0m REFER PLAN	PILE CAP	PEG-15= 22m-60kN	966 kNm	59 kN	TYPE 11	SEE SECTION	1200 mm DIA	2.00m	3.30M	5.30M	20M30 @ 950 PCD
3.0m REFER PLAN	PILE CAP	PEG-16= 22m-60kN	966 kNm	59 kN	TYPE 11	SEE SECTION	1200 mm DIA	2.00m	3.30M	5.30M	20M30 @ 950 PCD
3.0m REFER PLAN	PILE CAP	PEG-17= 22m-60kN	966 kNm	59 kN	TYPE 11	SEE SECTION	1200 mm DIA	1.50m	3.30M	4.80M	20M30 @ 950 PCD
3.0m REFER PLAN	PILE CAP	PEG-18= 22m-60kN	966 kNm	59 kN	TYPE 11	SEE SECTION	1200 mm DIA	1.50m	3.30M	4.80M	20M30 @ 950 PCD
3.0m REFER PLAN	PILE CAP	PEG-19= 20m-60kN	966 kNm	61 kN	TYPE 12	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m ESTIMATE	3.30M	4.30M	20M30 @ 910 PCD
3.0m REFER PLAN	PILE CAP	PEG-20= 20m-60kN	966 kNm	61 kN	TYPE 12	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m ESTIMATE	3.30M	4.30M	20M30 @ 910 PCD
n/a	SINGLE PILE	PEG-21= 20m-60kN	966 kNm	61 kN	TYPE 6	NO IMPACT ANTICIPATED	1200 mm DIA	1.00m	3.30M	4.30M	20M30 @ 910 PCD
n/a	SINGLE PILE	PEG-22= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.50m	3.30M	4.80M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-23= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	3.00m	3.30M	6.30M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-24= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	3.00m	3.30M	6.30M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-25= 18.5m-40kN	820 kNm	54 kN	TYPE 14	SEE SECTION	1200 mm DIA	3.00m	7.50M	10.50M	16M30 @ 790 PCD
n/a	SINGLE PILE	PEG-26= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	3.00m	3.30M	6.30M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-27= 20m-60kN	954 kNm	60 kN	TYPE 6	NO IMPACT ANTICIPATED	1200 mm DIA	1.80m	3.30M	5.10M	20M30 @ 910 PCD
n/a	SINGLE PILE	PEG-28= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-29= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
3.0m REFER PLAN	PILE CAP	PEG-30= 22m-40kN	942 kNm	55 kN	TYPE 13	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 860 PCD
3.0m REFER PLAN	PILE CAP	PEG-31= 22m-40kN	942 kNm	55 kN	TYPE 13	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 860 PCD
n/a	SINGLE PILE	PEG-32= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-33= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-34= 20m-60kN	966 kNm	61 kN	TYPE 6	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	20M30 @ 910 PCD
n/a	SINGLE PILE	PEG-35= 20m-60kN	966 kNm	61 kN	TYPE 6	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	20M30 @ 910 PCD
n/a	SINGLE PILE	PEG-36= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-37= 20m-40kN	966 kNm	61 kN	TYPE 7	NO IMPACT ANTICIPATED	1200 mm DIA	1.70m	3.30M	5.00M	16M30 @ 820 PCD
n/a	SINGLE PILE	PEG-38= 18.5m-40kN	820 kNm	54 kN	TYPE 14	SEE SECTION	1200 mm DIA	2.00m	7.50M	9.50M	16M30 @ 790 PCD
8.35m REFER PLAN	SINGLE PILES	PEG-39= 28m-100kN	2420 kNm	99 kN	TYPE 8	NO IMPACT ANTICIPATED	1500 mm DIA	2.00m	4.00M	6.00M	24M36 @ 1200 PCD
8.35m REFER PLAN	SINGLE PILES	PEG-40= 28m-100kN	2420 kNm	99 kN	TYPE 8	NO IMPACT ANTICIPATED	1500 mm DIA	2.00m	4.00M	6.00M	24M36 @ 1200 PCD
6.4m REFER PLAN	SINGLE PILES	PEG-41= 26m-60kN	383 kNm	24 kN	TYPE 9	NO IMPACT ANTICIPATED	1200 mm DIA	nil	0.00M	4.50M	24M30 @ 1020 PCD
6.4m REFER PLAN	SINGLE PILES	PEG-42= 26m-60kN	383 kNm	24 kN	TYPE 9	NO IMPACT ANTICIPATED	1200 mm DIA	nil	0.00M	4.50M	24M30 @ 1020 PCD
7.89m REFER PLAN	SINGLE PILES	PEG 43=24m-80kN	896 kNm	51 kN	TYPE 10	NO IMPACT ANTICIPATED	1200 mm DIA	0.50m	3.30M	3.80M	24M30 @ 1080 PCD
7.89m REFER PLAN	SINGLE PILES	PEG 44=24m-80kN	896 kNm	51 kN	TYPE 10	NO IMPACT ANTICIPATED	1200 mm DIA	0.50m	4.30M	4.80M	24M30 @ 1080 PCD

TABLE NOTES:
ALL FOOTINGS TO BE FOUNDED IN ROCK, DESIGN COHESION OF ROCK 200KPA AS PER GEOTECHNCIAL REPORT

BATTER PROXIMITY ASSESSMENT - BASED ON LIMITED AVAILABLE ACCESS, WE HAVE GROUPED THE PILES INTO THE FOLLOWING CATEGORIES:
- NO IMPACT ANTICIPATED. MEANS GRADING AROUND POLES NOT EXPECTED TO EXCEED 5% AND POLE POSITION NOT EXPECTED TO BE WITHIN 10 METERS OF A SUBSTANTIAL BATTER (SUCH AS RAIL LINE)
- SEE SECTION. POLE WITHIN ZONE OF INFLUENCE OF RAIL CORRIDOR. REFER SECTION ON S06, S07 AND S08
- ESTIMATE DEPTH TO ROCK REFERS TO GEOTECHNICAL DATA FOUND IN GEOTECH REPORT JH/C12292 ON THE 14/11/2022. WHERE NO BORE HOLE DATA HAS BEEN COLLECTED, AN ESTIMATE HAS BEEN BASED ON SURROUNDING BORE HOLE DATA.

VERIFIER: DB
JOB MANAGER: SB
DESIGNED: SB
DRAWN: JG

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT: ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK. NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT: TRANSMISSION LINES

DRAWING TITLE: STRUCTURAL SERVICES GENERAL NOTES AND STRUCTURAL TABLE

JOB NUMBER: CR213453

DRAWING NUMBER: S01 REVISION: A

DRAWING SHEET SIZE = A1

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT
ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

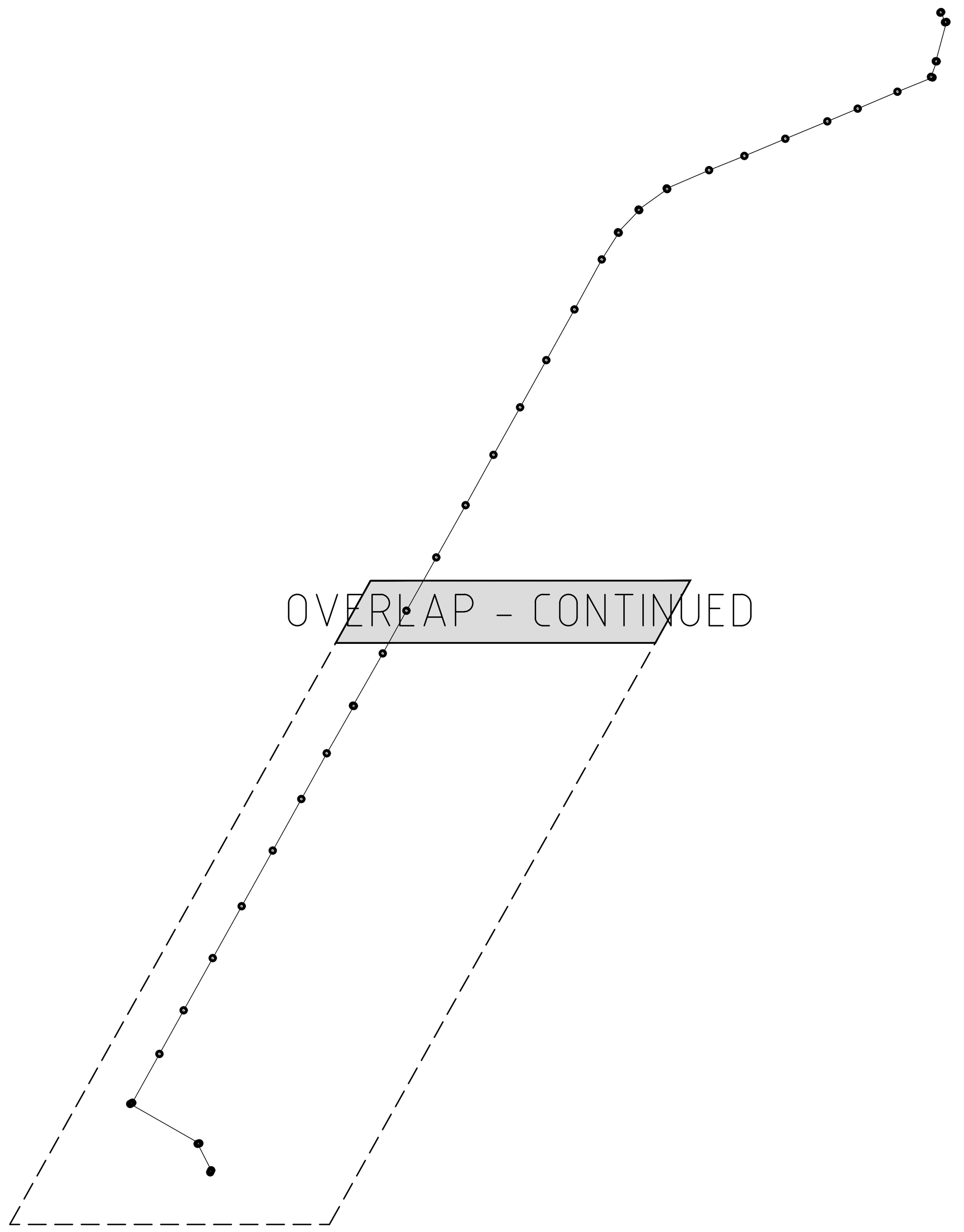
PROJECT
TRANSMISSION LINES

DRAWING TITLE
STRUCTURAL SERVICES TRANSMISSION LINE PLAN PART 1

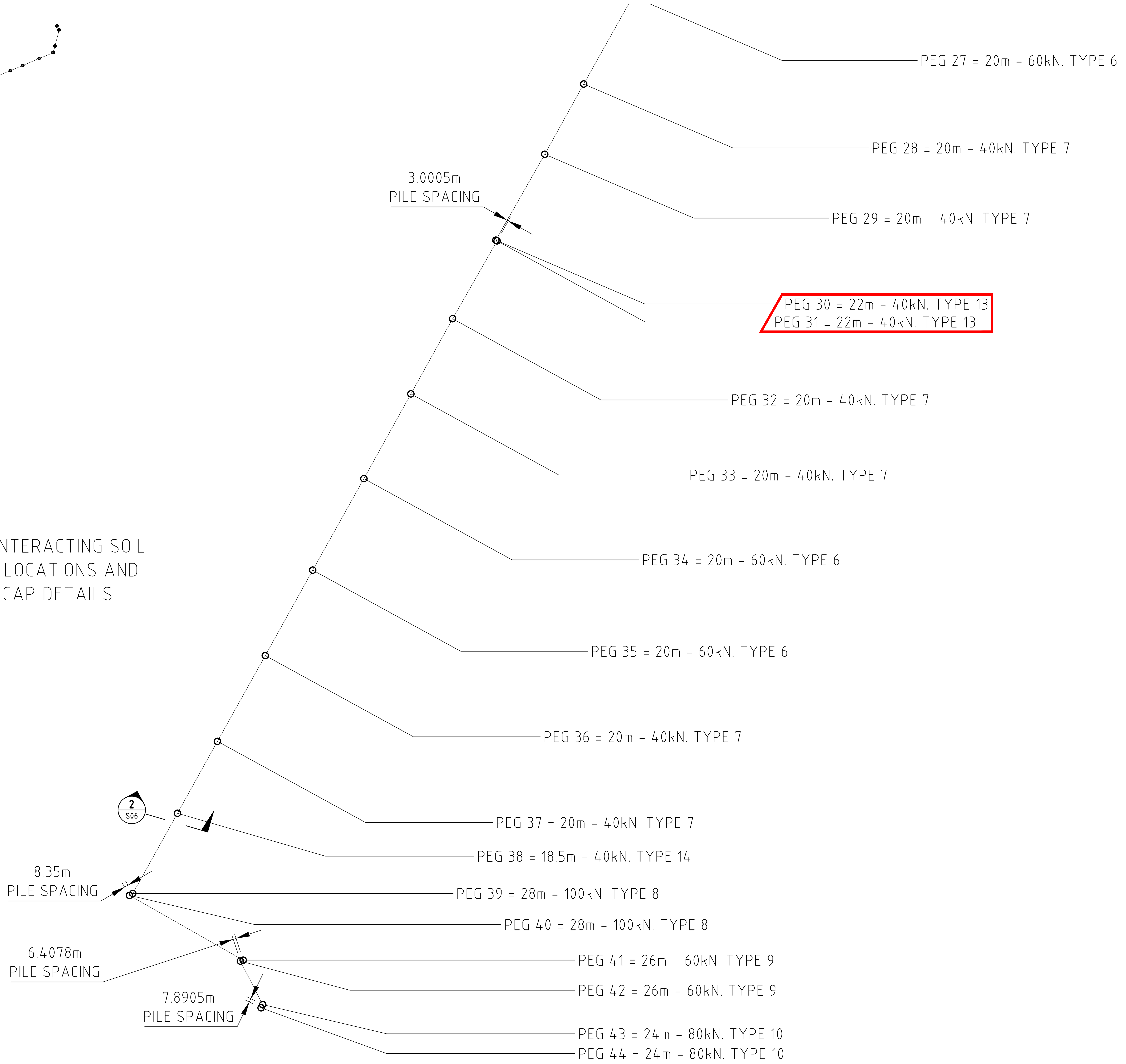
JOB NUMBER
CR213453

DRAWING NUMBER **S02** REVISION **A**

DRAWING SHEET SIZE = A1



DENOTES TWO PILES WITH INTERACTING SOIL PROFILES. REFER PLAN FOR LOCATIONS AND PEG #. REFER S05 FOR PILE CAP DETAILS



VERIFIER: DB
JOB MANAGER: SB
DESIGNED: SB
DRAWN: JG

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT
ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT
TRANSMISSION LINES

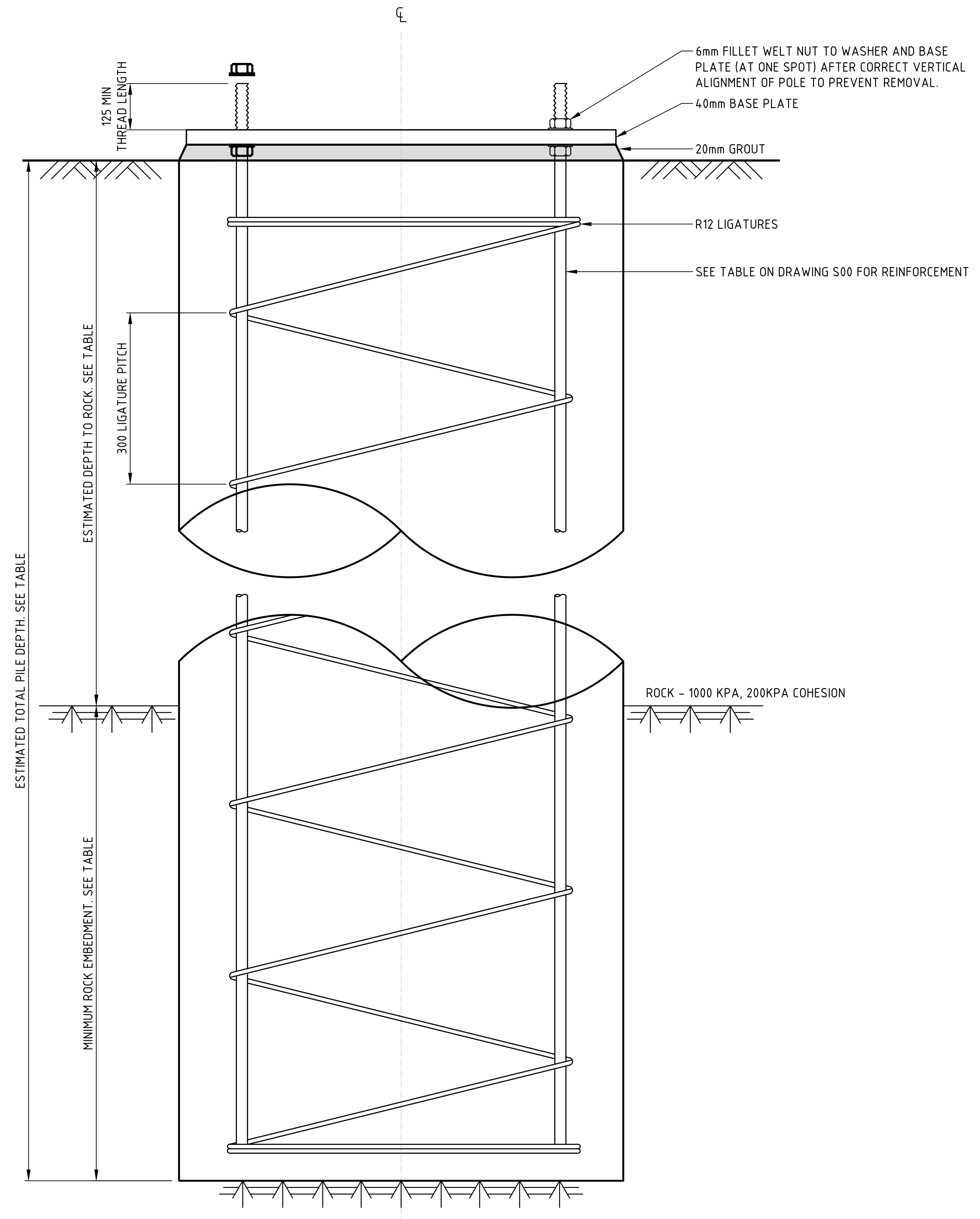
DRAWING TITLE
STRUCTURAL SERVICES TRANSMISSION LINE PLAN PART 2

JOB NUMBER
CR213453

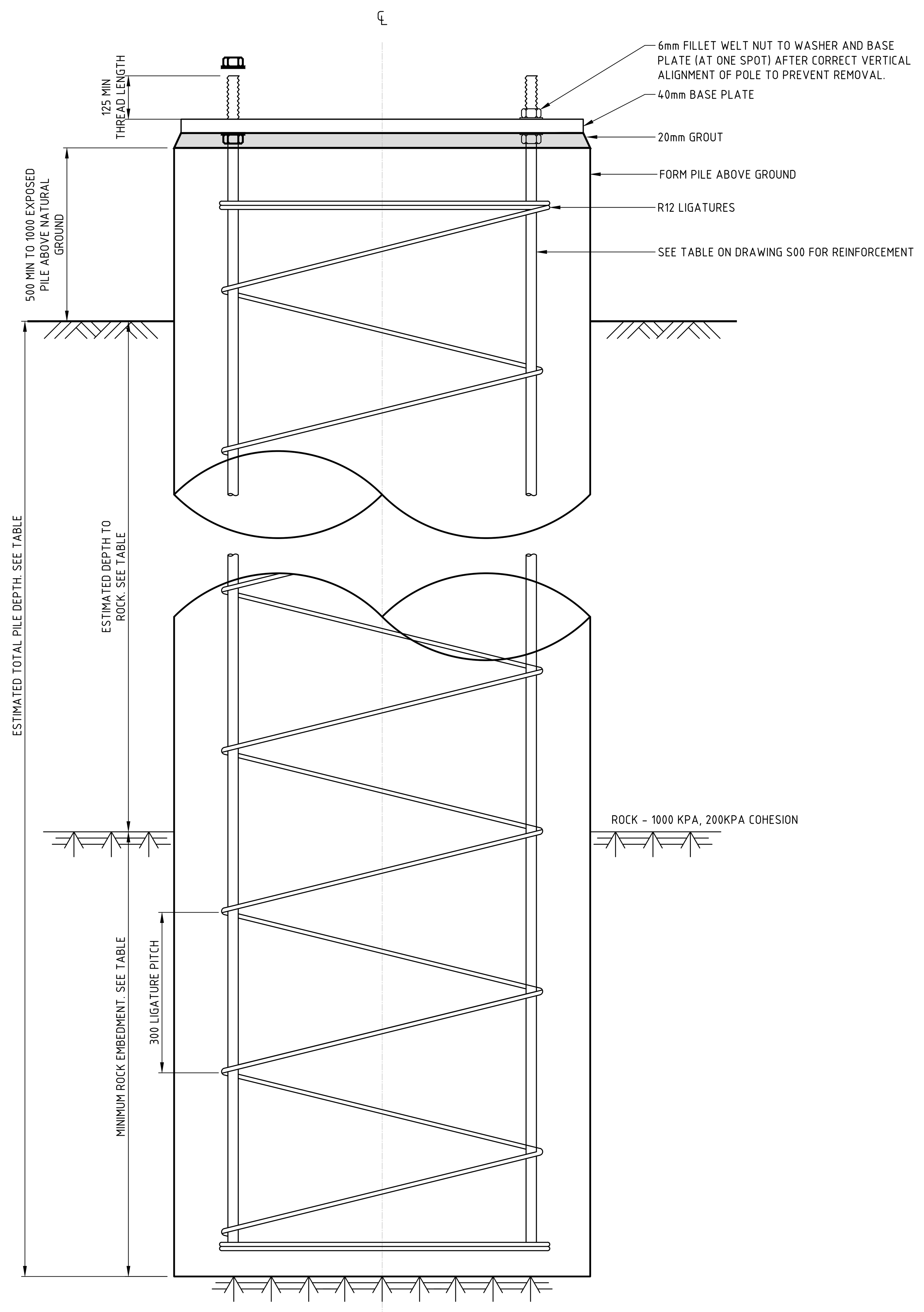
DRAWING NUMBER
S03

REVISION
A

DRAWING SHEET SIZE = A1



TYPICAL PILE FOOTING DETAIL FOR
TYPE 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 AND 14



TYPICAL TYPE 1A PILE FOOTING DETAIL

DRAWN: JG
DESIGNED: SB
JOB MANAGER: SB
VERIFIER: DB

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT
ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT
TRANSMISSION LINES

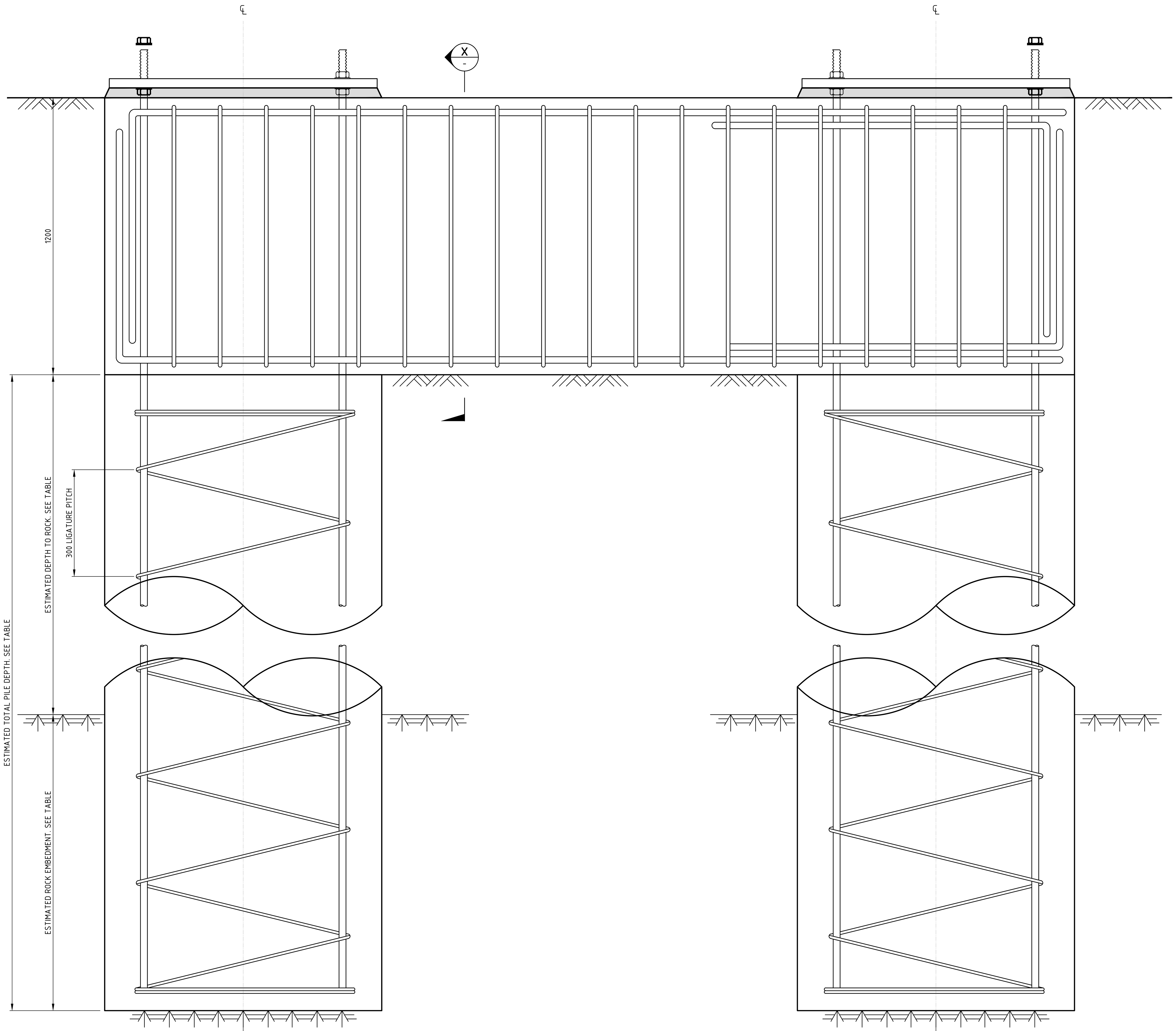
DRAWING TITLE
STRUCTURAL SERVICES
TYPICAL PILE DETAILS

JOB NUMBER
CR213453

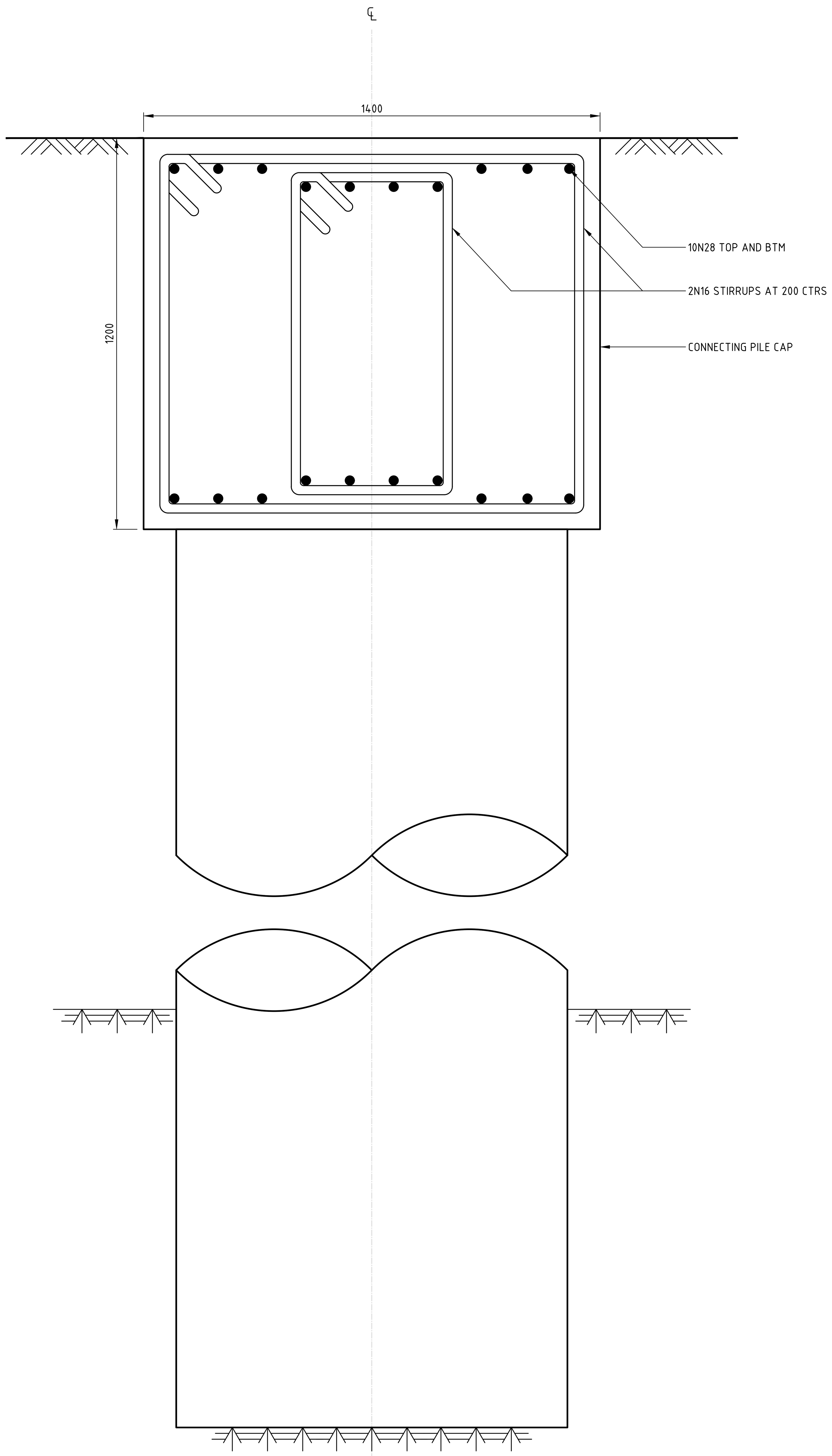
DRAWING NUMBER
S04

REVISION
A

DRAWING SHEET SIZE = A1



TYPICAL PILE FOOTING DETAIL
FOR TYPE 11, 12 AND 13



SECTION X
SCALE 1:10 AT A1

VERIFIER: DB
JOB MANAGER: SB
DESIGNED: SB
DRAWN: JG

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT
ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT
TRANSMISSION LINES

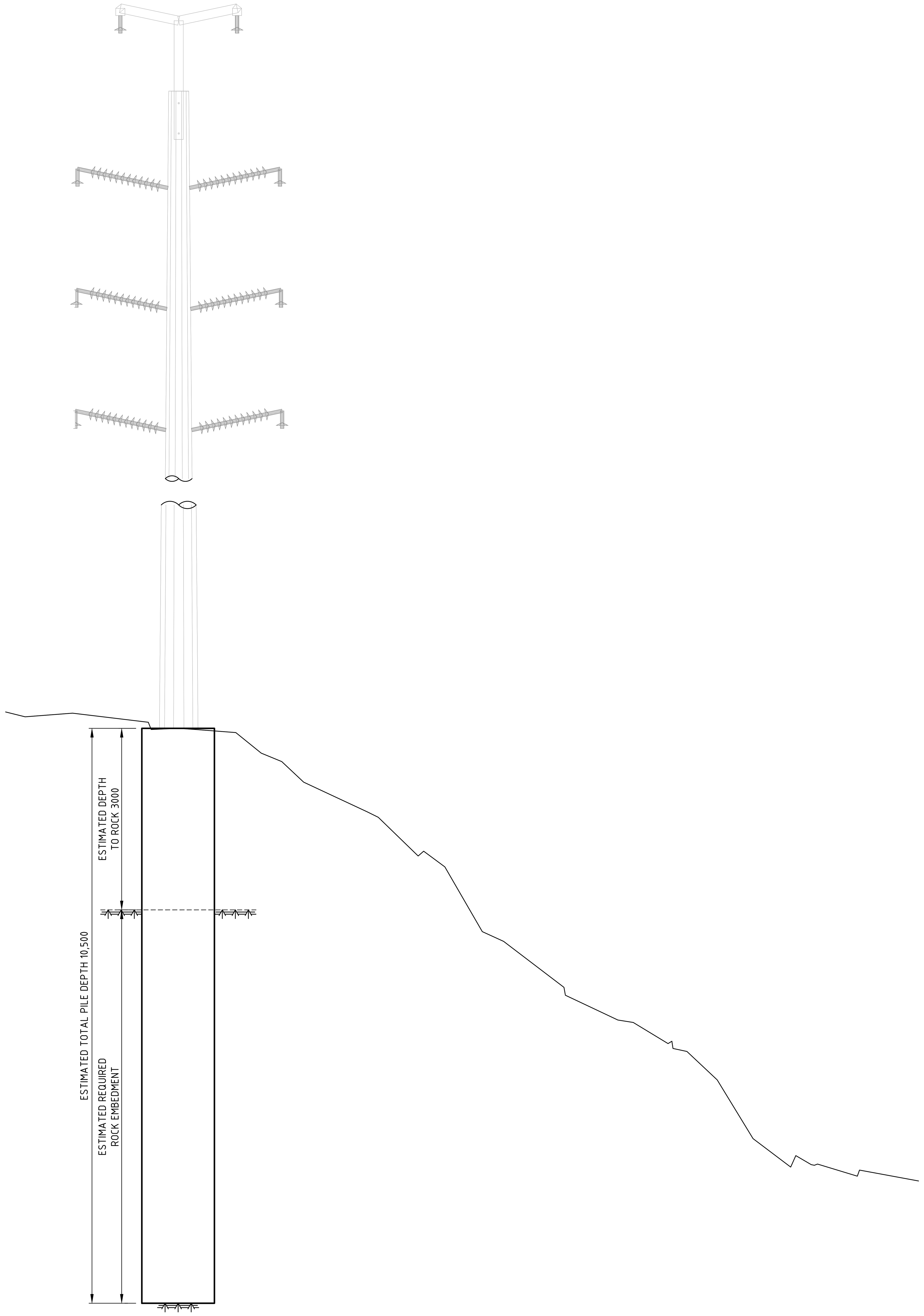
DRAWING TITLE
STRUCTURAL SERVICES
TYPICAL PROXIMITY PILE
DETAILS

JOB NUMBER
CR213453

DRAWING NUMBER
S05

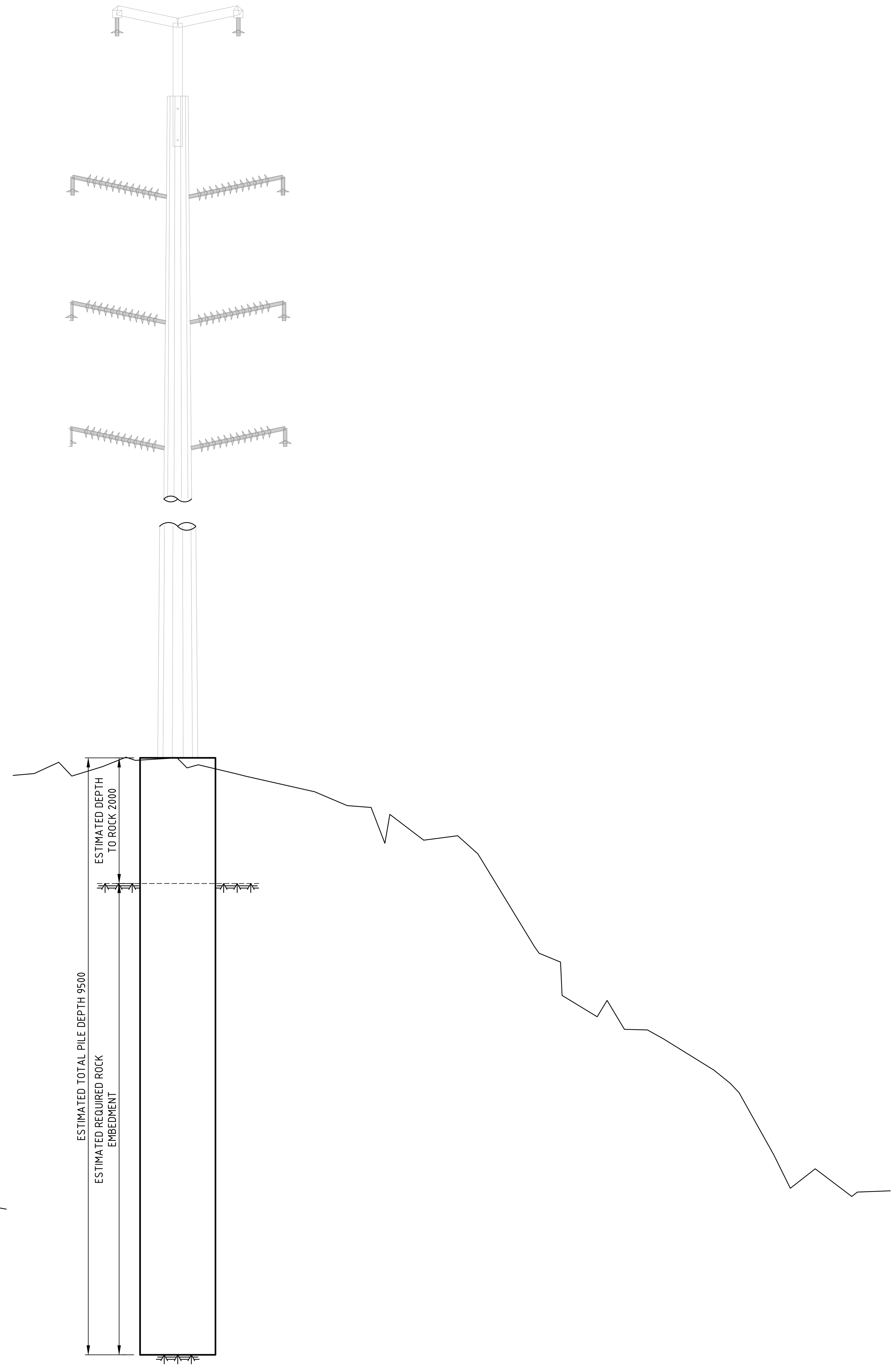
REVISION
A

DRAWING SHEET SIZE = A1



SECTION 1 / S02
SCALE 1:100 AT A1

PEG#25 ANGLE OF INCIDENCE SECTION



SECTION 2 / S03
SCALE 1:100 AT A1

PEG#38 ANGLE OF INCIDENCE SECTION

DRAWN: JG
DESIGNED: SB
JOB MANAGER: SB
VERIFIER: DB

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	JG		SB	12.12.2022
2	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT: **ESSENTIAL ENERGY**

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK. NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT: **TRANSMISSION LINES**

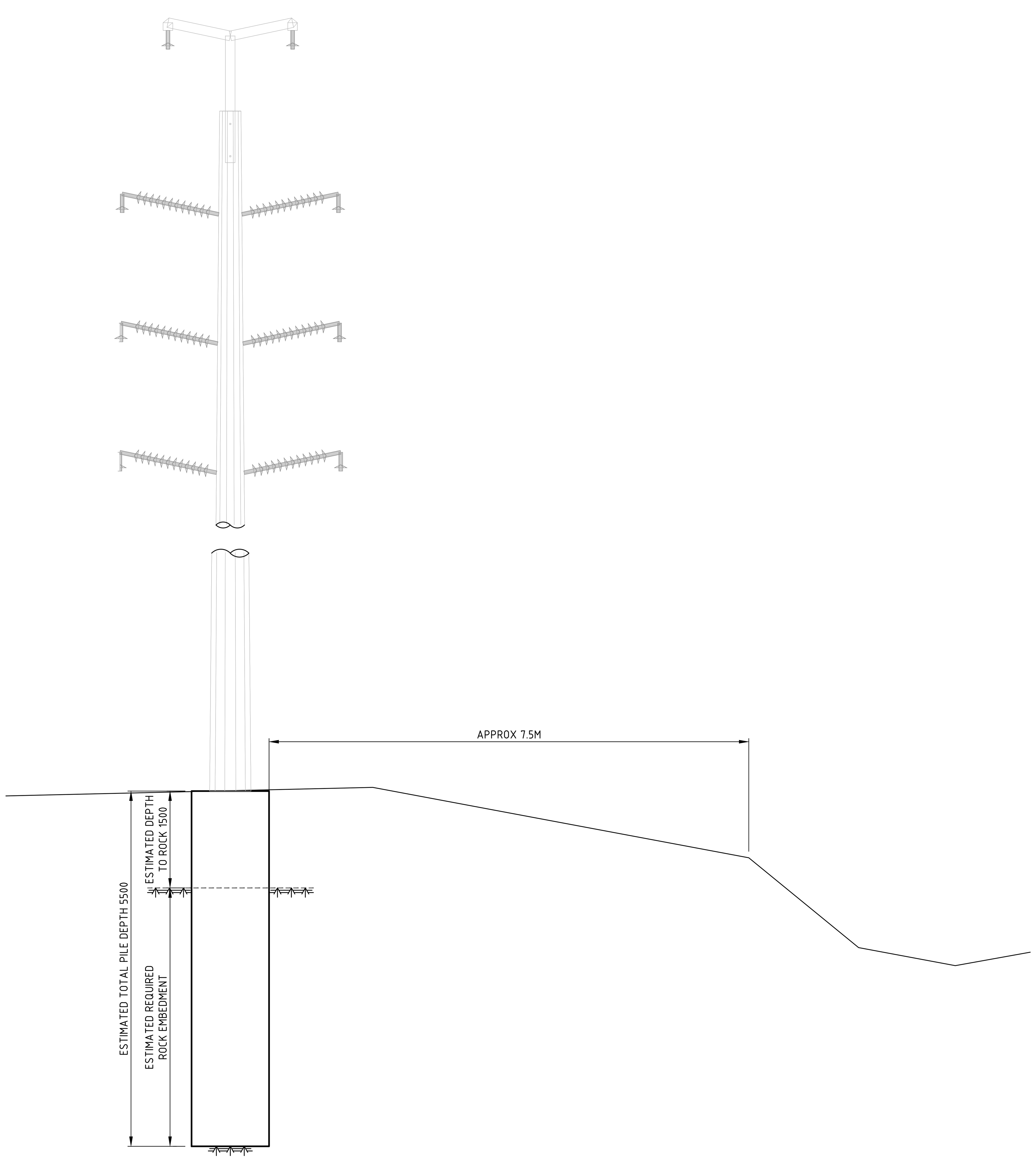
DRAWING TITLE: **STRUCTURAL SERVICES PEG SECTIONS #25 AND #38**

JOB NUMBER: **CR213453**

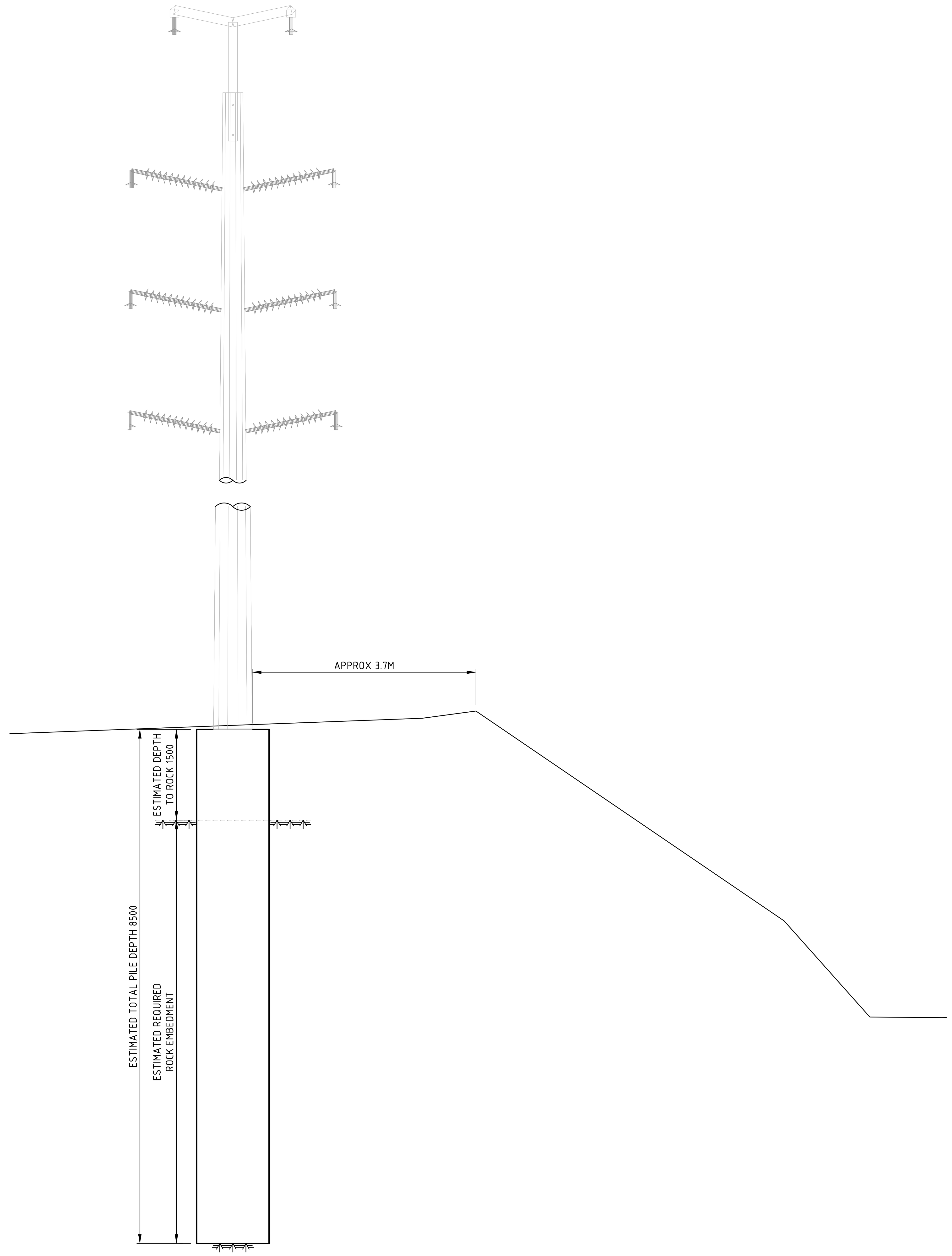
DRAWING NUMBER: **S06**

REVISION: **A**

DRAWING SHEET SIZE = A1



SECTION 3 / S02
SCALE 1:100 AT A1
PEG#10 ANGLE OF INCIDENCE SECTION



SECTION 4 / S02
SCALE 1:100 AT A1
PEG#11 ANGLE OF INCIDENCE SECTION

VERIFIER: VERIFIER
JOB MANAGER: SB
DESIGNED: SB
DRAWN: JG

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT: ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

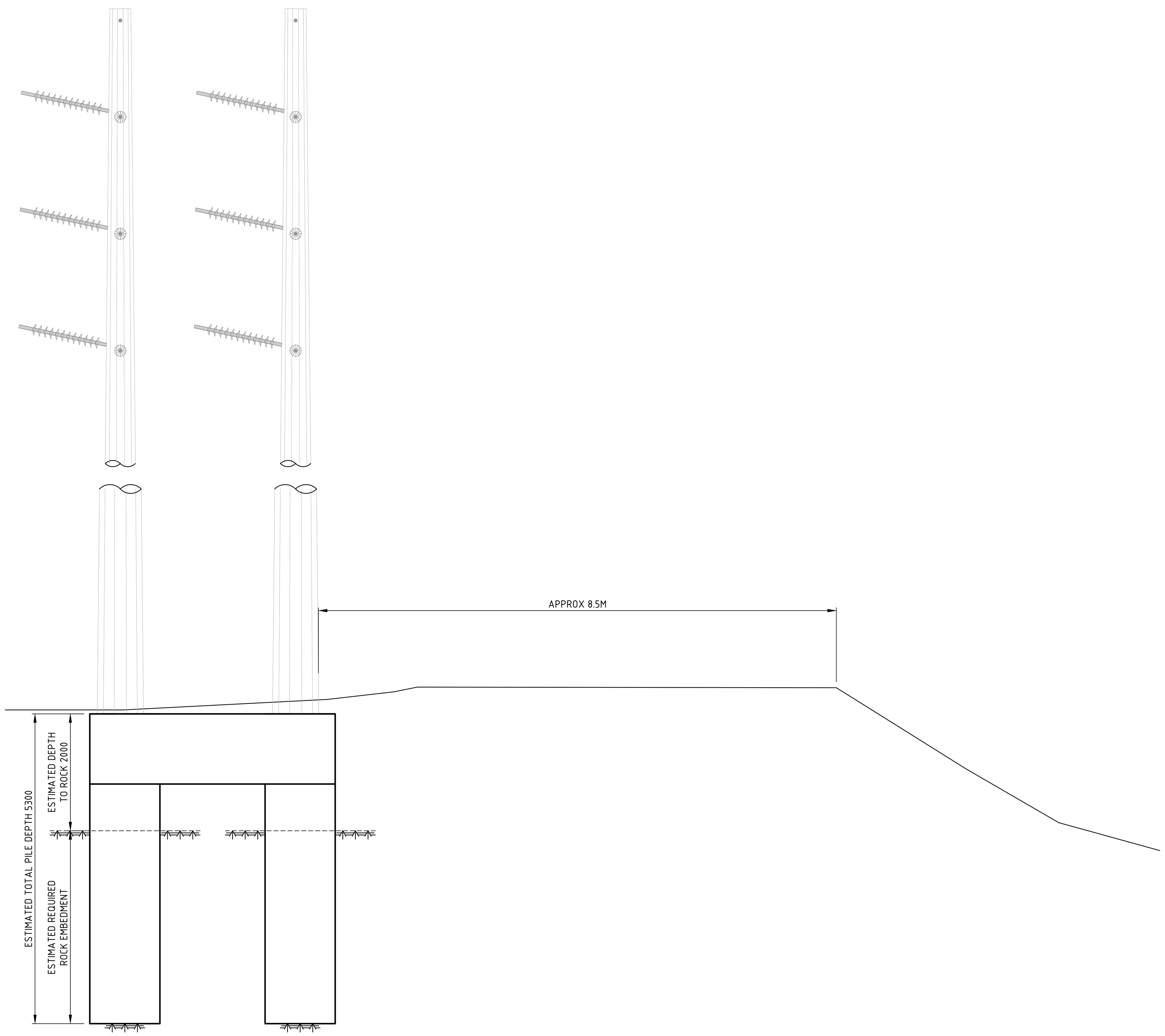
PROJECT: TRANSMISSION LINES

DRAWING TITLE: STRUCTURAL SERVICES PEG SECTIONS #25 AND #38

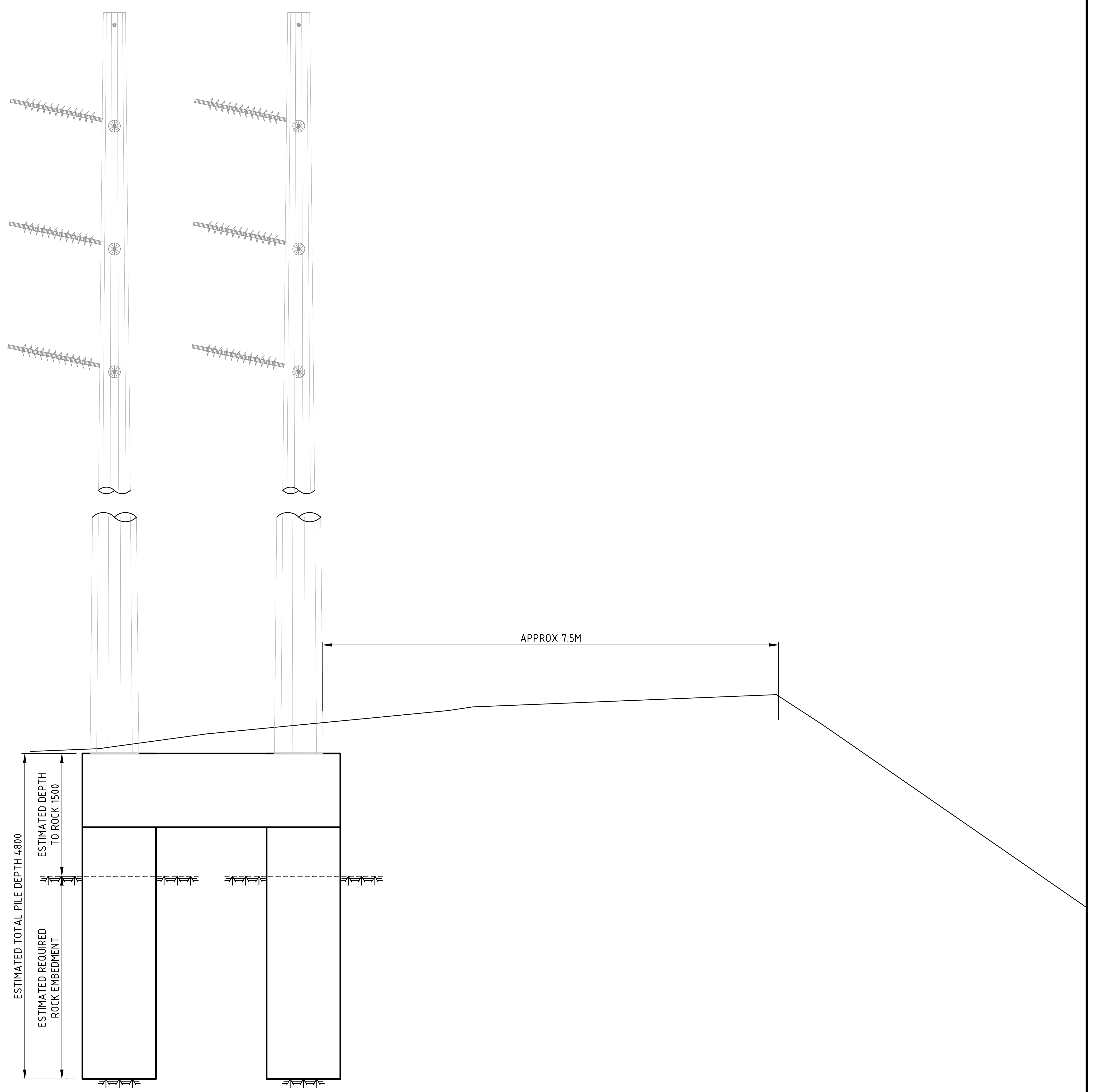
JOB NUMBER: CR213453

DRAWING NUMBER: S07 | REVISION: A

DRAWING SHEET SIZE = A1



SECTION 5 / S02
SCALE 1:100 AT A1
PEG#15-16 ANGLE OF INCIDENCE SECTION



SECTION 6 / S02
SCALE 1:100 AT A1
PEG#17-18 ANGLE OF INCIDENCE SECTION

VERIFIER: DB
JOB MANAGER: SB
DESIGNED: SB
DRAWN: JG

FOR CONSTRUCTION

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
1	FOR APPROVAL	SB		SB	16.12.2022
A	FOR CONSTRUCTION	JG	DB	SB	22.12.2022

CLIENT
ESSENTIAL ENERGY

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT

ALL SETOUT TO ARCHITECT'S DRAWINGS, DIMENSIONS TO BE VERIFIED WITH THE ARCHITECT AND ON SITE BEFORE MAKING SHOP DRAWINGS OR COMMENCING WORK.
NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Canberra
Level 6, 224 Bunda Street (PO Box 213) Canberra ACT 2608
Ph (02) 6285 1822 Fax (02) 6285 1863
Email canberra@northrop.com.au ABN 81 094 433 100

PROJECT
TRANSMISSION LINES

DRAWING TITLE
STRUCTURAL SERVICES
PEG SECTIONS
#25 AND #38

JOB NUMBER
CR213453

DRAWING NUMBER
S08

REVISION
A

DRAWING SHEET SIZE = A1

Appendix B – Ecological Issues and Assessment Report

gunninah

PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

ECOLOGICAL ISSUES & ASSESSMENT REPORT

F Dominic Fanning

May 2023

PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

ECOLOGICAL ISSUES & ASSESSMENT REPORT

F Dominic Fanning
May 2023

PART A	INTRODUCTION & INFORMATION BASE

1 INTRODUCTION

1.1 The Proposed Activity

Essential Energy has proposed the construction of a new dual circuit 132 kV powerline between Queanbeyan and Environa – to the immediate southeast of the Australian Capital Territory (ACT). The new powerline is required to provide electricity requirements to the burgeoning residential development of Environa (to the immediate southwest of Queanbeyan).

The proposed powerline is approximately 8km long and is located mostly along the NSW/ACT border (on the NSW side) – along a disused railway easement (Figure 1.1; Attachment A). It extends from an existing Essential Energy powerline near the existing (TransGrid) Queanbeyan substation (which is located within the Oaks Estate in the ACT) along the disused railway easement and ends at a proposed substation in Environa, NSW (Figures 1.2 to 1.5).

1.2 The Project Area

As noted above, the majority of the land on which the proposed powerline between Queanbeyan and Environa is located (Figure 1.1; Attachment A) consists of a disused railway easement along the NSW/ACT border. The southwestern extremity of the proposed powerline is located along an existing road alignment (Tompsitt Drive); with the southwestern terminal of the line at a new substation at Environa (Figures 1.2 to 1.5; Attachment A).

In addition, there is an area of land at Environa (at the southwestern end of the alignment) which contains native vegetation - mostly derived and/or disturbed native grasslands (within the Queanbeyan Nature Reserve and other areas set aside as biodiversity offsets).

The project site and surrounding landscape are generally flat to gently undulating, with little notable variation in elevation and no relevant hills. There are no significant watercourses which traverse the proposed powerline alignment; with only a few small highly modified drainage lines present.

The northern part of the proposed powerline alignment is surrounded by existing urban development whilst the southern part is surrounded by rural properties or land dedicated for conservation (including the Queanbeyan Nature Reserve).

1.3 Statutory Circumstances

The proposed powerline is the subject of a *Review of Environmental Factors* (REF) – which is being prepared by Essential Energy.

The project is the subject of the standard statutory requirements and environmental planning provisions – as addressed in the following chapters of this *Ecological Issues & Assessment Report* (EIAR).

- NSW *Environmental Planning & Assessment Act 1979* (EP&A Act).
- NSW *Biodiversity Conservation Act 2016* (BCon Act).
- Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act).

Relevantly, the proposed powerline project is defined as an "*activity*" in the EP&A Act. It is to be assessed pursuant to Part 5 Division 5.1 of the EP&A Act and Section 7.3 of the BCon Act; as well as pursuant to the relevant requirements of the EPBC Act.

Importantly, Section 7.2 of the BCon Act states that "*the biodiversity offsets scheme threshold*" does not apply to the proposed powerline project – as the "*activity*" is "*subject to environmental impacts assessment*" pursuant to Part 5 of the EP&A Act.

1.4 Assumptions

It is assumed for the purposes of this EIAR that the construction and ongoing maintenance of the proposed powerline project will be conducted in an environmentally responsible and sound manner - utilising up-to-date and 'best practice' measures and systems for the protection of the environment and biodiversity.

It is also an assumption of this EIAR that the recommended measures documented in the EIAR for the protection of specific ecological matters will be properly implemented as part of the project.

Figure 1.2 Northern portion of the proposed transmission line

Figure 1.3 Central-northern portion of the proposed transmission line

Figure 1.4 Central-southern portion of the proposed transmission line

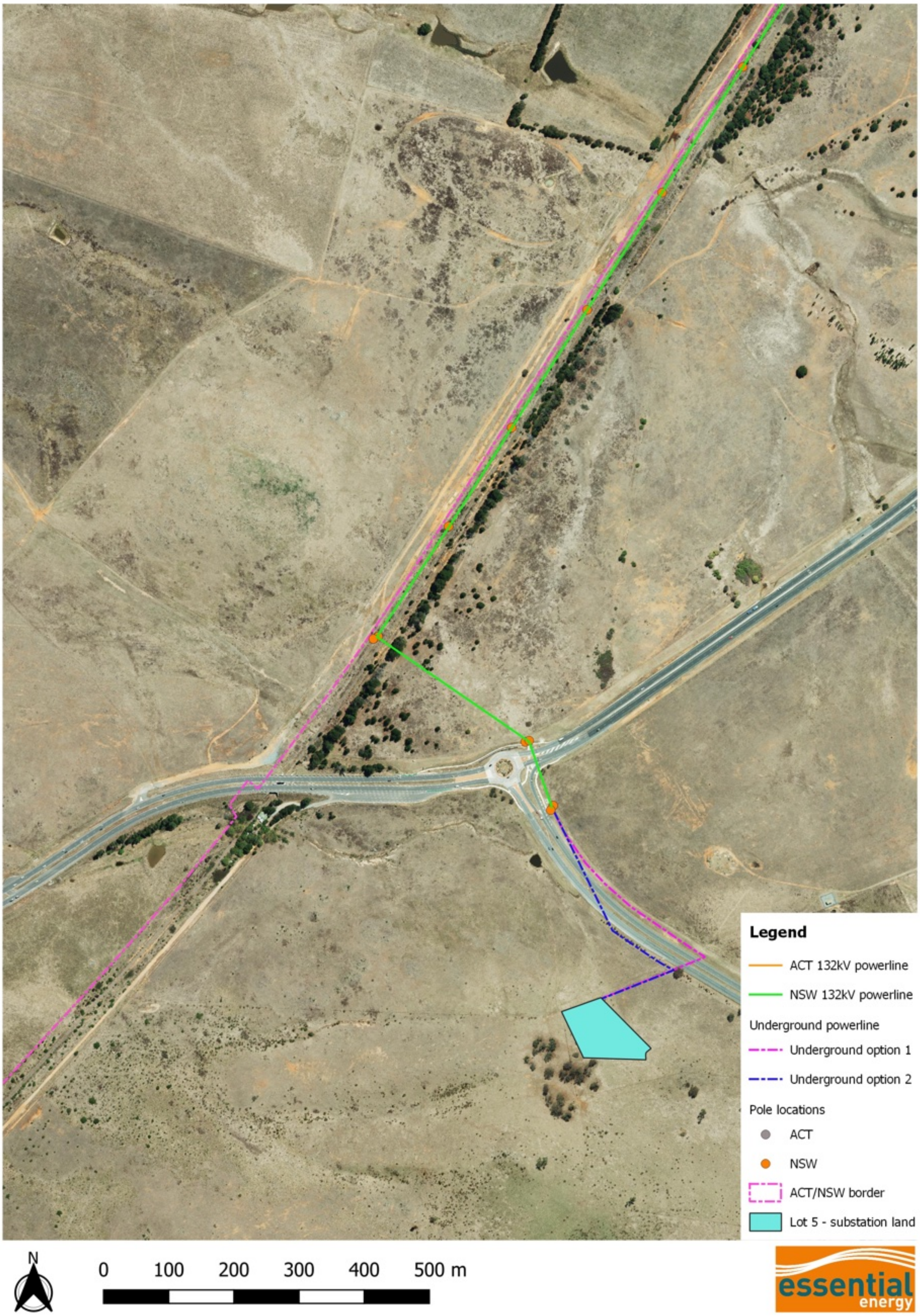


Figure 1.5 Southern portion of the proposed transmission line

2 PROJECT and CONSTRUCTION DETAILS

The powerline project will involve the following activities. For full details of the works and activities (including diagrams), and the impact amelioration measures for the project, see the Essential Energy REF (2023).

- The construction of 1.2m to 1.5m diameter concrete footings at each pole location along the alignment.
    - Drilling of pilings into the ground as required at each location (3.8m – 10.5m deep) - using either a 20T excavator with an augering attachment (which is smaller and more agile) or a 50T drilling rig where necessary (for larger depth holes)
    - Insertion of reinforcing steel and pouring of the concrete pilings.
    - Construction of a 1.2m to 1.5m diameter concrete footings at each site.
- Attachment of high steel power poles (ranging from 18m to 28m in height) onto each footing – by crane (in most instances from existing adjacent tracks or roads); and bolted to the concrete footings.
- The removal and/or trimming of trees (to the minimal amount necessary) at the following locations.
    - Between pole #7 and Uriarra Road and the ACT border (at the northeasten extremity of the alignment).
    - Between Uriarra Road and Canberra Avenue.
    - Between Canberra Avenue to near Lanyon Drive (although most clearing/trimming ceases just to the southern extent of HMAS Harmon).
    - A small section of planted Cypress Pine trees near the southern end of the powerline - where the line turns off the railway easement and crosses the Queanbeyan Nature Reserve.
- Excavation of two trenches 2m wide and up to 2m deep along the Thompsitt Drive section of the alignment (where the powerline will be buried rather than on poles) and into the substation at Environa.
- Underboring or horizontal directional drilling beneath the Icon Water main Googong Dam supply line that crosses Tompsitt Drive, including entry and exit pits of 6m x 4m.

The disturbance footprints around each pole will be a **maximum** of 20m radius (to accommodate the positioning of required plant around the pole locations); although that will be substantially less in many instances - because the poles sites are mostly disturbed and/or level. For the purposes of this EIAR, the conservative larger potential impact area of 20m radius has been assumed for all pole locations (noting that the actual disturbance area will be considerably less in most circumstances).

Existing access roads, tracks and/or pathways (including Woods Lane) will be utilised to wherever possible to minimise disturbance to and from the pole locations. However, vehicles will need to travel along the corridor in some locations (*eg* from Uriarra Road along the edge of the alignment towards to Railway Street).

Installation of the conductors between each pole will be undertaken using light 4WD vehicles along the powerline corridor. In most instances, this will require a single passage by a single vehicle; but may in some instances require additional activities.

As is usual Essential Energy practice, the Jerrabombera powerline project will implement an array of standard environmental protection measures such as the management and control of soils and sediment erosion, the control of wastes (*eg* tight controls on concrete and other waste materials), minimal removal of native vegetation, and the reinstatement of any disturbed areas.

The design of the powerline has, from its inception, incorporated environmental impact avoidance principles - as is demonstrated by the selection of a heavily disturbed railway corridor as the main route for the powerline alignment. Furthermore, much of the ecological values along the corridor involve only low-growing species plant, which can be retained or allowed to re-colonise at the completion of construction activities.

Recommended additional environmental protection protocols and environmental management measures to be undertaken during the powerline project include *inter alia* the following.

- Where located in identified threatened species habitat (or potential habitat), the disturbance footprints at each pole location will be inspected prior to the conduct of any works.
- Any potential 'No Go' areas (not particularly likely given the disturbed nature of almost all of the powerline alignment) will be identified and communicated to contractors and Essential Energy staff.
- Vehicle movements between power poles (other than to the north of Uriarra Road) will be minimised; with priority given to the use of existing tracks and roads.

3 INFORMATION BASE

3.1 Field Investigations and Surveys

The proposed powerline has been the subject of a previous flora and fauna investigation by Umwelt within the 'Project Area'[1] in September 2021 (Umwelt 2022 – Attachment B).

The Umwelt investigation involved the mapping of vegetation and threatened species habitats as well as the undertaking of *Biodiversity Assessment Method* (BAM) vegetation integrity plots plus opportunistic fauna and flora searches and threatened species habitat mapping. No targeted surveys for threatened species were conducted by Umwelt.

Date	Survey type	Weather conditions
20 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 7.7 Maximum temperature (C°): 16.7 Rainfall (mm): 0 Wind at 9 am (km/hr): 33
21 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): -2.0 Maximum temperature (C°): 13.9 Rainfall (mm): 2.2 Wind at 9 am (km/hr): 7
22 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): -2.3 Maximum temperature (C°): 16.8 Rainfall (mm): 0 Wind at 9 am (km/hr): 6
23 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 2.6 Maximum temperature (C°): 19.5 Rainfall (mm): 0 Wind at 9 am (km/hr): 7
24 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 6.3 Maximum temperature (C°): 20.0 Rainfall (mm): 0 Wind at 9 am (km/hr): 31

A subsequent detailed survey for the relevant threatened biota and for predatory bird species has been conducted in early 2023 by AREA Heritage & Environmental Consultants. That investigation (Attachment D) involved dedicated searches for and observations of potential predatory bird species, as well as the Pink-tailed Worm-lizard and the Grassland Earless Dragon along the proposed alignment.

[1] The 'Project Area' is defined by Umwelt (2022) as "*a 20m buffer along the length of the proposed powerline on land within NSW*".

Surveys by AREA involved walked surveys along the full length of the project in the morning, mid-afternoon (1300-1500) and late afternoon (1600 to dusk) on 3 days (06 and 07 February 2023) by two ecologists (see details in Attachment C). In addition, observations were made on Tompsitt Drive adjacent to native grassland and potential habitat for the Grassland Earless Dragon.

The undersigned has reviewed the Umwelt and AREA *Reports* (Attachments B and C), and accepts the information provided. The undersigned also generally concurs with the assessments and conclusions of those *Reports*.

3.2 Additional Information

A comprehensive analysis of the potential for the proposed powerline project to facilitate or enhance the predation by raptors and predatory birds of species such as the Grassland Earless Dragon has been prepared by Mr Brett Hayward (of Essential Energy).

That *Report* (Hayward 2023; Attachment D) was reviewed by the undersigned and provides a valuable consideration of the relevant, or potentially relevant, issues.

Additional information accessed for the purpose of preparing this EIAR includes the following.

- The OEH database – a 10km radius search.
- EPBC Act search – a 10km radius search.
- Species Profiles and Conservation Advice contained in the OEH and EPBC websites for the relevant threatened biota.
- Published material on threatened biota.

4 FLORA and VEGETATION

4.1 Vegetation Types

The vegetation types present on the subject land and in the Project Area are described in detail by Umwelt 2022 (see Attachment B) and as documented below.

The Umwelt *Report* identifies four native vegetation communities (covering 11.09ha) in the Project Area as well as 14.23ha of exotic vegetation, bare or cleared land and existing infrastructure (as documented below).

The native vegetation communities identified by Umwelt within the Project Area are as follows.

- PCT 320 Kangaroo Grass/Redleg Grass/Forb-rich Temperate Tussock Grassland of the Northern Monaro, ACT and Upper Lachlan River Regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion (Temperate Tussock Grassland).
- PCT 654 Apple Box/Yellow Box Dry Grassy Woodland of the South Eastern Highlands Bioregion (Box Grassy Woodland).
- PCT 1289 Wallaby Grass/Red-grass/Tall Spear-grass/Kangaroo Grass Dry Tussock Grassland of the Northwestern and Eastern Southern Tablelands in the South Eastern Highlands Bioregion (Dry Tussock Grassland).
- PCT 1330 Yellow Box/Blakely's Red Gum Grassy Woodland on the Tablelands, South Eastern Highlands Bioregion (Box/Gum Grassy Woodland).

The details provided below have been extracted by the undersigned from the Umwelt 2022 *Report* (Attachment B).

Temperate Tussock Grassland (PCT 320)

Temperate Tussock Grassland occurs in the southern portion of the Project Area - where it is associated with areas of natural temperate grassland. Stands are present as either of two ‘condition classes’ - low (0.49 ha) and moderate-high (2.60 ha).

PCT 320 (moderate-high) is characterised by a high cover of Kangaroo Grass *Themeda triandra* and a diversity of native forb species typical of natural grasslands (*Chrysocephalum apiculatum*, *Plantago varia*, *Goodenia pinnatifida*, *Vittadinia* spp and *Wahlenbergia* spp).

PCT 320 (low) typically supports a higher component of exotic grass species - including *Avena spp* and *Phalaris* aquatica. However, perennial exotic cover was less than perennial native cover. A moderate diversity of native non-grass species was also present.

Box Grassy Woodland (PCT 654)

Box Grassy Woodland is located within a portion of the woodland adjacent Norse Road in the northern section of the Project Area; occupying an area of 0.43 hectares.
All of this vegetation type is in moderate-high condition.

PCT 654 in the Project Area is characterised by an overstorey dominated by Apple Box *Eucalyptus bridgesiana* with a mid-storey consisting of *Acacia spp* and exotic trees such as *Prunus cerasifera* and *Cotoneaster pannosus*. The groundcover is dominated by native grasses and grass-like species - including Kangaroo Grass, *Rytidosperma* spp, *Austrostipa scabra* and *Lomandra* spp. A moderate to low diversity of native forbs is also present. Introduced groundcover species are also common such as Phalaris *Phalaris aquatica*, Cocksfoot *Dactylis glomerata* and St John's Wort *Hypericum perforatum*.

Dry Tussock Grassland (PCT 1289)

The Dry Tussock Grassland is located in the southern portion of the Project Area. Stands are present as either of two 'condition classes' - low (3.16 ha) and moderate-high (0.92 ha).

Dry Tussock Grassland is dominated by Wallaby Grasses *Rytidosperma spp* and Spear Grasses *Austrostipa spp*. PCT 1289 (moderate-high) in the Project Area has a diverse assemblage of native forbs - typically consisting of *Chrysocephalum apiculatum*, *Triptilodiscus pygmaeus*, *Goodenia pinnatifida* and *Convolvulus angustissimus*; and has high floristic diversity.

PCT 1289 (low) is dominated by the same grass species, but lacks a diversity of native forbs and also often contains a large component of exotic annual and perennial grasses (such as *Avena spp*. and *Phalaris aquatica*).

Box/Gum Grassy Woodland (PCT 1330)

The Box/Gum Grassy Woodland is located predominantly in the northern portion of the Project Area. Stands of the community are present as either of two 'condition classes' – derived native grassland and moderate/high.

Box/Gum Grassy Woodland occurs in various forms and conditions along the Project Area.

- Areas of PCT 1330 (low) and PCT 1330 (moderate-high) are characterised by an overstorey dominated by Blakely's Red Gum *E. blakelyi* and Yellow Box *E. melliodora*. The mid-storey in all zones is generally sparse, often lacking shrubs but contains *Eucalypt* regrowth and some *Acacia spp*.
- In areas of PCT 1330 (moderate /high), PCT 1330 (DNG – moderate – high) and PCT1330 (native plantation) the groundcover is dominated by Kangaroo Grass, *Austrostipa spp* and *Rytidosperma spp*, and contains a high diversity of forbs (consisting of species such as Hoary Sunray, *Goodenia pinnatifida*, *Wahlenbergia spp*, *Vittadinia spp*, Common Everlasting *Chrysocephalum apiculatum* and Common Sunray (*Triptilodiscus pygmaeus*.
- Areas of PCT 1330 (low) and (derived native grassland – low) are characterised by a groundcover layer that lacks many of the characteristic forb species, and is instead dominated by exotic grass species (including *Avena spp*, *Dactylis glomerata* and *Phalaris aquatica*).

Exotic Vegetation

Exotic vegetation is the most widely distributed vegetation type in the Project Area (see maps in Attachment C); occupying a total area of 10.18 ha.

Stands or areas of this vegetation type primarily consist of an exotic grassland dominated by Phalaris *Phalaris aquatica*, *Avena* spp, African Love Grass *Eragrostis curvula* and Tall Fescue *Festuca arundinacea*. Exotic shrubs and trees such as blackberry *Rubus fruticosus*, *Cotoneaster* spp, Radiata Pine *Pinus radiata* and White Poplar *Populus alba* are also common.

4.2 Threatened Biota

Threatened Plant Species

Two threatened flora species listed in the BCon Act and/or the EPBC Act have been recorded along the proposed powerline alignment.

- Hoary Sunray *Leucochrysum albicans* var. *tricolor* - which is listed as 'endangered' in the EPBC Act. Umwelt mapped approximately 1.10ha of potential suitable habitat for this species along the proposed alignment.
- Button Wrinklewort *Rutidosis leptorhynchoides* – which is listed as 'endangered' in both the BCon Act and the EPBC Act. Umwelt mapped approximately 0.42ha of potential suitable habitat for this species along the proposed alignment.

There are only a few records for these species along the alignment and relatively small areas of potential habitat (see Figures 3.4-1 to 3.4-4 in Attachment B).

Threatened Ecological Communities

According to Umwelt (2022 – Attachment B), PCT 320 and PCT 1289 meet the diagnostic criteria for the '*Natural Temperate Grassland of the South Eastern Highlands*' community – which is a '*Critically Endangered Ecological Community*' (CEEC) listed in the EPBC Act.

In addition, PCT 654 and PCT 1330 meet the diagnostic criteria for the '*White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*' community – which are listed as CEECs in both the BCon Act and EPBC Act.

The distribution of these CEECs is identified in Figures 3.1-1 to 3.2-4 of the Umwelt 2022 *Report* (Attachment B).

According to Umwelt (2022 – Attachment B), the Box Gum Grassy Woodland CEEC occupies approximately 3.91ha (BCon Act) or 2.76ha (EPBC Act) of the Project Area, whilst the Temperate Grassland CEEC occupies approximately 3.9ha of the Project Area.

5 FAUNA and FAUNA HABITATS

5.1 Fauna Habitats

As documented in Attachments B and C, the majority of the proposed powerline alignment at Queanbeyan is moderately to very highly degraded and/or modified. Even those portions of the proposed powerline alignment which contain native vegetation (as mapped by Umwelt 2022; Attachment B) are modified (by extensive previous clearing of trees) and/or exist only as modified woodland patches or 'derived' grasslands.

Whilst the majority of the proposed powerline alignment contains very limited habitat for most native fauna, there are several specialist grassland species (including the threatened species discussed below and in Attachments B, C and D) that are or could be present within the powerline alignment. The habitat requirements for such species include 'tussock grasslands' and/or surface rocks.

Other specialist habitat features for a range of native (including threatened) species – such as swamps, ponds, watercourses and hollow-bearing trees – are either absent along the alignment or are only occasional scattered specimens (hollow-bearing trees).

Most of the native fauna observed and recorded along the proposed powerline alignment at Queanbeyan (Attachments B and C) are common and ubiquitous urban and peri-urban species – unsurprisingly given the location of the project (see aerial photographs in Attachments A, B and C).

5.2 Threatened Species

Potential habitat for five threatened fauna species was identified along the proposed powerline alignment (Umwelt 2022); although the undersigned does not accept that any of the vegetation along the alignment is of any real relevance for the Gang Gang Cockatoo.

The more likely relevant threatened fauna species discussed by Umwelt are as follows (see detailed mapping by Umwelt in Attachment B).

- Golden Sun Moth *Synemon plana* – which is listed as 'vulnerable' in the BCon Act and 'endangered' in the EPBC Act. Umwelt (2022) mapped 8.11ha of potential grassland habitat for this species along the alignment (Figures 3.8-1 to 3.8-4 in Attachment B).
- Grassland Earless Dragon *Tympanocryptis lineata* – which is listed as 'critically endangered' in the BCon Act and 'endangered' in the EPBC Act. Umwelt (2022) mapped 6.95ha of potential grassland habitat for this species along the alignment.
- Pink-tailed Worm-lizard *Aprasia parapulchella* – which is listed as 'vulnerable' in both the BCon Act and the EPBC Act. Umwelt (2022) mapped 0.08ha of potential rocky grassland habitat for this species along the alignment.
- Striped Legless Lizard *Delma impar* – which is listed as 'vulnerable' in both the BCon Act and the EPBC Act. Umwelt (2022) mapped 12.42ha of potential grassland habitat for this species along the alignment.

As noted above, the habitats and resources along the proposed powerline alignment are not considered likely to be of real value or any significance for the Gang Gang Cockatoo. This species is highly noticeable but was not recorded by either Umwelt (2022) or AREA (2023). Potential habitat and resources for this species are sparse and limited; and have been disturbed or degraded over time.

Fourteen additional threatened fauna species were identified by Umwelt (2022) as possibly or potentially occurring along the proposed powerline alignment or in the immediate vicinity – particularly associated with the woodland vegetation along the alignment.

- Aerial bird species – including Spotted Harrier and Little Eagle.
- Woodland bird species – including Superb Parrot, Swift Parrot, Speckled Warbler, Varied Sittella, Flame and Scarlet Robins, Dusky Wood-swallow and Diamond Firetail.
- Microchiropteran bats – including the Large (Common) Bent-wing Bat and the Eastern False Pipistrelle.
- The Grey-headed Flying Fox.

It is relevant to note that none of these species are regarded as of any or any particular relevance to the proposed powerline project – because there are only limited potential resources present for these species; because the project will involve only minimal loss of any potential resources; and because all of these species are highly mobile.

Nevertheless, these species have been considered in the development design and are addressed in the following chapters of this EIAR.

6 GENERAL IMPACTS on the NATURAL ENVIRONMENT

As documented above and in detail in Attachments C, D and E, the proposed powerline alignment at Queanbeyan is not considered likely to be of significance or particular value with respect to the natural environment in general or with respect to biodiversity conservation outcomes in particular.

The proposed powerline project is located predominantly along a disused (but long disturbed and degraded or modified) railway easement. The project site is also girt along much of its length by long-established urban development (see aerial photographs in Attachment A).

In addition, the proposed powerline project involves only very limited removal of vegetation – as the project requires the installation of separated transmission poles with subsequent habitat rehabilitation in disturbed areas. Other than the trees and other taller growing species, low growing and terrestrial ecosystems and areas of potential ecological value will be retained.

In addition to limiting the extent of clearing for the proposed powerline, the project will facilitate the natural regeneration of areas of native vegetation which are disturbed; and will avoid long0term impacts along the alignment.

A critically important consideration in assessing the potential impacts of the proposed powerline project is that the majority of identified ecosystems and areas of potential ecological value can readily co-exist with a powerline. An additional important consideration is the nature of the proposal and the restoration of disturbed areas following construction.

The vegetation is a mixture of remnant and introduced trees with a predominantly introduced understorey, and the only native fauna present or likely to be present are cosmopolitan, urban-tolerant and often aggressive species (*eg* the Australian Magpie and Pied Currawong). The trees and other vegetation present do not represent any significant ecological function at this location.

The proposed powerline alignment at Queanbeyan, in accordance with the current development design would not involve the imposition of any impacts on the natural environment that could be considered unreasonable or inappropriate.

7 POTENTIAL EFFECTS on THREATENED FAUNA

Two particular issues which have been raised for the proposed powerline at Queanbeyan are as follows.

- The potential for the powerline to provide enhanced opportunities for avian predators to prey on several threatened fauna species which are known to or may occur along the powerline corridor (in particular the Grassland Earless Dragon).
- The potential for the powerline to cause injuries to predatory birds – particularly the Little Eagle (which is known to inhabit the area).

These issues with respect to the proposed powerline at Queanbeyan are addressed in a dedicated *Report* - prepared by Mr Brett Hayward (Hayward 2023; Attachment D).

The *Hayward Report* "*considers the potential impact of the development on increasing predation efficiency and predator abundance due to the erection of poles and lines adjacent to grasslands and the potential impacts of increasing mortality of birds due to collisions with powerlines, particularly for Little Eagles (Hieraaetus morphnoides)*".

Potential for Bird Strike

The *Hayward Report* has determined the following with respect to the potential for increased injuries to or deaths of native (including) predatory birds.

- There is (doubtless) the potential for some birds to 'strike' powerlines; although generally the incidence of bird mortalities and/or injuries associated with fixed power lines is low.
- The "*largest at risk group of birds for powerline interactions relate more to short-winged, large-bodied birds*".
- In addition, a range of other factors - such as limited visual acuity (narrow visual fields), certain physical features (size, weight, wingspan *etc*) and even migratory habits - can affect the likelihood of bird strike on power lines.
- Diurnal raptors (such as the Little Eagle) "*are generally more agile and have superior eyesight*". The high visual acuity of diurnal raptors, and their high manoeuvrability render such species much less likely to collide with powerlines in general.
- Other bird species recorded along the proposed powerline corridor and in the vicinity (such as the Galah, Australian Raven, Australian Magpie, Australian Kestrel and Black-shouldered Kite) are "*not likely to collide with powerlines*".

The *Hayward Report* concludes that the proposed powerline at Queanbeyan is **NOT** likely to increase "*the mortality of birds due to collisions with the .. powerline*". In particular, the proposed powerline is **NOT** likely to result in an increase in the mortality of the Little Eagle – *inter alia* because it is "*an agile and nimble bird*".

The undersigned concurs with the conclusions of the *Hayward Report* (Attachment D) – on the basis both of the clear analysis in the *Report* and the experience of the undersigned with powerlines and ecological observations over a period of 50+ years.

In particular, it is extremely highly unlikely that the Little Eagle would be adversely affected by the proposed powerline at Queanbeyan.

Potential Increased Bird Predation

The potentially relevant threatened biota that could (theoretically at least) be affected by any potential increase in avian predation include the following.

- Golden Sun Moth *Synemon plana*
- Grassland Earless Dragon *Tympanocryptis lineata*
- Pink-tailed Worm-lizard *Aprasia parapulchella*
- Striped Legless Lizard *Delma impar*

The issue of potential increased bird predation on threatened lizards (particularly the Grassland Earless Dragon) has been specifically addressed in the detailed investigation and analysis in the *Report* by AREA (Attachment C) for the proposed powerline at Queanbeyan and in the *Hayward Report* (Hayward 2023; Attachment D).

The detailed investigations and *Reports* (Attachments C and D) conclude *inter alia* the following.

- Whilst there is an array of potential predatory bird species present in the vicinity of the proposed powerline at Queanbeyan (including the Australian Raven, Australian Magpie, Pied Currawong, Pied Butcherbird, Australian Kestrel and Black-shouldered Kite), the powerline project will not provide relevant additional opportunities for predation by these species.
- For species that hover or soar (such as the Australian Kestrel and Black-shouldered Kite), the powerline is not likely to enhance predation on the relevant terrestrial fauna species. Indeed, the powerline is likely to reduce predation because the raptors are likely to avoid close proximity to the line.
- For other more opportunistic predators (such as the Australian Raven, Australian Magpie, Pied Butcherbird and Pied Currawong), the powerline structures will not provide suitable perches or predation sites – either being too elevated or of inappropriate structure.

AREA (2023) identifies the Australian Magpie and the Australian Kestrel as "the most likely predators of Earless Grasslands Dragon". According to the undersigned, these two species are also the most likely predators of the other threatened fauna species (the Pink-tailed Worm-lizard, Striped Legless Lizard and Golden Sun Moth); although other more opportunistic predators (such as the Australian Raven, Australian Magpie, Pied Butcherbird and Pied Currawong) could also prey upon these species (if present).

However, none of these predators are likely to rely on, or even use, the structures associated with the proposed powerline project. Most of these species either use lower perches or hunt while on the ground, or alternatively are aerial hunters (*eg* the Australian Kestrel).

The conclusions of the *Reports* cited above (Hayward 2023; AREA 2023) demonstrate that the proposed powerline project will not increase the levels of predation on the relevant threatened species.

Based on the long term experience of the undersigned with electricity powerlines throughout Australia, the undersigned concurs with the conclusions of the *Reports* cited above. It is not likely that the proposed powerline project will increase the levels of predation on any relevant threatened (or any other native) species.

8 SECTION 5.5 of the EP&A ACT

As discussed above, the proposed powerline project at Queanbeyan constitutes an "*activity*" pursuant to the NSW EP&A Act; and is therefore assessable pursuant to Part 5 of that Act.

Relevantly, Section 5.5(1) of the EP&A Act requires the following considerations and environmental assessment in respect of an "*activity*" such as the proposed powerline at Queanbeyan.

- "*For the purpose of attaining the objects of this Act relating to the protection and enhancement of the environment, a determining authority in its consideration of an activity shall, notwithstanding any other provisions of this Act or the provisions of any other Act or of any instrument made under this or any other Act, examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity*".

As documented in the *Reports* of Umwelt (Attachment B) and AREA (Attachment C), and as discussed above, much of the alignment is grassland and/or shrubland with parts also being disturbed or modified – being located along a now-disused railway corridor.

Areas of woodland containing trees occur predominantly along the northern parts of the alignment. However, these have all been modified (as a result of the long-term previous uses of the corridor) and hollow-bearing trees are rare along the proposed alignment (see the Umwelt Report – Attachment B).

Additional relevant matters in considering the likely impacts of the proposed powerline project at Queanbeyan on the natural environment include the following.

- The nature of the project – being a (mostly) elevated powerline with poles located approximately 220 metres apart and minimal disturbance between the poles except along a small section between the ACT border and Uriarra Road (in the northern part of the alignment).
- Most of the pole sites along the alignment are able to be accessed from existing adjacent roads or tracks; thus limiting the potential 'disturbance footprint' for the project.
- Essential Energy staff and contractors will be advised about relevant issues and sensitive native biota and locations.
- The project also includes a commitment to the restoration of the relatively small areas which will be affected during the construction program – including temporary vehicle tracks and pole locations.

Importantly, given the nature of the project and the environment along the alignment, the proposed powerline project at Queanbeyan is not likely to impose any significant or unacceptable adverse impacts upon any biodiversity values or upon any relevant features of the natural environment at this location.

9 NSW BIODIVERSITY CONSERVATION ACT

9.1 The Statutory Regime

The *Biodiversity Conservation Act 2016* (BCon Act) has modified the *Environmental Planning & Assessment Act 1979* (EP&A Act) *inter alia* by the provision of specific requirements for the consideration and assessment of the clearing of native vegetation and the potential for impacts to be imposed upon "*threatened species*"[2].

Section 7.2(1) of the BCon Act details the following required considerations.

> *(1) For the purposes of this Part, development or an activity is* ***likely to significantly affect threatened species*** *if:*
>
> *(a) it is likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in section 7.3, or*
>
> *(b) the development exceeds the biodiversity offsets scheme threshold if the biodiversity offsets scheme applies to the impacts of the development on biodiversity values, or*
>
> *(c) it is carried out in a declared area of outstanding biodiversity value.*

It is noted that Section 7.2(2) of the BCon Act states specifically that "*subsection (1)(b)* [of Section 7.2(1) of the Act] ***does not apply*** *to development that is an activity subject to environmental impact assessment under Part 5*" of the EP&A Act.

As a consequence, the "*biodiversity offsets scheme*" and the "*biodiversity offsets scheme threshold*" do not apply to the proposed powerline project. Therefore, the extent of any removal of vegetation (limited though it is by design) is not of relevance to any considerations of environmental impacts (including on threatened biota) as a result of the proposed powerline project.

Nevertheless, the proposed powerline project has taken into account the potential impacts of the project on threatened biota and their habitats; and has been designed to minimise or limit any potential impacts on any such biota and their habitats.

---

[2] The term "*threatened species*" includes "*threatened species, populations and ecological communities*" listed in the *Biodiversity Conservation Act 2016*.

9.2 Section 7.2(1) of the BCon Act

Consideration of the proposed powerline project at Queanbeyan pursuant to the relevant parts of Section 7.2(1) of the BCon Act (see above) provides the following assessments.

(a) likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in section 7.3

The undersigned has considered in detail the five factors listed in Section 7.3 of the BCon Act with respect to the 'likelihood' (or not) of a "*significant effect*" being imposed on any threatened biota or their habitats (see Chapter 9.3).

Despite the presence (or potential presence) of an array of "*threatened species or ecological communities, or their habitats*" along various portions of the powerline alignment, the project (by virtue of its nature) is able to avoid significant (or in many instances any) adverse impacts on those biota or their habitats (as documented in previously in this EIAR).

Development of the project design by Essential Energy has taken into account, and avoided or minimised, the potential for adverse impacts upon those biota.

As detailed in Chapter 9.3 of this *Report*, the proposed powerline project at Queanbeyan is **not** "*likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in section 7.3*" of the BCon Act.

(b) The biodiversity offsets scheme

As noted above, the "*biodiversity offsets scheme*" and the "*biodiversity offsets scheme threshold*" do not apply to the proposed powerline project.

(c) It is carried out in a declared area of outstanding biodiversity value

The proposed powerline project is not located "*in a declared area of outstanding biodiversity value*".

Nor is there any "*declared area of outstanding biodiversity value*" in the vicinity or locality which could conceivably be affected by the proposed powerline project at Queanbeyan.

Given the considerations documented above, the proposed powerline project at Queanbeyan is not "*likely to significantly affect threatened species*" - pursuant to Section 7.2(1) of the BCon Act.

9.3 Section 7.3 of the BCon Act

Section 7.3 of the BCon Act provides the matters that "*must be taken into account*" and the specific "*Test for determining whether* [a] *proposed development or activity* [is] *likely to significantly affect threatened species or ecological communities, or their habitats*" referred to in Section 7.2(a) of the BCon Act (as noted above).

In addition to the factors which "*must be taken into account*" (where relevant) pursuant to Section 7.3(1) of the BCon Act, Section 7.3(2) of the Act identifies that the "*Minister may, by order published in the Gazette with the concurrence of the Minister for Planning, issue guidelines relating to the determination of whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats*".

Where relevant, such guidelines have been taken into account by the undersigned in the consideration of potential impacts on threatened biota of the proposed powerline project at Queanbeyan.

Further, as discussed elsewhere in this Report, the nature, condition and circumstances of the subject land (as described in detail above) are an important and highly relevant consideration in addressing the *Assessment of Significance* pursuant to Section 7.3 of the BCon Act.

Factor (a) Threatened Species – Risk of Extinction

As documented in Chapters 4 and 5 of this EIAR, there are two threatened species listed in the BCon Act known to be present along the proposed powerline project at Queanbeyan as well as an array of listed threatened biota that could be present.

- Threatened biota known to be present are two plant species (the Hoary Sunray and the Button Wrinklewort).
- Additional threatened biota that could potentially be present include other terrestrial grassland species (the Grassland Earless Dragon, Pink-tailed Worm-skink, Striped Legless Lizard and the Golden Sun Moth), birds (the Little Eagle, Gang Gang Cockatoo and several woodland species) and an array of microchiropteran bats plus the Grey-headed Flying Fox.

With respect to the known and potential terrestrial fauna species identified above, the proposed powerline project has a focus on minimising the project footprint (for example by using adjoining existing infrastructure – roads and tracks) and by limiting the disturbance to potential habitats for said terrestrial species. In addition, pre-clearing searches will be undertaken in areas of 'habitat' for those species (as identified by Umwelt – Attachment C) and disturbed areas will be allowed to regenerate.

There are only a few specimens of the known threatened plant species identified above along the proposed powerline corridor (Umwelt 2022; Attachment B). Again, minimising the project footprint (by using adjoining existing infrastructure – roads and tracks) and by limiting the disturbance to potential habitats for those plant species limits the potential for a significant effect to be imposed.

The other threatened fauna species which could potentially occur along the proposed powerline corridor are highly mobile and generally wide-ranging species – individuals of a few threatened microchiropteran bats, the Grey-headed Flying Fox and possibly a few highly mobile threatened bird species known from the locality (see Attachments B and C).

However, given the circumstances of the proposed powerline project (predominantly involving grasslands and being located along an existing disturbed railway corridor), there is no likelihood that even a single individual of any such species would be dependent on the alignment for its survival in this locality. There are very few hollow-bearing trees along the alignment – so species dependent on this resource would be rare (if present at all). The areas of woodland are highly disturbed and do not provide habitat or resources either of high value or which are unique to the alignment.

There is no likelihood that any of those additional potential threatened species would be adversely affected to a significant extent (if indeed to any extent) by the proposed powerline project – as indicated in the summaries provided below.

Given the considerations discussed above and throughout this EIAR, it is **not** "*likely*" that a "*viable local population*" of any "*threatened species*" would be "*placed at risk of **extinction***" (emphasis added) by the proposed powerline project at Queanbeyan.

Grassland Earless Dragon

- Not likely that a "*viable local population*" of this species would be confined to or dependent on those parts of the powerline alignment to be affected.
- Minimal disturbance footprint of the actual project by design - involving only limited areas of potential habitat for this species.
- No likelihood that any "*viable local population*" of this species would be "*placed at risk of **extinction***" (emphasis added) by the project.

Button Wrinklewort

- Only two known records along the alignment.
- Not likely that a "*viable local population*" of this species would be confined to or dependent on those parts of the powerline alignment to be affected.
- Minimal disturbance footprint of the actual project by design - involving only limited areas of potential habitat for this species.
- No likelihood that any "*viable local population*" of this species would be "*placed at risk of **extinction***" (emphasis added) by the project.

Other Terrestrial Species

- Not likely that a "*viable local population*" of any of these species (even if present) would be confined to or dependent on those parts of the powerline alignment to be affected.
- Minimal disturbance footprint of the actual project by design - involving only extremely limited areas of potential habitat for any of these species.
- No likelihood that any "*viable local population*" of any of these species would be "*placed at risk of **extinction***" (emphasis added) by the project – even if a "*viable local population*" of any such these species is present along the alignment.

Threatened Birds

- Given the high mobility of all of the threatened bird species that could potentially occur along the powerline project alignment, and the limited potential resources present for any such species, it is not conceivable that a "*viable local population*" of any of these species (even if present in the vicinity or locality) would be confined to or dependent on those parts of the powerline alignment to be affected.

- Minimal disturbance footprint of the actual project by design - involving only extremely limited areas of disturbed potential habitat (woodlands, woodland trees and/or hollow-bearing trees) for any of these species.
- Extremely limited likelihood of individuals of any such species (if present) colliding with the powerlines.
- No likelihood that any "*viable local population*" of any of these species would be "*placed at risk of **extinction***" (emphasis added) by the project – even if a "*viable local population*" of any such these species is present along the alignment.

Microchiropteran Bats

- Given the very high mobility of all of the threatened microchiropteran bat species that could potentially occur along the powerline project alignment and the limited potential resources present for any such species, as well as their highly adaptable natures,it is not conceivable that a "*viable local population*" of any of these species (even if present in the vicinity or locality) would be confined to or dependent on those parts of the powerline alignment to be affected.
- Minimal disturbance footprint of the actual project by design - involving only extremely limited areas of disturbed potential habitat (woodlands, woodland trees and/or hollow-bearing trees) for any of these species.
- No removal of potential roosting resources of any likely relevance.
- Extremely limited likelihood of individuals of any such species (if present) colliding with the powerlines.
- No likelihood that any "*viable local population*" of any of these species would be "*placed at risk of **extinction***" (emphasis added) by the project – even if a "*viable local population*" of any such these species is present along the alignment.

Grey-headed Flying Fox

- No possibility of a "*viable local population*" of the Grey-headed Flying Fox (even if present in the locality) would be confined to or dependent on those parts of the powerline alignment to be affected.
- Minimal disturbance footprint of the actual project by design - involving only extremely limited areas of potential habitat for this species.
- No likelihood that any "*viable local population*" of the Grey-headed Flying Fox would be "*placed at risk of **extinction***" (emphasis added) by the project.

Factor (b) Threatened Ecological Communities – Risk of Extinction

As discussed above and as documented in Umwelt 2022 (Attachment B), there are stands of the '*White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*' (Box Gum TEC) community located along the proposed powerline alignment. Relevantly, the Box Gum TEC community is not confined to the powerline alignment; and is widespread in similar circumstances through the general vicinity and locality.

As discussed elsewhere in this EIAR, the proposed powerline project utilises (to the maximum extent possible) adjoining existing infrastructure (existing roads and tracks and disturbed parts of the railway easement) for access purposes and also limits disturbance to the Box Gum TEC community by minimising the footprint of the activity wherever possible.

Given the considerations discussed above and throughout this EIAR, it is **not** "*likely*" that the '*White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*' – which is present in part along the powerline alignment - would be "*placed at risk of **extinction***" (emphasis added) by the proposed powerline project at Queanbeyan.

Box Gum TEC

- Only a small part of the "*local occurrence*" of the Box Gum TEC is located within the powerline alignment to be affected; with much greater areas of this community beyond the alignment.
- Minimal disturbance footprint of the actual project by design - involving only limited areas of this community and minimal disturbance wherever possible.
- No likelihood that the "*local occurrence*" of the Box Gum TEC would be "*placed at risk of **extinction***" (emphasis added) by the project.

Factor (c) Impacts on Habitat for Threatened Biota

Relevantly, the proposed powerline project at Queanbeyan (a) is located within a disturbed railway easement; (b) proposes to utilise existing infrastructure and design approaches to limit the extent of and/or nature of potential impacts; and (c) natural regeneration of areas of potential habitat to be affected will ensue.

Given the circumstances and the approach of the powerline project at Queanbeyan, the following considerations apply to "*the action proposed*" with respect to Factor (c) of Section 7.3(1) of the BCon Act.

- The "*extent*" of even potential habitat for any potential threatened biota that is to be "*removed or modified*" from the proposed powerline is insignificant – given the existing condition of the subject land; the minimal impact approach of the project (using existing infrastructure for access *etc*); the nature of the project (requiring only 'scattered' on-ground disturbance) and the subsequent rehabilitation of habitat.

  No threatened biota would be dependent on the vegetation or the 'habitats' which will be disturbed for the proposed powerline project for their survival along the alignment, in the vicinity or in the locality - Factor (c)(i).

- The proposed powerline will not result in any relevant habitat for any threatened biota becoming "*fragmented or isolated from other areas of habitat*" – Factor (c)(ii).

  Given the location, nature and condition of the powerline alignment and the nature of the surrounding landscape, as well as the nature of the relevant (or potentially relevant species), no such potential impacts could be imposed.

- Given all of the considerations detailed above, the proposed powerline alignment and/or project cannot conceivably be regarded as of importance with respect to "*the long-term survival*" of any of the potential threatened biota known or likely to occur "*in the locality*" – Factor (c)(iii).

Factor (d) Impacts on Areas of Outstanding Biodiversity Value

There is no "*declared area of outstanding biodiversity value*" in the vicinity of the proposed powerline project at Queanbeyan; and there is no possibility of the project imposing any adverse impact on any "*declared area of outstanding biodiversity value*".

Factor (e) Key Threatening Processes

The proposed powerline project at Queanbeyan does involve the imposition or the exacerbation of a "*key threatening process*" (KTP) listed in the BCon Act – being the "*removal of native vegetation*".

However, as discussed in detail throughout this EIAR, the project has specifically addressed this issue and has limited the extent of the required clearing of native vegetation to the maximum extent possible – within the context of constructing a new powerline. Access to construction sites along the corridor has been limited; controls will be imposed on areas of disturbance; the removal or lopping of trees will be minimised; rehabilitation of disturbed areas will occur.

Relevantly, any imposition or exacerbation of any KTP listed in the BCon Act for the purposes of the proposed powerline project at Queanbeyan is not "*likely*" to impose a "*significant effect*" upon any "*threatened species or ecological communities, or their habitats*".

9.4 Conclusions

Given the matters detailed above, the proposed powerline project at Queanbeyan is not "*likely*" to impose a "*significant effect*" (or, indeed, any relevant effect) upon any "*threatened species or ecological communities, or their habitats*" that are present in the vicinity or that could occur at this location - pursuant to Section 7.3(1) of the BCon Act.

10 APPLICATION of the EPBC ACT

10.1 Statutory Considerations

Significant Guidelines for MNES pursuant to the EPBC Act
In the event that such an "*impact*" is "*likely*" to be imposed, the activity proposed must be referred to the Commonwealth for determination as to whether it constitutes a "*controlled action*". Where a development activity does constitute a "*controlled action*", an approval from the Commonwealth Minister of the Environment is required.

The proposed powerline project at Queanbeyan could not possibly affect any MNES other than (theoretically at least) the following.

- Listed threatened species and ecological communities (as documented throughout this EIAR).
- Migratory species.

10.2 Threatened Biota

Threatened Flora

Two threatened flora species listed in the EPBC Act have been recorded within the proposed powerline project alignment – the Button Wrinklewort *Rutidosis leptorhynchoides* and the Hoary Sunray *Leucochrysum albicans* var. *tricolor*. The Umwelt 2022 *Report* states that no other threatened plant species are likely to occur within the subject land at Queanbeyan.

There are only a few records of these species within the proposed powerline project alignment and the extent of potential habitat is limited (see maps in Attachment B). Further, it is recommended that pre-clearing surveys for these species be undertaken within areas of potential habitat identified by Umwelt (see Chapter 2).

Given the nature of the proposed powerline project at Queanbeyan, it is not "*likely*" that the proposed powerline project would impose a "*significant impact*" on either the Button Wrinklewort or the Hoary Sunray, or any other potential threatened plant species.

- The project will not lead to any decrease in a population of these species or "*reduce the area of occupancy*" of either species.
- The proposed powerline project will not fragment a population of these species or disrupt the breeding cycle of either species.
- The proposed powerline project will not "*adversely affect habitat critical to the survival of*" or adversely affect the potential habitat of these species.
- The proposed powerline project will not involve the imposition of invasive species or disease that could adversely affect these species.
- The proposed powerline project will not "*interfere with the recovery*" of these, or any other, threatened plant species.

Threatened Fauna

Potentially relevant threatened fauna species (listed in the EPBC Act) which could or might occur along the proposed powerline project include all of those discussed above in Chapters 4 and 5 of this EIAR. Relevant species include the Golden Sun Moth (now a 'vulnerable', not an endangered, species), Grassland Earless Dragon, Pink-tailed Worm-skink, Striped Legless Lizard, Gang Gang Cockatoo plus an array of other threatened birds, microchiropteran bats and the Grey-headed Flying Fox.

The analyses of the potential impacts of the proposed powerline project with respect to threatened fauna species pursuant to the BCon Act (Chapter 9.3) also apply to the EPBC Act threatened fauna species; with the following specific consideration pursuant to the *Significant Guidelines* for MNES pursuant to the EPBC Act.

Given the nature of the proposed powerline project at Queanbeyan, it is not "*likely*" that the proposed powerline project would impose a "*significant impact*" on any of the threatened fauna species identified above, or any other potential threatened fauna species.

- There is no likelihood that the project would lead to any decrease in any population of or "*reduce the area of occupancy*" of any of those species.
- The proposed powerline project will not fragment a population of those threatened fauna species or disrupt the breeding cycle of any such species.
- The proposed powerline project will not "*adversely affect habitat critical to the survival of*" or adversely affect the potential habitat of any such species.
- The proposed powerline project will not involve the imposition of invasive species or disease that could adversely affect any such species.
- The proposed powerline project will not "*interfere with the recovery*" of these, or any other, threatened fauna species.

It is not "*likely*" that the proposed powerline project would impose a "*significant impact*" upon any threatened fauna species listed in the EPBC Act.

Threatened Ecological Communities

There are two TECs listed in the EPBC Act present along the subject land at Quenbeyan - the '*Natural Temperate Grassland of the South Eastern Highlands*' community and the '*White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*' community – each listed as a '*Critically Endangered Ecological Community*' (CEEC) in the EPBC Act.

The areas of the TECs within the proposed powerline are already moderately to highly modified and are also just part of a mosaic of native vegetation and TECs scattered through the locality. In addition, the proposed powerline project has been designed and will be constructed to limit impacts on the native vegetation present (including the stands of the relevant TECs).

Given the nature of the proposed powerline project at Queanbeyan, it is not "*likely*" that the proposed powerline project would impose a "*significant impact*" on any of the TECs identified above.

- There is no likelihood that the project would reduce the extent of these ecological communities – as the powerline is located along an existing mostly cleared railway line.
- The proposed powerline project will not fragment or increase the fragmentation of the

relevant ecological communities, affect habitat necessary or critical to the survival of the relevant ecological communities, or affect the species composition of the relevant ecological communities – again given that the powerline is located along an existing mostly cleared railway line.

- The proposed powerline project will not adversely affect the viability of the relevant ecological communities with respect to invasive species or other effects; and will have no impact whatsoever on the "*recovery*" of the relevant ecological communities.

The proposed powerline project at Queanbeyan is not "*likely*" to impose a "*significant impact*" upon any TECs listed in the EPBC Act.

8.3 Migratory Species

The proposed powerline project at Queanbeyan contains no relevant or special habitat and/or resources for any migratory fauna listed in the EPBC Act. The only alleged 'migratory' species which could even conceivably occur on the subject land are highly mobile, wide-ranging and cosmopolitan.

The proposed powerline project at Queanbeyan will not impose a "*significant impact*" upon any migratory species listed in the EPBC Act.

8.4 Conclusions

The proposed powerline project at Queanbeyan will not impose a "*significant impact*" upon any MNES listed in the EPBC Act.

F Dominic Fanning
Gunninah

BIBLIOGRAPHY

Project Specific Reports

Umwelt. 2022. *132 KV Powerline Ecological Values Report – South Jerrabombera Section*.

AREA. 2023. *132 KV Powerline: Ecological Observation along the South Jerrabombera Section*.

Hayward. 2023. *Avian Interaction with Powerlines and Potential Consequences*.

Project Specific Reports

Benson D, Howell J and McDougall L. 1996. *Mountain Devil to Mangrove: A Guide to Natural vegetation in the Hawkesbury - Nepean Catchment*. Royal Botanic Gardens, Sydney.

Benson D and McDougall L. 1991. *Rare Bushland Plants of Western Sydney*. Royal Botanical Gardens, Sydney.

Briggs JD and JH Leigh. 1988. *Rare or Threatened Australian Plants*. Special Publication 14. Australian National Parks & Wildlife Service.

Briggs JD and JH Leigh. 1996. *Rare or Threatened Australian Plants*. CSIRO, Australia.

Brooker MIH and Kleinig DA. 1990. *Field Guide to Eucalypts Volume 1 - South-eastern Australia*. Inkata Press, Melbourne.

Brouwer J and Garnett S (*eds*). 1990. *Threatened Birds of Australia*: *An Annotated List*. Royal Australasian Ornithologists Union Report No. 68.

Churchill S. 2008. *Australian Bats*. New Holland Publishers.

Cogger HG. 1992. *Reptiles and Amphibians of Australia*. AH & AW Reed, Sydney.

Cropper SC. 1993. *Management of Endangered Plants*. CSIRO, East Melbourne.

Fairley A and Moore P. 1989. *Native Plants of the Sydney District*. Kangaroo Press, Sydney.

Garnett ST and Crowley GM. 2000. *The Action Plan for Australian Birds.* Environment Australia, Canberra.

Hall LS and Richards GC. 1979. *Bats of Eastern Australia*. Queensland Museum Booklet No. 12. Queensland Museum, Brisbane.

Harden G (e*d*). 1992. *Flora of NSW. Vol 3*. NSW University Press, Kensington.

Harden G (e*d*). 1993. *Flora of NSW. Vol 4*. NSW University Press, Kensington.

Harden G (e*d*). 2000. *Flora of NSW. Vol 1 (revised).* NSW University Press, Kensington.

Harden G (e*d*). 2002. *Flora of NSW. Vol 2 (revised).* NSW University Press, Kensington.

Higgins PJ (*ed*). 1999. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 4 - Parrots to Dollarbird.* Oxford University Press, Melbourne.

Higgins PJ and Davies SJJF (*eds*). 1996. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 3 - Snipe to Pigeons*. Oxford University Press, Melbourne.

Higgins PJ, Peter JM and Steele WK (*eds*). 2001. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 6 - Pardalotes to Shrike-thrushes*. Oxford University Press, Melbourne.

Higgins PJ and Peter JM (*eds*). 2002. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 5 - Tyrant-flycatchers to Chats*. Oxford University Press, Melbourne.

Higgins PJ, Peter JM and Cowling SJ (*eds*). 2006. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 7 Part A - Boatbill to Starlings*. Oxford University Press, Melbourne.

Higgins PJ, Peter JM and Cowling SJ (*eds*). 2006. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 7 Part B - Boatbill to Starlings*. Oxford University Press, Melbourne.

Marchant S and Higgins PJ. 1990a. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 1 Part A - Ratites to Ducks*. Oxford University Press, Melbourne.

Marchant S and Higgins PJ. 1990b. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 1 Part B - Ratites to Ducks*. Oxford University Press, Melbourne.

Marchant S and Higgins PJ (*eds*). 1993. *Handbook of Australian*, *New Zealand and Antarctic Birds*. *Volume 2 - Raptors to Lapwings*. Oxford University Press, Melbourne.

McDonald RC, Isbell RF, Speight JG, Walker J and Hopkins M. 1990. *Australian Soil and Land Survey Field Handbook* (2nd Edition). Inkata, Melbourne.

Mount King Ecological Surveys. 1992. Fauna Survey of Lot 10 DP 733241 and Lot 31 DP 808202, Myall Road, Tea Gardens. Mount King Ecological Surveys, Oberon, NSW.

Robinson L. 1991. *Field Guide to the Native Plants of Sydney*. Kangaroo Press, Sydney.

Robinson M. 1994. *A Field Guide to Frogs of Australia*. Australian Museum/Reed Books, Sydney.

Simpson K and Day N. 1998. *The Claremont Field Guide to the Birds of Australia (5th Edition)*. Penguin Books, Australia.

Slater P, Slater P and Slater R. 1989. *The Slater Field Guide to Australian Birds*. Weldon Publishing, Sydney.

Specht RL. 1988. Major Vegetation Formations in Australia. In *Ecological Biogeography of Australia*. Keast A (*ed*). Junk, The Hague.

Strahan R (*ed*). 1995. *The Mammals of Australia*. Reed Books, Chatswood.

gunninah

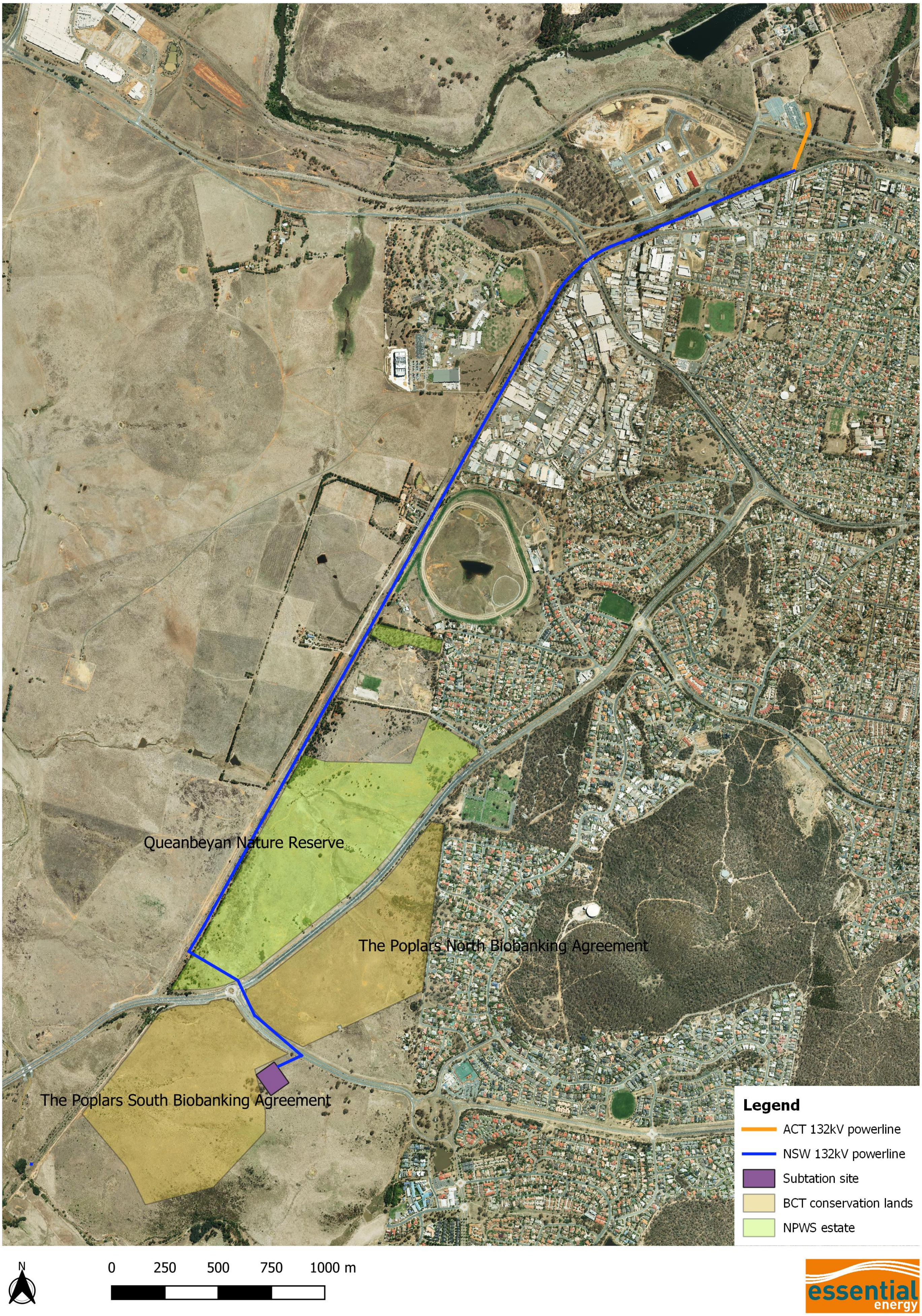
PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

ECOLOGICAL ISSUES & ASSESSMENT REPORT

ATTACHMENT A
RELEVANT PLANS and MAPS

F Dominic Fanning

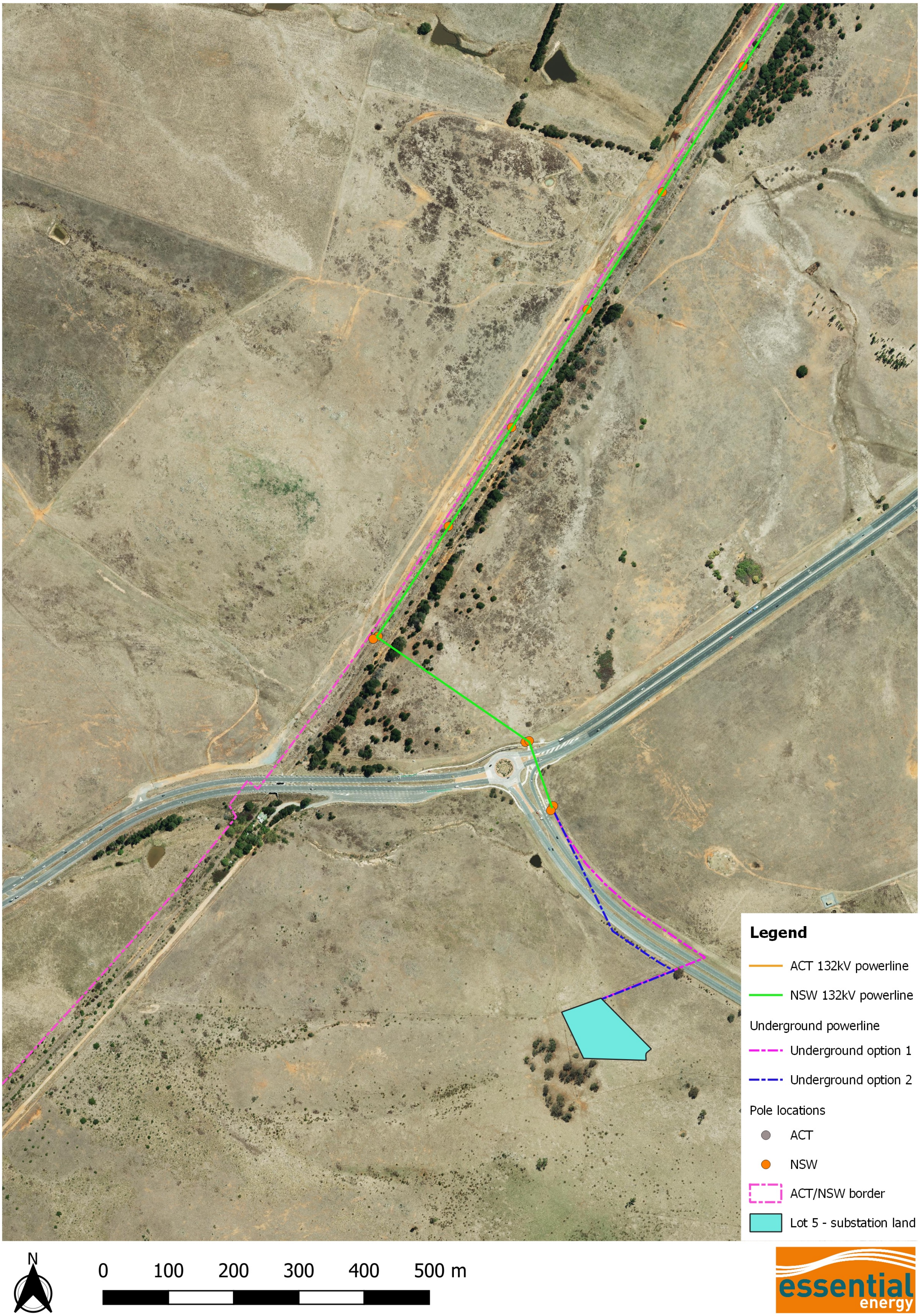
May 2023


Queanbeyan Nature Reserve
The Poplars North Biobanking Agreement
The Poplars South Biobanking Agreement
Legend
ACT 132kV powerline
NSW 132kV powerline
Subtation site
BCT conservation lands
NPWS estate
N
0
250
500
750
1000 m

Legend
ACT 132kV powerline
NSW 132kV powerline
Underground powerline
Underground option 1
Underground option 2
Pole locations
ACT
NSW
ACT/NSW border
Lot 5 - substation land
N
0
100
200
300
400
500 m


Legend
ACT 132kV powerline
NSW 132kV powerline
Underground powerline
Underground option 1
Underground option 2
Pole locations
ACT
NSW
ACT/NSW border
Lot 5 - substation land
N
0
100
200
300
400
500 m
essential
energy


Legend
ACT 132kV powerline
NSW 132kV powerline
Underground powerline
Underground option 1
Underground option 2
Pole locations
ACT
NSW
ACT/NSW border
Lot 5 - substation land
N
0
100
200
300
400
500 m
essential energy


Legend
ACT 132kV powerline
NSW 132kV powerline
Underground powerline
Underground option 1
Underground option 2
Pole locations
ACT
NSW
ACT/NSW border
Lot 5 - substation land
N
0
100
200
300
400
500 m

gunninah

PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

ECOLOGICAL ISSUES & ASSESSMENT REPORT

ATTACHMENT B
UMWELT 2022 REPORT

F Dominic Fanning

May 2023

132 KV POWERLINE ECOLOGICAL VALUES REPORT – SOUTH JERRABOMBERRA SECTION

South Jerrabomberra, NSW

FINAL

September 2022

132 KV POWERLINE ECOLOGICAL VALUES REPORT – SOUTH JERRABOMBERRA SECTION

South Jerrabomberra, NSW

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Essential Energy Pty Ltd

Project Director: David Moore
Project Manager: Mark Allen
Date: September 2022

Environmental & Social Consultants

Disclaimer

This document has been prepared for the sole use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that for which it was supplied by Umwelt (Australia) Pty Ltd (Umwelt). No other party should rely on this document without the prior written consent of Umwelt.

Umwelt undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. Umwelt assumes no liability to a third party for any inaccuracies in or omissions to that information. Where this document indicates that information has been provided by third parties, Umwelt has made no independent verification of this information except as expressly stated.

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Draft V1	David Moore	14/09/2022	David Moore	14/09/2022
Final V2	David Moore	29/09/2022	David Moore	29/09/2022

Executive Summary

Essential Energy has identified a need to augment the electricity supply network in the region to continue to foster and encourage economic development and increase electricity supply reliability through the installation of a new dual circuit 132 kV powerline. Essential Energy propose construction of a 132 kV powerline extending from the TransGrid Queanbeyan substation located within Oaks Estate in the ACT, along a disused railway corridor to a newly constructed substation in Environa, NSW. Approximately 8 km of the proposed powerline is located in NSW and 300 metres is located in the ACT. This report pertains to the NSW section of the proposed powerline.

This ecological assessment has been prepared by Umwelt Australia Pty Ltd (Umwelt), and presents vegetation community and zone mapping, vegetation condition assessment, threatened ecological community assessment and threatened species habitat assessment and documents ecological values in the Project Area focussing on matters listed in the NSW *Biodiversity Conservation Act 2016* (BC Act) and threatened species and ecological communities listed under either the BC Act or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

A literature review and a search of relevant publicly available databases were conducted to identify all threatened and migratory species, endangered populations, and threatened ecological communities (TECs) listed under the BC Act and / or the EPBC Act that had potential to occur in the Project Area. Field surveys were undertaken during September 2021. The vegetation mapping and integrity assessment consisted of rapid assessment and vegetation integrity plots in accordance with the Biodiversity Assessment Method (BAM) (Department of Planning, Industry and Environment (DPIE) 2022). No targeted threatened flora surveys or fauna species were conducted.

Native Vegetation

This ecological assessment identified 11.09 ha of native vegetation comprising:

- 3.09 ha of PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion in low and moderate-high condition
- 4.09 ha of PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion in low and moderate-high condition
- 0.21 ha of PCT 654 Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion in moderate-high condition
- 3.66 ha of PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion in low, moderate-high, derived native grassland (low) and derived native grassland (moderate-high) condition.

The remainder of the Project Area supported exotic vegetation, bare ground or infrastructure such as roads or rail infrastructure.

Threatened Ecological Communities

Areas meeting diagnostic criteria for one BC Act listed threatened ecological communities was confirmed present in the Project Area:

- 3.91 ha of native vegetation conforming to diagnostic criteria for BC Act listed White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland critically endangered ecological community.
- Two EPBC Act listed threatened ecological communities were confirmed in the Project Area, with condition thresholds met as follows:
  - 2.76 ha of native vegetation conforming to diagnostic criteria and condition thresholds for EPBC Act listed White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands critically endangered ecological community
  - 3.90 ha of native grassland conforming to diagnostic criteria and condition thresholds EPBC Act listed Natural Temperate Grassland of the South Eastern Highlands critically endangered ecological community.

Threatened Fauna

19 threatened fauna species comprising 12 bird species, one invertebrate, three mammal species and three reptile species have either been recorded in the Project Area or were assessed as having a moderate or higher likelihood of occurrence in the Project Area. No targeted threatened species surveys were completed for the purposes of this assessment. Relevant local survey data has been reviewed and included for the purposes of assessing species potential to occur.

The following fauna habitat was identified in the project area:

- 2.37 ha of woodland foraging habitat for Gang-gang cockatoo (*Callocephalon fimbriatum*), listed as vulnerable under the BC Act and endangered under the EPBC Act; while no breeding habitat was detected foraging habitat would meet criteria for classification as critical habitat under the Commonwealth listing advice
- 8.11 ha of grassland habitat for golden sun moth (*Synemon plana*), listed as endangered under the BC Act and vulnerable under the EPBC Act
- 6.95 ha of grassland habitat for grassland earless dragon (*Tympanocryptis pinguicolla* / *lineata*) listed as critically endangered under the BC Act and endangered under the EPBC Act
- 0.08 ha of rocky grassland habitat for pink-tailed worm-lizard (*Aprasia parapulchella*) listed as vulnerable under both the BC Act and the EPBC Act
- 12.42 ha of grassland habitat for striped legless lizard (*Delma impar*) listed as vulnerable under both the BC Act and the EPBC Act.

Targeted surveys for the above species were not completed. However, on the basis of records in adjacent and continuous habitat areas, there is a high likelihood of these species occurring in identified habitat. Species-specific test of significance are recommended for the above species.

Breeding habitat for bird species dependent on large hollows, primarily gang-gang cockatoo and superb parrot is absent, as were large stick nests suitable for little eagle.

Highly mobile species with a moderate to high – likelihood of utilising the site, but for which the site does not support any specifically important habitat characteristics that distinguish it from habitat elsewhere in the landscape. Tests of significance for the following species may be grouped and completed in summarised form:

- 2.37 ha of potential foraging habitat for threatened mammal species large bent-winged bat, eastern false pipistrelle and grey-headed flying fox, as well as potential roosting habitat eastern false pipistrelle. A single railroad underpass was assessed as potential non-breeding roosting location for large bent-winged bat, however no targeted survey was completed and no evidence of occupancy was recorded. No breeding habitat was present for large bent-winged bat.
- 2.37 ha of suitable habitat for threatened woodland birds.

Targeted surveys were not completed hence potential for occurrence is assumed only. It is unlikely that development in the project area would adversely impact the availability of habitat in the landscape for these species. Grouped tests of significance are recommended for these species.

Threatened Flora

Two threatened flora species were confirmed present in the Project Area:

- 1.10 ha supporting hoary sunray (*Leucochrysum albicans var. tricolor)*, listed as endangered under the EPBC Act
- 0.42 ha supporting button wrinkle wort (*Rutidosis leptorhynchoides*), listed as endangered under both the EPBC Act and the BC Act.

Following site inspection and based on the level of survey effort completed along the linear Project Area, no other threatened flora is likely to be present in the Project Area.

Recommendations

Following confirmation of the proposed alignment, impact footprint and the nature of indirect impacts, the potential significance of impacts on NSW BC Act listed and EPBC Act listed entities should be assessed as follows:

- 5 part tests under the NSW BC Act are required to determine whether the proposed activity is likely to have a significant impact on NSW BC Act listed species, and
- EPBC Act Assessment of Significance in accordance with Significant Impact Guidelines 1.1, including consideration of species or community specific guidelines and listing advice to ascertain if referral to the Minister of the Environment is warranted to determine if the proposed powerline would be a controlled action.

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

1.1 Proposal Background

Essential Energy engaged Umwelt (Australia) Pty Ltd (Umwelt) to undertake an ecological assessment at the installation site of a proposed 132 kV dual circuit powerline, near Queanbeyan, NSW.

Essential Energy has identified a need to augment the electricity supply network in the region to continue to foster and encourage economic development and increase electricity supply reliability through the installation of a new dual circuit 132 kV powerline. The proposed 132 kV powerline would extend from an existing Essential Energy powerline, near the TransGrid Queanbeyan substation located within Oaks Estate in the ACT, along a disused railway corridor to a newly constructed substation in Environa, NSW (**Figure 1.1**). Approximately 8 km of the proposed powerline is located in NSW and 300 m is located in the ACT. This report pertains to the NSW section of the proposed powerline (herein the 'Proposal'). The Project Area comprises a 20 m wide buffer along the length of the proposed powerline on land within NSW only. The 20 m buffer and proposed pole locations are shown in **Figure 1.2**.

The purpose of this report was to complete comprehensive mapping of ecological values in the Project Area to inform project planning and future assessment of project impacts. Calculation or assessment of impacts has not been considered.

1.2 Legislative context

1.2.1 Biodiversity Conservation Act 2016

The purpose of the NSW Biodiversity Conservation Act 2016 (BC Act) is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. The BC Act outlines the framework for addressing the impact on biodiversity from development and clearing.

This report comprises identification of values protected under the BC Act, but does not include impact assessment, such as tests of significance for the impact to threatened species and endangered ecological communities (EEC) in accordance with s7.3 of the Act.

1.2.2 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) provides the legal framework for the protection and management of nationally and internationally important flora, fauna, ecological communities, and heritage places; defined as matters of national environmental significance (MNES). In addition to identifying and protecting MNES, the EPBC Act also incorporates measures for the protection of Commonwealth-owned land, assessing the actions of Commonwealth agencies, and the protection of marine species. If any proposed actions are likely to result in a significant impact to MNES (as defined under the EPBC Act), the project must be referred to the Minister for the Environment for assessment and approval. This process requires the proponent to assess likely impacts to MNES (direct, indirect, cumulative and facilitated, as appropriate) and the range of avoidance, mitigation, or offset measures incorporated into the project that address these impacts.

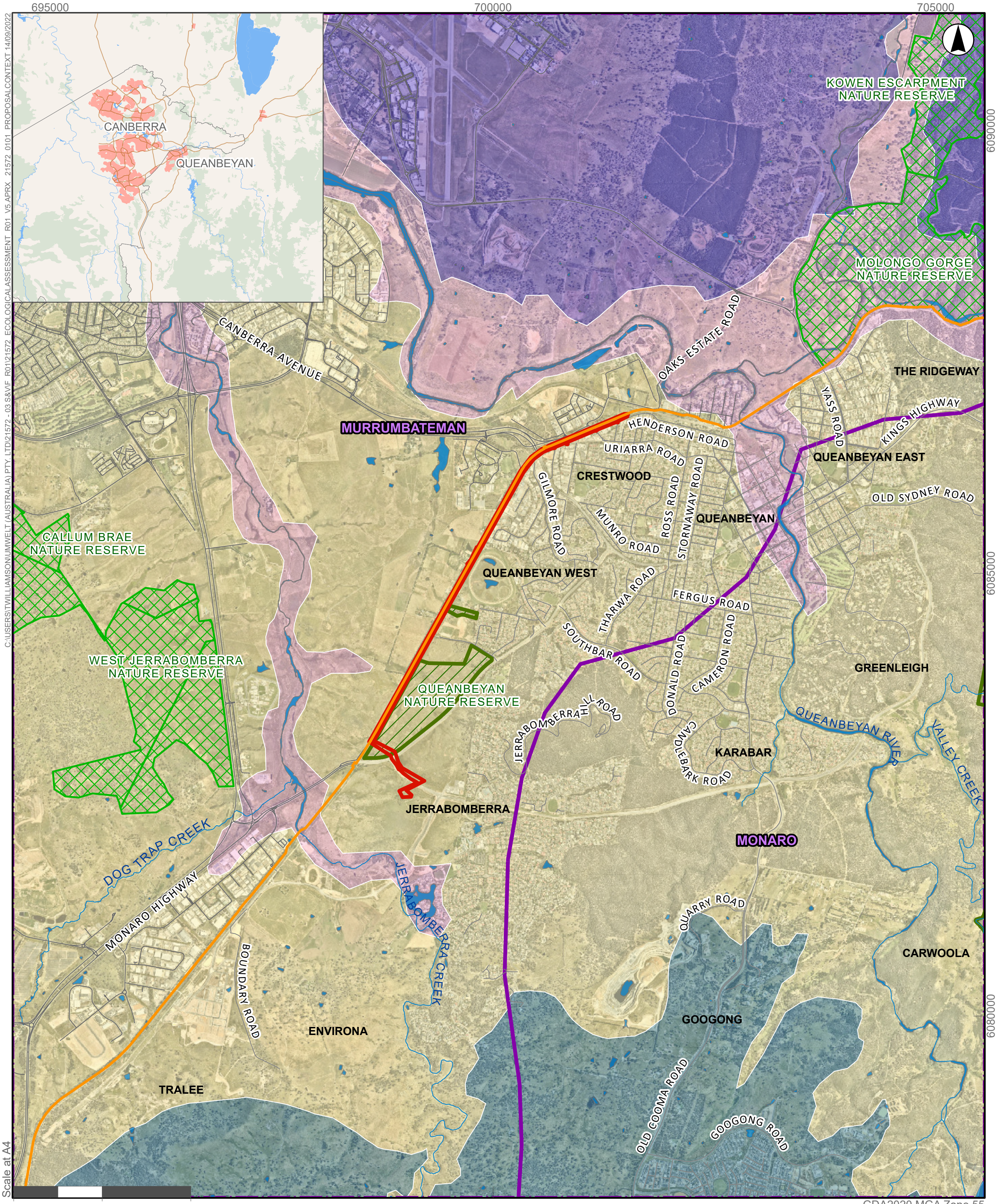
The EPBC Act was considered in this ecological assessment with regard to identifying the presence of threatened ecological communities or species and migratory species within the Project Area. Tests of significant are not included in this report.

1.2.3 NSW Biosecurity Act 2015

The NSW *Biosecurity Act 2015* requires any person who deals with any biosecurity matter, to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable. Biosecurity matters include weeds and pathogens. Weeds are managed in accordance with control regions. Within each of the regions are listed Priority Weeds. These Priority Weeds are allocated different measures based on their threat level.

1.2.4 ACT Legislative Context

The direct impacts of this project are expected to be located within NSW. This report does not consider impacts under the ACT Planning and Development Act or Nature Conservation Act, however threatened species habitats and ecological communities have been identified where they occur adjacent to the Project Area in the ACT.



C:\USERS\TWILLIAMSON\UMWELT (AUSTRALIA) PTY. LTD\21572 - 03 S&VF R01\21572 ECOLOGICALASSESSMENT R01 V5.APRX 21572 0101 PROPOSALCONTEXT 14/09/2022

Legend

- Roads
- Ibra-subregion
- Study Area
- ACT / NSW Boundary
- ACT Nature Reserves
- NSW NPWS Reserves

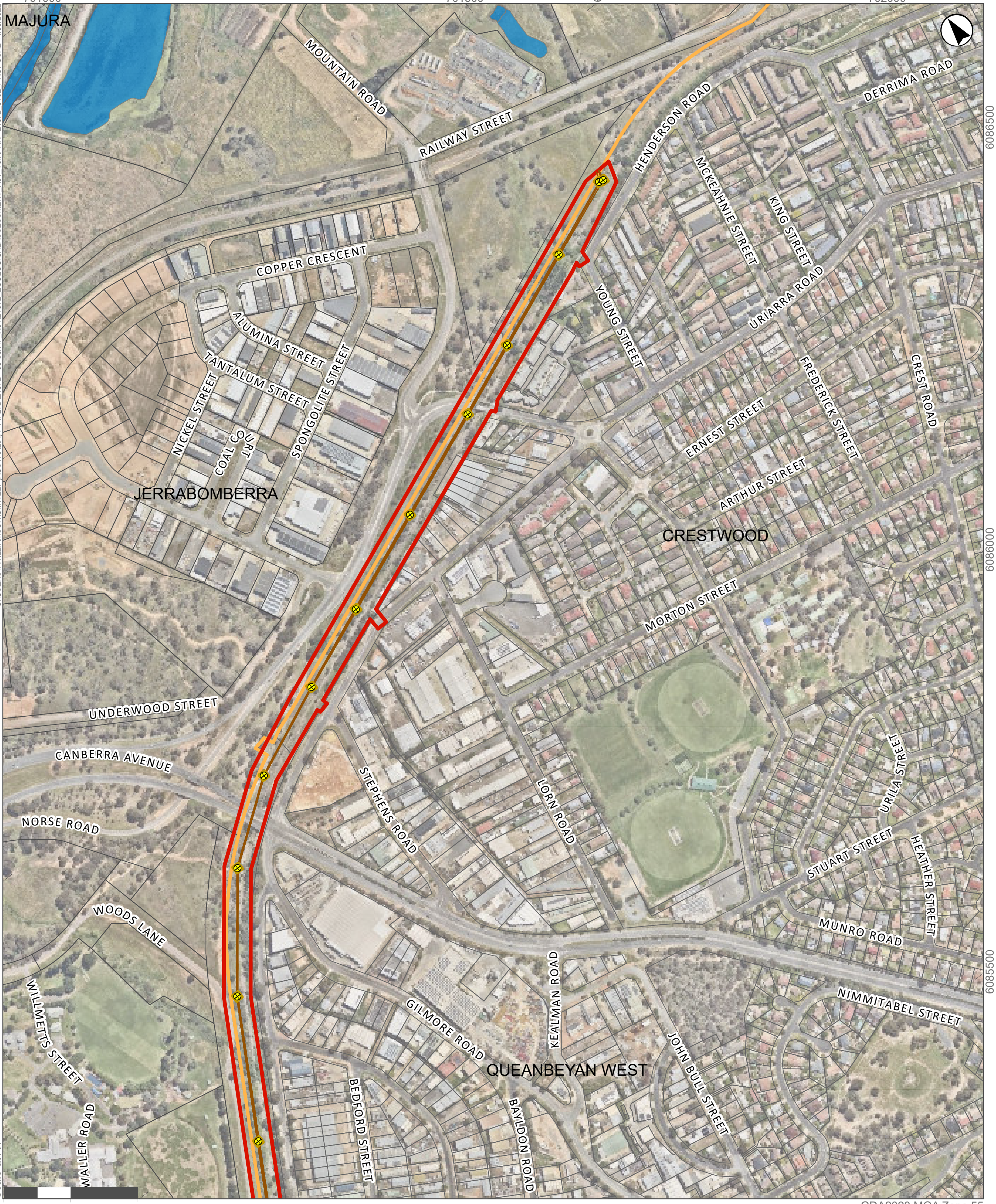
Mitchell Landscape

- Canberra Plains
- Dalton Hills
- Estuary/Water Added
- Molonglo Ranges
- Upper Murrumbidgee Channels and Floodplains

FIGURE 1.1

Proposal Context

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



C:\USERS\TWILLIAMSON\UMWELT (AUSTRALIA) PTY LTD\21572 - 03 S&VIF R01\21572 ECOLOGICAL ASSESSMENT R01 V5.APRX 21572_0102_PROPOSAL 14/09/2022

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)

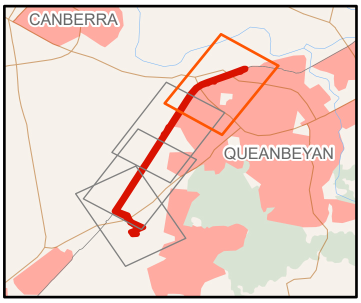


FIGURE 1.2-1

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend
- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

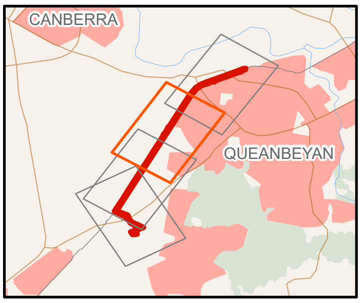


FIGURE 1.2-2

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

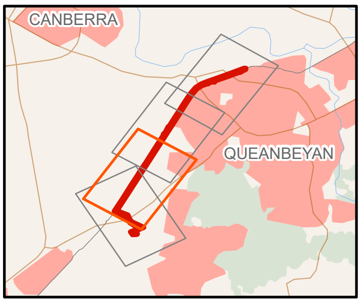
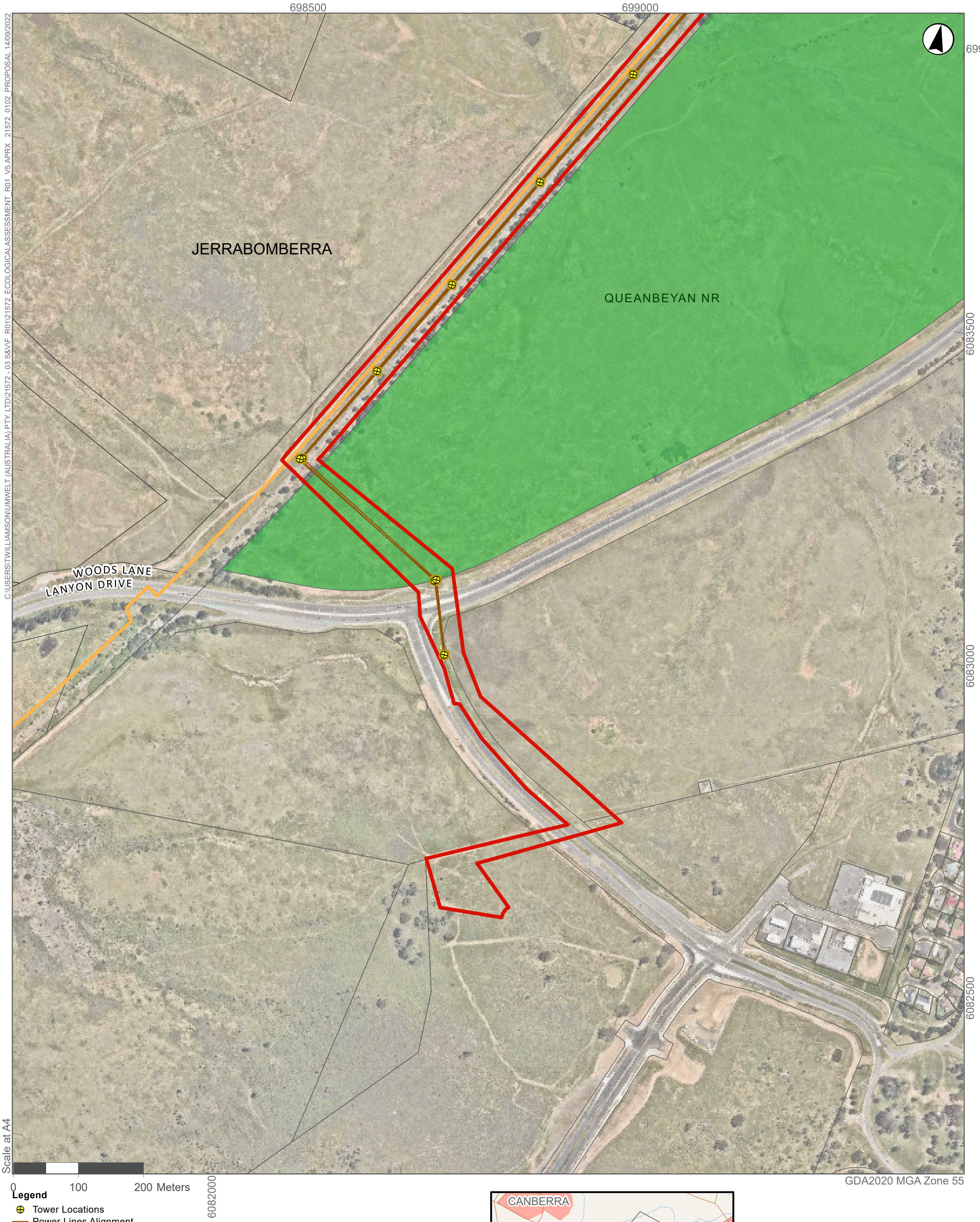


FIGURE 1.2-3

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend
- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

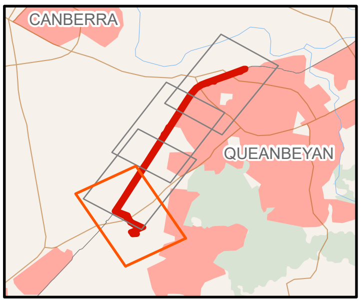


FIGURE 1.2-4

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

2.0 Methods

2.1 Desktop Assessment

A desktop assessment was conducted prior to the commencement of the field surveys. The objective of the desktop assessment was to gain an understanding of the presence or likelihood of occurrence of threatened species, populations, ecological communities and migratory species listed under the EPBC Act and / or the BC Act in the Project Area.

2.1.1 Literature Review

Previous ecological studies undertaken within or nearby to the Project Area were reviewed. The information obtained was used to assist in the assessment of potentially occurring threatened and migratory species, endangered populations and Threatened Ecological Communities (TECs) listed under the EPBC ACT and / or the BC Act. Relevant documents include:

- Overview of Potential Ecological Constraints: Oaks Estate ACT and Environa NSW (Umwelt Australia 2021).
- Poplars Innovation Precinct (Stage 1) Jerrabomberra, NSW. Biodiversity Development Assessment Report (Capital Ecology 2020).

2.1.2 Database Searches

A search of relevant databases was undertaken to obtain records of threatened species, endangered populations, and TECs listed under the EPBC Act and / or the BC Act previously recorded within 10 km of the Project Area. Database searches were also completed to obtain information on listed areas of ecological importance, key habitat features, vegetation communities and aquatic habitat. All current and preliminary listings under the BC Act, FM Act, and EPBC Act were considered. A summary of the sources interrogated is provided in **Table 2.1**.

Table 2.1 Databases reviewed for the desktop review

Database	Date Accessed	Search Area
NSW Planning and Environment (DPE) Datasets		
BioNet- the website for the Atlas of NSW Wildlife and Threatened Biodiversity Data Collection (TBDC) http://www.bionet.nsw.gov.au/	24 August 2022	10 km x 10 km
Vegetation information system (VIS) database http://www.environment.nsw.gov.au/NSWVCA20PRapp/LoginPR.aspx	3 November 2021	N/A
Vegetation Types Database: ***http://www.environment.nsw.gov.au/projects/BiometricTool.htm***	3 November 2021	N/A
Register of Declared Areas of Outstanding Biodiversity Value (AOBV)	9 February 2022	10 km buffer of the Project Area

Database	Date Accessed	Search Area
Biodiversity Values Map and Threshold Tool	9 February 2022	10 km buffer of the Project Area
NSW Department of Primary Industries (DPI) Datasets		
NSW DPI Fisheries Fish Records Viewer **https://www.dpi.nsw.gov.au/about-us/science-and-research/spatial-data-portal**	3 November 2021	10 km x 10 km
DPI's database for threatened aquatic species and communities **https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current**	3 November 2021	10 km x 10 km
Commonwealth Datasets		
The DoEE's Protected Matters Search Tool (PMST): **http://environment.gov.au/erin/ert/epbc/index.html**	11 August 2022	10 km x 10 km
DoEEs directory of important wetlands: **http://www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW**	3 November 2021	10 km x 10 km
Other NSW Datasets		
SEED datasets https://datasets.seed.nsw.gov.au	3 November 2021	10 km x 10 km
ACTmapi **https://www.actmapi.act.gov.au/home.html**	3 November 2021	1 km

2.1.3 Likelihood of Occurrence Assessment

The likelihood of occurrence of threatened species, populations and ecological communities listed under the EPBC Act and / or the BC Act in the Project Area was assessed against the criteria outlined in **Table 2.2**.

Table 2.2 Criteria used for assessing the likelihood of occurrence of listed species in the Project Area

Likelihood	Criteria
Recorded	The species was observed in the Project Area during the current field surveys.
High	Suitable habitat is present in the Project Area. Given the extent, quality and suitability of habitat in the Study Area, the location of the Project Area relative to existing contemporary records (past 20 yrs.) of the species (with consideration of sampling effort in the region and the species' detectability) it is highly likely that the species occurs in the Study Area. Also includes species likely to regularly occur in the Project Area during migratory, short-distance seasonal or nomadic movements.
Moderate	Potential or suitable habitat is present in the Study Area though given the species' status/the distribution of records in the surrounding region a moderate rating for likelihood of occurrence is deemed more appropriate than a low or high rating. Includes species that may be present or may occasionally utilise the Project Area but for which there may be little information or those that are

Likelihood	Criteria
	either cryptic or occur at low densities. Also includes species that may occasionally occur in the Study Area during migratory, short-distance seasonal or nomadic movements.
Low	The Project Area either contains no suitable habitat or potential/marginal habitat. The species is either very scarce or absent in the surrounding region in habitat similar to that present in the Study Area in the region. The species is deemed unlikely to occur in the Project Area based on the aforementioned factors. The species may disperse through or near the Project Area infrequently.
Nil	Potential habitat is absent from the Project Area and / or the species is a vagrant in the region.

2.2 Field Assessment

Field surveys were undertaken in the Project Area during September 2021. Field surveys comprised vegetation mapping, Biodiversity Assessment Method (BAM) vegetation integrity plots, opportunistic fauna and flora searches and threatened species habitat mapping. No targeted surveys for threatened species were conducted. A summary of the survey dates, type of surveys conducted, and weather conditions is provided in **Table 2.3.**

Table 2.3 Field surveys summary

Date	Survey type	Weather conditions
20 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 7.7 Maximum temperature (C°): 16.7 Rainfall (mm): 0 Wind at 9 am (km/hr): 33
21 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): -2.0 Maximum temperature (C°): 13.9 Rainfall (mm): 2.2 Wind at 9 am (km/hr): 7
22 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): -2.3 Maximum temperature (C°): 16.8 Rainfall (mm): 0 Wind at 9 am (km/hr): 6
23 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 2.6 Maximum temperature (C°): 19.5 Rainfall (mm): 0 Wind at 9 am (km/hr): 7
24 September 2021	Vegetation mapping, BAM vegetation integrity plots, opportunistic threatened species searches, habitat assessment	Minimum temperature (C°): 6.3 Maximum temperature (C°): 20.0 Rainfall (mm): 0 Wind at 9 am (km/hr): 31

2.2.1 Vegetation Assessment

Vegetation surveys were conducted in the Project Area during September 2021. Vegetation mapping and vegetation integrity assessments were completed in line with the BAM (DPIE 2022) (see Part 2 of the BAM).

2.2.1.1 Vegetation community mapping

Available vegetation mapping for the Proposal Area was reviewed in GIS. The vegetation within the Proposal Area and immediate surrounds were stratified into vegetation zones in accordance with the BAM (DPIE 2022) using a combination of:

- regional vegetation mapping previously prepared for the locality
- soil and topography mapping
- interpretation of aerial photographs.

Umwelt conducted site-specific vegetation surveys based on existing vegetation mapping for the Project Area. The vegetation within the Project Area was assessed to verify the condition and extent of each vegetation community. The Umwelt vegetation mapping process, based largely on that specified in the BAM (DPIE 2022), comprised:

- transects and traverses using a hand-held tablet containing ArcCollector to record boundaries of, and variation within, stratification units not apparent from aerial imagery
- collection of data from Rapid Mapping Points (RMP) to obtain information on vegetation community structure and distribution, to accurately assign stratification units to vegetation communities
- collection of plot and transect data in line with the BAM 2022 in the Project Area to assist in PCT allocation.

The RMP collection method was primarily used to inform assessment of the boundaries of vegetation types present in the Project Area. RMP survey effort was limited to collecting data on dominant species, including cover and abundance, within a 20 x 20 m quadrat. Incidental notes recording details on the presence of weeds, evidence of pests, pathogens, and disturbance regimes were also noted to justify condition class as required.

2.2.1.2 Plant community type (PCT) allocation

Each of the vegetation communities identified within the Project Area were aligned to an equivalent PCT as detailed in the VIS Classification Database (DoE 2022). For each vegetation community identified in the Project Area, the dominant and characteristic species were compared to those of possibly occurring PCTs. The profiles for each of the possible PCTs were then interrogated and the most appropriate PCT was assigned based on floristic, structure, soil, landform and distribution details. Vegetation communities were further stratified into vegetation zones based on relatively homogenous broad condition states.

2.2.1.3 Vegetation integrity assessment (BAM plots/transects)

Vegetation integrity plots were completed in accordance with the BAM (DPIE 2020a) to assist in PCT identification and permit calculation of vegetation integrity scores. Plot-based full floristic surveys were completed based on a nested 20 x 50 m quadrat layout, in line with Section 3.0 of the BAM (DPIE 2022).

Plots surveys were completed in September 2021. Plot data and locations were collected using ESRI Survey123 for Arc and location data was recorded with a general accuracy of ± 5 m.

A total of 10 vegetation integrity plots were conducted in the Project Area. Plot locations were determined by pacing within each vegetation zone at random with the collection of the data along the compass bearing that best fit within the vegetation zone. The floristic plot survey effort for each native vegetation zone is shown in **Table 2.4**. The location of floristic plots in each vegetation zone is shown in **Figure 2.1**.

During each plot survey approximately 45 to 60 minutes was spent searching for all vascular flora species present within each of the 20 x 20 m vegetation integrity plots. Searches of each 20 x 20 m plot were generally undertaken through parallel transects from one side of the plot to the other. The majority of the effort was spent on examining the groundcover, which typically supported the majority of species present. The composition of any shrub, mid-storey, canopy and emergent layers were also recorded.

For each flora species recorded in the vegetation integrity plot, the following data was collected in accordance with BAM (DPIE 2022):

- stratum/layer in which the species occurs
- growth form
- scientific name and common name
- cover
- abundance.

At each vegetation integrity plot the following attributes were also recorded in accordance with the BAM (DPIE 2022):

- Composition – native plant species richness by growth form (within the 20 x 20-metre plot).
- Structure – estimate foliage cover of native and exotic species by growth form (within the 20 x 20 m plot).
- Function – (within the 20 x 50 m plot) including the number of large trees, presence or otherwise of tree stem size classes, presence or otherwise of canopy species regeneration, length of fallen logs, percentage cover for litter (recorded from five 1 x 1 m plots), number of trees with hollows and high threat exotic plant cover.

2.3 Threatened Flora and Fauna Assessment

No targeted threatened flora or fauna surveys were conducted in the Project Area. 17 threatened / migratory fauna species and two threatened flora species listed under the EPBC Act and / or the BC Act were assessed as having a moderate or higher likelihood of occurrence in the Project Area (**Table 3.11 and Table 3.13**). Habitat assessments and mapping conducted in lieu of targeted surveys (**Section 2.3.1**) in accordance with the scope of works.

2.3.1 Habitat Assessments

Habitat assessments for threatened species identified as having a moderate or higher likelihood of occurring in the Project Area (barring species listed solely as migratory under the EPBC Act) were conducted in lieu of targeted surveys.

Flora habitat assessments included consideration of vegetation structure and floristics, edaphic conditions, fire history, and the presence of microhabitats such as creeklines, soaks and rock outcrops. Habitat structure and habitat degradation potentially influencing flora threatened species habitat mapping were recorded.

Fauna habitat assessments included consideration of important indicators of habitat condition and complexity including the occurrence of microhabitats such as tree hollows, fallen logs, bush rock and wetland areas such as creeks and soaks, and the presence of mistletoe and flowering trees for nectivorous bird species. Habitat assessments were completed on an ongoing basis in conjunction with other surveys, including PCT mapping and vegetation integrity assessment. Specific habitat assessments comprised:

- Identification of stick nests potentially utilised by threatened raptor species.
- Identification and assessment of potential roosting and breeding habitat for threatened microbats.
- Identification of potential breeding and foraging habitat for threatened woodland birds in the form of woodland, hollow-bearing trees, areas of regenerating woodland. Assessment of hollow-bearing trees comprised searching all trees in the Project Area from ground level for hollows. For each hollow-bearing tree the following data were recorded:
  - tree species
  - estimate of the diameter at breast height in centimetres
  - presence/absence of hollows in the following size classes
  - the abundance of hollows in the following size classes:
    - extra-small hollows <2.5 cm
    - small hollows 2.5–5 cm
    - medium hollows 5–10 cm
    - large hollows 10–30 cm
    - extra-large hollows >30 cm.
- Identification of native grassland which comprises potential or suitable grassland earless dragon (*Tympanocryptis pinguicolla*) habitat.
- Identification of native grassland and derived native grassland which comprises potential or suitable striped legless lizard (*Delma impar*) habitat.

- Identification of potentially suitable rocky habitat for pink-tailed worm-lizard (*Aprasia parapulchella*). Pink-tailed worm-lizard habitat in the Study Area was identified and mapped with reference to the habitat condition classes outlined in **Table 2.4**.
- Identification of natural temperate grassland and derived native grassland which comprises potential or suitable golden sun moth (*Synemon plana*) habitat. Golden sun moth habitat was assessed and mapped in accordance with criteria relating to habitat condition outlined in **Table 2.5**.

Table 2.4 Pink-tailed worm-lizard habitat condition categories (Wong and Osbourne 2010)

Habitat Condition	Description
High	Suitable rocky areas primarily dominated by kangaroo grass (*Themeda* australis) supporting a moderate to high diversity of native forbs and characterised by a moderate to high density of partially embedded rocks. Exotic annual species may be present.
Moderate	Suitable rocky areas primarily dominated by spear grasses (*Austrostipa spp*.) and wallaby grasses (*Rytidosperma spp*.) supporting native forbs and characterised by a moderate to high density of partially embedded rocks. Exotic annual species may be present.
Low	Suitable rocky areas that have been subject to high levels of disturbance in the recent past displaying high levels of disturbance to the soil layer or dominated by sown pasture grasses, other agronomic species and weeds; includes former sheep camps that no longer support native ground cover.

Table 2.5 Golden sun moth habitat condition categories and threshold criteria

Habitat Condition	Notes	Minimum Criteria
High Quality	Primary NTG or native pasture dominated by native larval food plants (i.e., *Rytidosperma sp*. and/or *Austrostipa sp*.), with low weed cover and some bare ground.	• >10 % cover *Rytidosperma sp.* • >15 % cover *Rytidosperma sp*. and *Austrostipa sp* combined • >5 % bare ground • <5% broadleaf • low to moderate biomass • moderate to high native plant diversity.
Moderate Quality	Primary or secondary grassland, with a moderate component of *Rytidosperma sp*. and/or *Austrostipa sp*., and/or moderate weed cover.	• >5 % cover *Rytidosperma sp.* • >10 % cover *Rytidosperma sp*. and/or *Austrostipa sp* combined • >3 % bare ground • <10% broadleaf • low to moderate biomass • moderate native plant diversity.
	OR	
	Native-dominated grassland with a high component of *Rytidosperma sp*. and/or *Austrostipa sp*., but less than High quality habitat because of one or more of the following conditions:	• on a steep slope or hilltop • on a south or east-facing slope • soil very shallow and/or stony, rock outcrops present • secondary grassland or contains scattered trees.

Habitat Condition	Notes	Minimum Criteria
Low Quality	Larval food plants (*Rytidosperma sp*., *Austrostipa sp*. and/or Chilean needle grass) are a minor component of the ground layer, growing sparsely or in patches among unsuitable vegetation such as:	• exotic species (excluding Chilean needle grass) • native C4 grasses (such as *Themeda triandra*.) • other unsuitable native ground cover (e.g., *Poa labillardieri*, rushes / sedges).
		AND
		• >10 % cover *Rytidosperma sp*. and/or *Austrostipa sp* combined • <20 % broadleaf.
	Grassland dominated by Chilean needle grass (*Nassella neesiana*)	• >50 % Chilean needle grass.

2.4 Threatened Ecological Community Assessment

2.4.1.1 Box-gum woodland

Following vegetation type identification and mapping, each of the vegetation zones identified as PCT 654 - Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion or PCT 1330 - Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion were assessed against the condition thresholds identified in the Commonwealth significant impact guidelines (DoEH 2006) to determine whether zones meet diagnostic criteria for White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, a critically endangered ecological community listed under the EPBC Act. The criteria for the EPBC listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ecological community is outlined in **Table 2.6**.

Each vegetation zone identified as PCT 654 - Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion or PCT 1330 - Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion was also assessed against criteria for classification as the BC Act listed White Box - Yellow Box – Blakely’s Red Gum Grassy Woodland critically endangered ecological community (DoECC 2007). In accordance with the identification guidelines, any areas of vegetation that; contain, or would have recently been likely to contain, white box, yellow box or Blakely’s red gum and support a ground layer that is mostly grassy are considered to constitute this listed ecological community. Further, areas of degraded woodland that meet the two aforementioned criteria that have the potential for assisted natural regeneration of the tree layer or the understory also constitute this listed ecological community.

Table 2.6 Criteria for the EPBC Act listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland Critically Endangered Ecological Community

Diagnostic Criteria and Condition Thresholds	
Is, or was previously, at least one of the most common overstorey species White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*), or Blakely's Red Gum (*Eucalyptus blakelyi*)? and,	
Does the patch have a predominantly native understorey? and either	
If the patch is 0.1 ha or greater in size:	Are there 12 or more native non-grass understorey species present? Is there at least one important species*?
If the patch is 2 ha or greater in size:	Does the patch have an average of 20 or more mature trees per hectare, or is there regeneration of the dominant over storey eucalypts

* Important species as defined in the Listing Advice (DoEH, 2006).

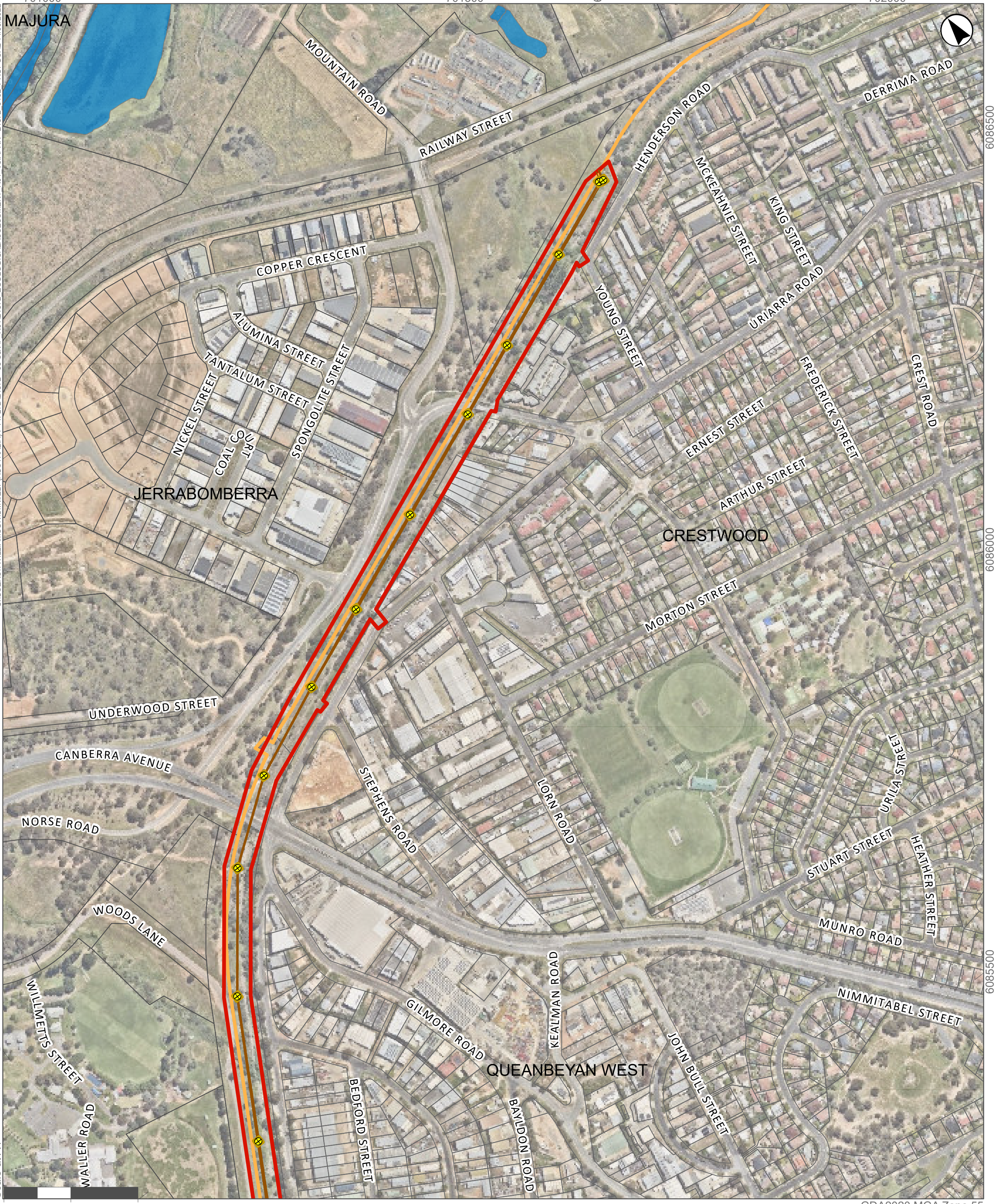
2.4.1.2 Natural temperate grassland

Following vegetation validation and mapping, each vegetation zone that was identified as PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion or PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion were assessed against the condition thresholds identified in the Commonwealth guidelines (DoEE 2016) (**Table 2.7**) to determine whether the zones meet criteria for inclusion in the EPBC Act listed Natural Temperate Grassland of the South Eastern Highlands critically endangered ecological community.
The assessment was undertaken during the field assessment (which was consistent with the favourable sampling time as required to assess the vegetation against the criteria) using the floristic and structural data collected in 20 x 20 m plots (i.e., vegetation integrity plots and rapid assessment points).

Table 2.7 Criteria for the EPBC listed Natural Temperate Grassland of the South-Eastern Highlands

High-Very High Condition Threshold	Moderate – High Condition Threshold	Native Pasture
Favourable sampling times: At least 12 non-grass native species **OR** At least 3 indicator species **OR**	Favourable sampling times: At least 8 non-grass native species **OR** At least 2 indicator species **OR** A FVS of at least 5	The patch lacks the minimum native understorey for classification as natural temperate grassland

High-Very High Condition Threshold	Moderate – High Condition Threshold	Native Pasture
A floristic value score (FVS) of at least 6.5	Characterised by at least 50% foliage cover of the ground of: *Themeda triandra* (Kangaroo Grass) OR *Poa labillardierei* (River Tussock Grass), (generally in flats and drainage lines where this vegetation type naturally occurs). **OR** *Carex bichenoviana* (a native sedge) (or at least 50 tussocks for every 100 m^2).	



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)

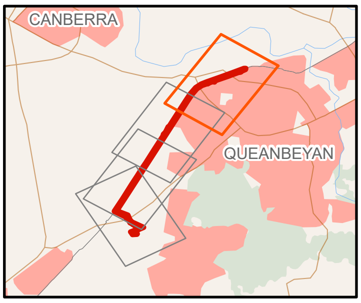


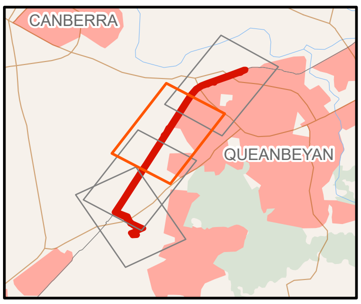
FIGURE 1.2-1

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves



umwelt

FIGURE 1.2-2

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

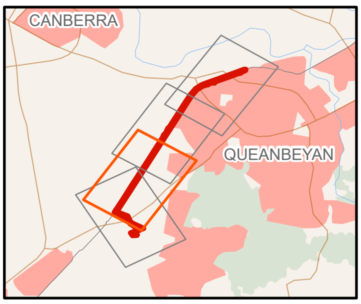


FIGURE 1.2-3

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

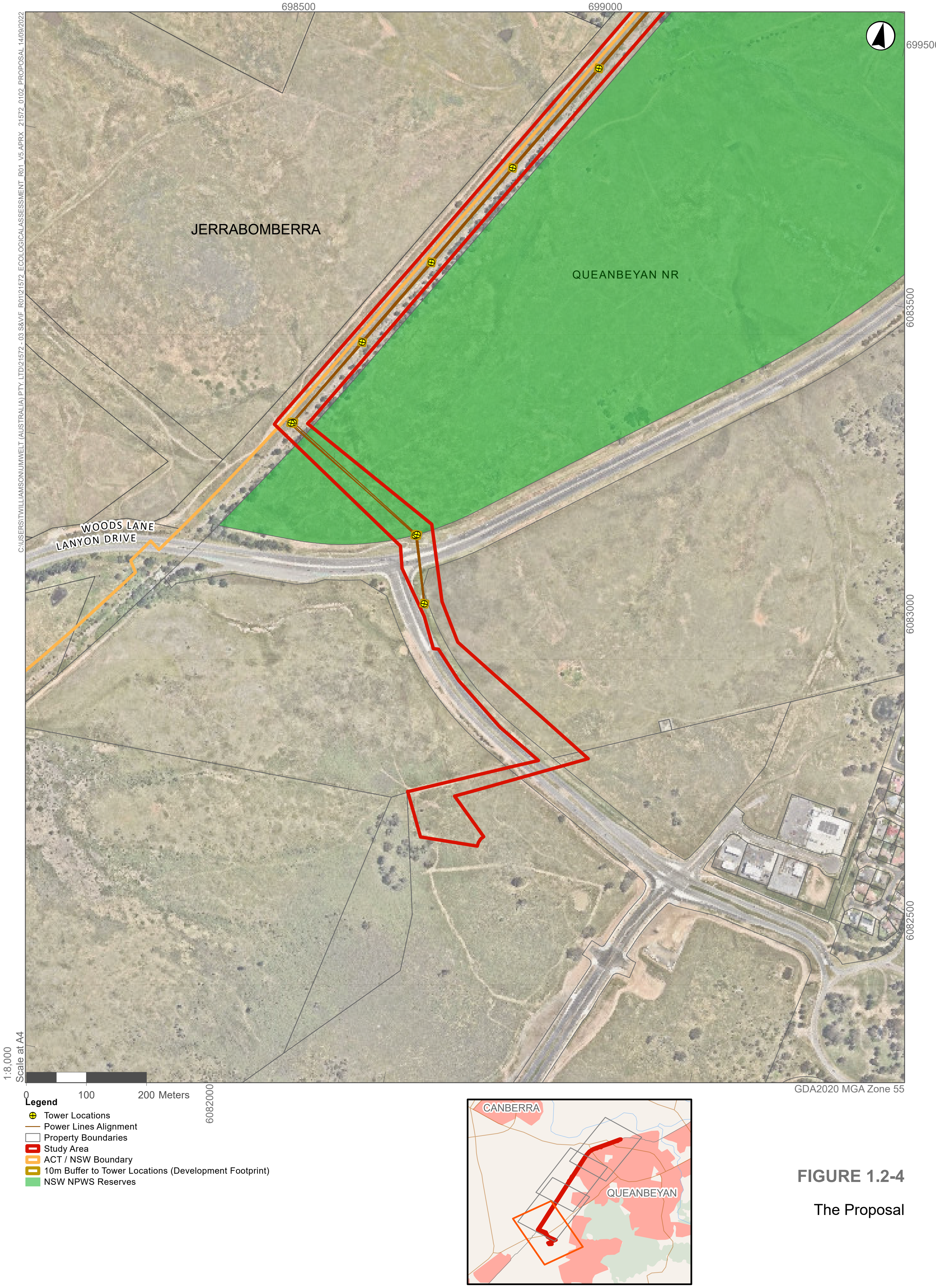


FIGURE 1.2-4

The Proposal

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

3.0 Existing Environment

3.1 Landscape Context

The landscape context of the Project Area is outlined in **Table 3.1**. The total Project Area assessed was 25.32 ha.

Table 3.1 Landscape attributes relevant to biodiversity in the Project Area

Landscape Features	
IBRA Bioregion	South Eastern Highlands.
IBRA Subregion	Murrumbateman.
Mitchell Landscape	Canberra Plains.
Land Tenure, Parks and Reserves	The Project Area is located between the Jerrabomberra East Grasslands Nature Reserve and the West Jerrabomberra Grasslands Nature Reserve. The majority of the landscape in the southern portion of the Project Area, to the east and west are state nature reserves.
Rivers, Streams, Estuaries	Jerrabomberra Creek crosses and the Molonglo River are located within 1 km of the Project Area.
Wetlands (within, adjacent to and downstream)	No wetlands or coastal environment areas are within the development footprint.
Total Project Area (ha)	25.32.
Cover Class	>70 per cent.
Areas of Geological Significance or Soil Hazard Features	No areas of geological significance have been identified in the Project Area. No area(s) of acid sulphate soil risk occur in the Project Area.
Connectivity	The Project Area is located between Jerrabomberra East Grasslands Nature Reserve and Queanbeyan Nature Reserve. Queanbeyan Nature Reserve is mapped as a biodiversity corridor in DPIE's *South East and Tablelands Region Plan Corridors* map (DPIE 2017).

3.2 Plant Community Types

Vegetation communities and zones present in the Project Area including candidate threatened ecological communities listed under the BC Act or EPBC Act are summarised in in **Table 3.2**. A map of the vegetation zones in the Project Area is provided in **Figure 2.1**.

The field survey and desktop assessment identified the following four native vegetation communities covering 11.09 ha in the Project Area:

- PCT 320: Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion

- PCT 654: Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion
- PCT 1289: Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion
- PCT 1330: Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion.

The remainder of the Project Area supported exotic vegetation, bare ground or infrastructure.

PCT 320 and PCT 1289 meet diagnostic criteria for the Natural Temperate Grassland of the South Eastern Highlands, a critically endangered ecological community (CEEC) listed under the EPBC Act. Assessment of associated vegetation zones against the condition thresholds is presented in **Section 3.3.1.1**.

PCT 654 and PCT 1330 meets diagnostic criteria for the White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland critically endangered ecological communities listed under the BC Act and EPBC Act. All associated vegetation conform to the BC Act CEEC. Assessment of associated vegetation zones against the condition thresholds for the nominated CEECs are presented in **Section 3.3.1.1** and **Section 3.3.1.3**.

Table 3.2 Vegetation communities mapped in the Project Area

Vegetation community	Veg zone	Candidate BC Act TEC	Candidate EPBC Act TEC	Area in Project Area (ha)
PCT 320: Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Low	Not listed	Natural Temperate Grassland of the South Eastern Highlands	0.49
	Moderate-high			2.60
PCT 654: Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion	Moderate-high	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)	White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands	0.21
PCT 1289: Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion	Low	Not listed	Natural Temperate Grassland of the South Eastern Highlands	3.16
	Moderate-high			0.92
PCT 1330: Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion	Low	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions	White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands	0.45
	Moderate-high			1.71
	DNG low			0.87
	DNG moderate-high			0.63
	Native Plantation			0.04
Exotic vegetation	Exotic	Not listed	Not listed	10.18
Bare	Bare	Not listed	Not listed	0.01
Infrastructure	Infrastructure	Not listed	Not listed	4.04
Total Area				**25.32**
Total (native vegetation)				**11.09**

3.2.1.1 PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion

A summary of PCT 320 in the Project Area is provided below and in **Table 3.3**. PCT 320 forms part of the KF_CH4 Grasslands vegetation formation and the Western Slopes Grasslands vegetation class. There are two vegetation zones assigned to PCT 320 in the Project Area, namely low (0.49 ha) and moderate-high (2.60 ha). PCT 320 occurs in the southern portion of the Project Area where it is associated with areas of natural temperate grassland.

PCT320 (moderate- high) is characterised by a kangaroo grass (*Themeda triandra*) and the diversity of native forb species typical of natural grasslands including natural temperate grassland indicator species, *Chrysocephalum apiculatum*, *Plantago varia*, *Goodenia pinnatifida*, *Vittadinia spp.* and *Wahlenbergia spp*. PCT 320 (moderate-high) in the Project Area generally contains a high cover of native forbs and grasses.

PCT 320 (low) typically supports a higher component of exotic grass species including *Avena spp*. and *Phalaris aquatica* however perennial exotic cover was lesser than perennial native cover. A moderate diversity of native non-grass species was present, including several natural temperate grassland indicator species.

Examples of the PCT across the two condition classes are shown in **Plate 3.1** and **Plate 3.2**.

Table 3.3 PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland description

PCT 320: Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion		
Vegetation formation	KF_CH4 Grasslands	
Vegetation class	Western Slopes Grasslands	
Conservation status	Occurrences of PCT 320 in both moderate-high and low condition in the Project Area meet diagnostic criteria and condition thresholds for the Natural Temperate Grassland of the South Eastern Highlands CEEC listed under the EPBC Act. See **Section 3.3.1.1** for further assessment of these vegetation zones against the relevant classification criteria.	
Estimate of percent cleared	96 (%) (DPIE 2021)	
Dominant characteristic native species recorded		
Upper stratum	-	
Middle stratum	Urn heath (*Melichrus urceloatus*)	
Ground stratum	Kangaroo grass (*Themeda triandra*), hairy panic (*Panicum effusum*), *Rytidosperma* spp., snow grass (*Poa siberiana*), *Juncus* spp., *Vittadinia cuneata,* fluke bogrush (*Schoenus apogon*), *Pimelea* spp., common everlasting (*Chrysocephalum apiculatum*), *Plantago varia, Wahlenbergia* spp., *Dianella revoluta, Geranium* spp., *Euchiton spp., rock fern (Cheilanthes sieberia).*	
Vegetation zones	**Low**	**Moderate - high**
Extent in Project Area (ha)	0.49	2.60
Total number of plots conducted	1 (P_20211119_003)	1 (P_20211029_001)

Plate 3.1. PCT 320 Moderate - high

Plate 3.2. PCT 320 Low

3.2.1.2 PCT 654 Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion

A summary of PCT 654 in the Project Area is provided in **Table 3.4**. PCT 654 forms part of the KF_CH3 Grassy Woodlands vegetation formation and the Southern Tablelands Grassy Woodlands vegetation class as specified in the BioNet Vegetation Classification System. PCT 654 comprising one vegetation zone (moderate-high) is present in the Project Area (0.43 hectares). PCT 654 was mapped within a portion of the woodland adjacent Norse Road in the northern section of the Project Area. The PCT is shown in **Plate 3.3**.

PCT 654 in the Project Area is characterised by an overstorey dominated by apple box (*Eucalyptus bridgesiana*) with a midstorey consisting of *Acacia spp*. and exotic trees such as *Prunus cerasifera* and *Cotoneaster pannosus*. The groundcover is dominated by native grasses and grass-like species including kangaroo grass (*Themeda triandra*), *Rytidosperma* spp., *Austrostipa scabra* and *Lomandra* spp. A moderate to low diversity of native forbs were present. Introduced groundcover species were also common such as Phalaris (*Phalaris aquatica*), cocksfoot (*Dactylis glomerata*) and St John's Wort (*Hypericum perforatum*).

Table 3.4 PCT 654: Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion description

PCT 654: Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion	
Vegetation formation	KF_CH3 Grassy Woodlands
Vegetation class	Southern Tablelands Grassy Woodlands
Conservation status	All occurrences of PCT (moderate-high) in the Project Area meet condition criteria and diagnostic thresholds (where applicable) for: • White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions, a CEEC listed under the BC Act). See **Section 3.3.1.1** for assessment of this vegetation zone against the relevant classification criteria. • White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands, a CEEC listed under the EPBC Act). See **Section 3.3.1.3** for assessment of this vegetation zone against the relevant classification criteria.
Estimate of percent cleared	95 (%) (DPIE 2021)
Dominant characteristic native species recorded	
Upper stratum	Apple box (*Eucalyptus bridgesiana*).
Middle stratum	*Acacia* spp.
Ground stratum	kangaroo grass (*Themeda triandra*), *Rytidosperma* spp., *Austrostipa scabra*, *Lomandra* spp., *Oxalis perannans*, *Wahlenbergia communis* (Blue bell), Rock fern (*Cheilanthes sieberi*).
Vegetation zones	**Moderate - high**
Extent in Project Area (ha)	0.21
Total number of plots conducted	1 (P_20211123_001)

Plate 3.3. PCT 654 Moderate - good

3.2.1.3 PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion

A summary of PCT 1289 in the Project Area is provided in **Table 3.5**. PCT 1289 forms part of the KF_CH4 Grassy Woodlands vegetation formation and the Temperate Montane Grasslands vegetation class as specified in the BioNet Vegetation Classification System. All areas of PCT 1289 are located in the southern portion of the Project Area. An example of the PCT is shown in **Plate 3.4**. PCT 1289 was classified into two vegetation zones, low condition (3.16 hectares) and moderate-high condition (0.92 hectares).

PCT 1289 is characterised by natural grassland dominated by wallaby grasses (*Rytidosperma spp*.) and spear grasses (*Austrostipa spp*.). PCT 1289 (moderate-high) in the Project Area has a diverse assemblage of native forbs typically consisting of *Chrysocephalum apiculatum*, *Triptilodiscus pygmaeus*, *Goodenia pinnatifida* and *Convolvulus angustissimus* and has high floristic diversity. PCT 1289 (low) is dominated by the same grass species as the moderate-high vegetation zone, however it lacks a diversity of native forbs and often contains a large component of exotic annual and perennial grasses such as *Avena spp*. and *Phalaris aquatica*.

Table 3.5 PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland description

PCT 320: Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion		
Vegetation formation	KF_CH4 Grasslands.	
Vegetation class	Temperate Montane Grasslands.	
Conservation status	All occurrences of PCT 1289 (moderate-high) in the Project Area constitute Natural Temperate Grassland of the South Eastern Highlands, a CEEC listed under the EPBC Act. See **Section 3.3.1.1** for assessment of this vegetation zone against the relevant classification criteria. Occurrences of PCT 1289 (low) in the Project Area do not meet condition thresholds for the Natural Temperate Grassland of the South Eastern Highlands CEEC listed under the EPBC Act. See **Section 3.3.1.1** for assessment of this vegetation zone against the relevant classification criteria.	
Estimate of percent cleared	57 (%) (DPIE 2021)	
Dominant characteristic native species recorded		
Upper stratum	-	
Middle stratum	-	
Ground stratum	*Rytidosperma* spp., *Austrostipa* spp., red grass (*Bothriochloa macra*), *Lomandra* spp., common everlasting (*Chrysocephalum apiculatum*), scrambled eggs (*Goodenia pinnatifida*), common sunray (*Triptilodiscus pygmaeus*), *Wahlenbergia* spp., rock fern (*Cheilanthes sieberi*)	
Vegetation zones	**Low**	**Moderate - high**
Extent in Project Area (ha)	3.16	0.92
Total number of plots conducted	1 (P_20211119_002)	1 (P_20211119_001)

Plate 3.4. PCT 1289 Moderate to Good

3.2.1.4 PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion

A summary of PCT 1330 in the Project Area is provided in **Table 3.6**. PCT 1330 forms part of the KF_CH3 Grassy Woodlands vegetation formation and the Southern Tablelands Grassy Woodlands vegetation class. Five vegetation zones associated with PCT 1330 is present in the Project Area. Examples of PCT 1330 across the two condition classes present in the Project Area (i.e., 'moderate – good' and 'DNG – moderate – good') are shown in **Plate 3.5** and **Plate 3.6** respectively.

Areas of PCT 1330 (low) and PCT 1330 (moderate-high) are characterised by an overstorey dominated by Blakely's red gum (*Eucalyptus blakelyi*) and yellow box (*Eucalyptus melliodora*). The midstorey in all zones is generally sparse, often lacking shrubs but containS *Eucalypt* regrowth and some *Acacia spp*. In areas of PCT 1330 (moderate – high), PCT 1330 (DNG – moderate – high) and PCT1330 (native plantation) the ground cover is dominated by kangaroo grass (*Themeda triandra*), *Austrostipa spp*. and *Rytidosperma spp*., and contains a high diversity of forbs consisting of species such as hoary sunray (*Leucochrysum albicans var. tricolor*), *Goodenia pinnatifida*, *Wahlenbergia spp*., *Vittadinia spp*., common everlasting (*Chrysocephalum apiculatum*) and common sunray (*Triptilodiscus pygmaeus*). Areas of PCT 1330 (low) and (DNG – low) are characterised by a ground cover layer that lacks many of the characteristic forb species and is instead dominated by exotic grass species including *Avena spp*., *Dactylis glomerata* and *Phalaris aquatica*.

A stand of planted southern blue gum (*Eucalyptus bicostata*) is present in the northern section of the Project Area adjacent Norse Road. A mixed assemblage of native and exotic groundcover species was recorded. Native groundcover species present include kangaroo grass (*Themeda triandra*), *Austrostipa* spp. and diverse forbs including the threatened hoary sunray (*Leucochrysum albicans* var. *tricolor*), consistent with the area being derived from box – gum woodland grassy woodland.

Table 3.6 PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion description

PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion					
Vegetation formation	KF_CH3 Grassy Woodlands				
Vegetation class	Southern Tablelands Grassy Woodland				
Conservation status	All occurrences of PCT 1330 (moderate – high, low, DNG moderate – high and DNG low, and native plantation) constitute White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions, a CEEC listed under the BC Act. See **Section 3.3.1.1** for assessment of this vegetation zone against the relevant classification criteria. All occurrences of PCT 1330 (moderate – high quality) and PCT1330 (native plantation) present in the Project Area conform with classification criteria for White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands, a CEEC listed under the EPBC Act. Due to patch size and connectivity restrictions, not all patches of the remaining zones meet. A total of 3/6 occurrences of PCT 1330 (low quality), 6/8 occurrences of PCT 1330 (DNG moderate – high quality) and 3/5 occurrences of PCT 1330 (DNG low quality) present in the Project Area also conform with classification criteria for White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands listed under the EPBC Act. See **Section 3.3.1.3** for assessment of these vegetation zones associated with PCTs 654 and 1330 against the relevant classification criteria.				
Estimate of percent cleared	94 (%) (DPIE 2021)				
Dominant characteristic native species recorded					
Upper stratum	Blakely's red gum (*Eucalyptus blakelyi*), apple box (*Eucalyptus bridgesiana*)				
Middle stratum	Not present				
Ground stratum	kangaroo grass *(Themeda triamdra), weeping grass (Microlaena stipoides), red grass (Bothriochloa macra), Gonocarpus tetragynus, stinking pennywort (Hydrocotyle laxiflora)*				
Vegetation zones	**Low**	**Moderate - high**	**DNG - low**	**DNG Moderate - high**	**Native Plantation**
Extent in Project Area (ha)	0.45	1.50	0.87	0.63	0.04
Total number of plots conducted	1 (20211119_004)	1 (21211028_001)	1 (20211119_005)	1 (20211123_002)	1 (20211028_002)

Plate 3.5. PCT 1330 Moderate to Good

Plate 3.6. PCT 1330 Moderate - good DNG

3.2.1.5 Exotic vegetation

A summary of exotic vegetation in the Project Area is provided in **Table 3.7**. Exotic vegetation is the most widely distributed vegetation type in the Project Area (10.18 ha). Occurrences of this vegetation type primarily consists of an exotic grassland dominated by Phalaris (*Phalaris aquatica*), *Avena* spp., african love grass (*Eragrostis curvula*) and tall fescue (*Festuca arundinacea*). Exotic shrubs and trees such as blackberry (*Rubus fruticosus* spp. agg), *Cotoneaster* spp., radiata pine (*Pinus radiata*) and white poplar (*Populus alba*) were also common.

Table 3.7 Exotic vegetation description

Exotic vegetation	
Vegetation formation	NA
Vegetation class	NA
Conservation status	NA
Estimate of percent cleared	NA
Dominant characteristic native species recorded	
Upper stratum	radiata pine (Pinus radiata), white poplar (Populus alba)
Middle stratum	blackberry (*Rubus fruticosus* spp. agg.), *Cotoneaster* spp.
Ground stratum	Phalaris (*Phalaris aquatica*), Avena spp., african love grass (*Eragrostis curvula*), tall fescue (*Festuca arundinacea*)
Vegetation zones	
Extent in Project Area (ha)	10.18
Total number of plots conducted	0

3.3 Threatened Ecological Communities

Preliminary review of candidate threatened ecological communities identified one threatened ecological community listed under the BC Act as potentially occurring in the project area, the White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions Natural Temperate Grassland of the South Eastern Highlands, critically endangered ecological community. **Table 3.2** shows the potential PCTs that are candidates for this BC Act listed critically endangered ecological community. Consideration of vegetation zones against diagnostic criteria for this ecological community is presented in **Section 3.3.1.1**. The distribution of vegetation meeting diagnostic criteria for the critically endangered ecological community is listed in **Figure 3.1.**

Preliminary review of candidate threatened ecological communities identified two communities listed under the EPBC Act as potentially occurring in the Project Area:

- White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands, a critically endangered ecological community listed under the EPBC Act
- Natural Temperate Grassland of the South Eastern Highlands, a critically endangered ecological community listed under the EPBC Act.

Table 3.2 shows the potential PCTs that are candidates for each of the above EPBC Act listed critically endangered ecological communities, and final areas determined to meet. Assessment of vegetation zones that meet diagnostic criteria for the Natural Temperate Grassland of the South Eastern Highlands critically endangered community are assessed against condition thresholds for EPBC Act listed classification criteria is presented in **Table 3.9**. Assessment of vegetation zones that meet diagnostic criteria for against EPBC Act listed White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands classification criteria is presented in **Table 3.10**. The distribution of vegetation meeting diagnostic criteria and condition thresholds for threatened ecological communities listed under the EPBC Act is shown in **Figure 3.2** respectively.

Table 3.8 Threatened Ecological Communities associated with PCTs in the Project Area

TEC	PCT	Area (ha) that meets condition thresholds and diagnostic criteria
Natural Temperate Grassland of the South Eastern Highlands (critically endangered EPBC Act)	PCT 320 PCT 1289	3.90
White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands (critically endangered EPBC Act)	PCT 654 PCT 1330	2.76
White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)	PCT 654 PCT1330	3.05

3.3.1.1 White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)

White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (from here on in referred to as 'Box-gum woodland' (BC Act) is a TEC that was historically common across the NSW tablelands and western slopes. The distribution of this TEC has been significantly reduced and fragmented primarily due to agricultural practices. Most remnants now occur in lower parts of the landscape where soil fertility is higher compared to the surrounding landscape (DPIE 2020).

Box Gum Woodland can occur as an open woodland or as a derived native grassland where the canopy stratum has been removed and the native groundcover remains. The canopy assemblage is dominated by either white box (*Eucalyptus albens*), yellow box (*E. melliodora*) or Blakely's red gum (*E. blakelyi*). Other eucalypt species such as apple box (*E. bridgesiana*) and grey box (*E. microcarpa*) can occur. A diverse assemblage of groundcover species is characteristic of this TEC (the sub-layer if usually sparse) including species such as kangaroo grass (*Themeda triandra*), *Rytidosperma* spp., *Poa* spp., *Austrostipa* spp., common everlasting (*Chrysocephalum apiculatum*), small St John's wort (*Hypericum gramineum*) and *Wahlenbergia* spp.

Due to the absence of condition thresholds for NSW BC Act listed threatened ecological communities, all vegetation zones conforming to PCT 654 and PCT 1330 conform to the threatened ecological community. The following justification outlines how these PCTs conform:

- Location – The Project Area occurs in the South Eastern Highlands IBRA region and in the Murrumbateman IBRA subregion.

- Species assemblage – The mapped occurrences of PCT 654 and PCT 1330 within the Project Area support species characteristic of this TEC such as Blakely's red gum (*Eucalyptus blakelyi*), yellow box (*Eucalyptus melliodora*), apple box (*Eucalyptus bridgesiana*), kangaroo grass (*Themeda triandra*), weeping grass (*Microlaena stipoides*) and red grass (*Bothriochloa macra*). Derived native grasslands have a groundstorey supporting a higher proportion of perennial native species than exotic species.

- Vegetation structure – The mapped extents of PCT 654 and PCT 1330 occur as open woodlands or derived native grasslands.

- Soils – The soils supporting the mapped extents of PCT 320 and PCT 1289 are predominantly from the Williamsdale soil group. This soil group is derived from volcanic and igneous origins and includes some small areas of shale and limestone (Jenkins 2000).

3.3.1.2 Natural Temperate Grassland of the South Eastern Highlands (critically endangered EPBC Act)

Natural Temperate Grassland of the South Eastern Highlands (from herein referred to as Natural Temperate Grassland) occurs in the Monaro region, around Canberra, Bungendore, Gundary and the Yass Plains. Smaller patches have also been recorded around Crookwell and, the Upper Shoalhaven River, near Tumut and around Khancoban. Natural Temperate Grassland occurs at altitudes from 250 m to 1200 m at a variety of topographic positions. This TEC has been recorded on soils derived from granites, basalts, sedimentary rocks, colluvium and alluvium (DoE 2016).

Natural Temperate Grassland is a treeless to sparsely treed community characterised by an abundance of native tussock grasses (for example *Themeda triandra*, *Poa* spp. and *Rytidosperma* spp.). A shorter sub-stratum of herbs, forbs, sedges and rushes is usually present. Commonly recorded sub-stratum species include common everlasting (*Chrysocephalum apiculatum*), sheep's burr (*Acaena ovina*), cudweeds (*Euchiton* spp.), *Lomandra* spp. and *Plantago varia*. Variation in the composition of these stratum is dependent on drainage patterns, soil type and past agricultural practices. Given the overlap of several species between derived native grassland and Natural Temperate Grassland TECs, indicative mapping of the pre-1750s extent of Natural Temperate Grassland (**Figure 3.3**) was consulted during the site assessment to assist with delineating the boundary of the Natural Temperate Grassland TEC.

Within the Project Area, PCT 320 and PCT 1289 meet diagnostic criteria for the critically endangered ecological community:

- Location – The Project Area occurs in the South Eastern Highlands IBRA region and in the Murrumbateman IBRA subregion.
- Species assemblage – The mapped occurrences of PCT 320 and PCT 1289 within the Project Area support grass species characteristic of this TEC such as kangaroo grass (*Themeda triandra*), *Poa* spp., *Rytidosperma* spp., reg grass (*Bothriochloa macra*), and *Austrostipa* spp. Characteristic herb and forb species were also recorded in both PCTs including common everlasting (*Chrysocephalum apiculatum*), *Lomandra* spp. *Plantago varia* and *Wahlenbergia* spp.
- Vegetation structure – The mapped extents of PCT 320 and PCT 1289 occur as grassland within or near the modelled pre-1750s grassland extent (**Figure 3.3**). Trees are absent or isolated.
- Soils – The soils supporting the mapped extents of PCT 320 and PCT 1289 are predominantly from the Williamsdale soil group. This soil group is derived from volcanic and igneous origins and includes some small areas of shale and limestone (Jenkins 2000).

Condition thresholds are met for PCT 320 in moderate-high and low condition and PCT 1289 in moderate-high condition as specified in **Table 3.9**. PCT1289 in low condition did not support sufficient forb diversity to meet condition thresholds for the CEEC.

Table 3.9 Assessment against EPBC Act Natural Temperate Grasslands of the South Eastern Highlands community classification criteria

Condition threshold	PCT 1289 – Low	PCT 1289 – Moderate - high	PCT 320 – Low	PCT 320 – Moderate - high
Method A				
Is the patch at least 0.1 ha in size?	Yes	Yes	Yes	Yes
Is the patch characterised by at least 50% foliage cover of the ground of: If no, then proceed to assessment under the 'Minimum Condition Threshold – Method B'.				
Kangaroo Grass;	No	No	No	Yes
River tussock; or	No	No	No	No
Carex bichenoviana?	No	No	No	No
Method B				
Is the patch at least 0.1 ha in size?	Yes	Yes	Yes	Yes
Is the cover of native plants greater than the cover of perennial exotic plants?	Yes	Yes	Yes	Yes
In sampling plots of 0.04 ha in size (i.e. 20 m X 20 m) surveyed during non-favourable sampling times:				
• at least 4 native non-grass species recorded; or	N/A	N/A	N/A	N/A
• at least 1 indicator species; or	N/A	N/A	N/A	N/A
• a floristic value score of at least 3.	N/A	N/A	N/A	N/A
In sampling plots of 0.04 ha in size (i.e., 20 m X 20 m) surveyed during favourable sampling times:				
at least 8 native non-grass species recorded; or	No (5)	Yes (19)	Yes (10)	Yes (19)
at least 2 indicator species; or	No (0)	Yes (8)	Yes (5)	Yes (18)
a floristic value score of at least 5.	No (2.74)	Yes (32.89)	Yes (13.58)	Yes (50.24)
EPBC Act Natural Temperate Grassland of the South Eastern Highlands	**No**	**Yes**	**Yes**	**Yes**

3.3.1.3 White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands (critically endangered EPBC Act)

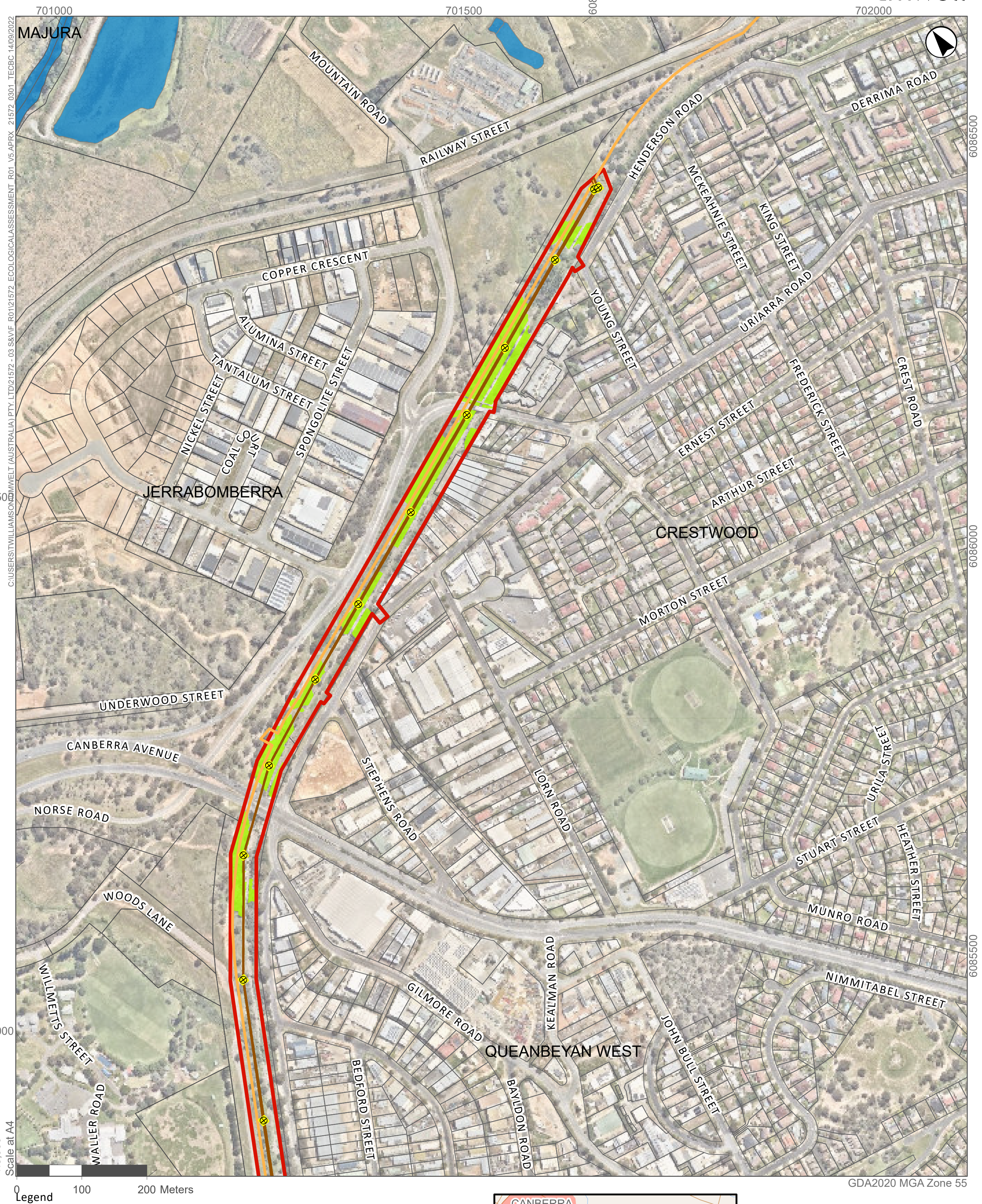
White Box - Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands is similar to the BC Act listed Box Gum Woodland as they both have (and had) similar distributions, they both have similar species assemblages, they both occur as open woodlands and can both occur as derived native grasslands. **Table 3.10** provides an assessment against condition thresholds for the White Box - Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands. All areas PCT 654 and selected patches of PCT 1330 conform to Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands. There is 2.86 hectares of this TEC in the Project Area, the distribution of which is shown in **Figure 3.1**.

Table 3.10 Assessment against EPBC Act listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland condition criteria

Criteria	Plot in PCT 654 (moderate- high)	Plot in 1330 (moderate – high)	Plot in 1330 (DNG moderate – high)	Plot in 1330 (low)	Plot in 1330 (DNG – low)	Plot in 1330 (native plantation)
Is, or was previously, at least one of the most common overstorey species white box, yellow box, or Blakely's red gum?	Yes	Yes	Yes	Yes	Yes	Yes
Does the patch have a predominantly native understorey?	Yes	Yes	Yes	Yes	Yes	Yes
If the patch 0.1 ha or greater in size.						
• Are there 12 or more native non-grass understorey species present? Is there at least one important species?	No	Yes	No	No	No	Yes
If the patch is 2 ha or greater in size:						
Does the patch have an average of 20 or more mature trees per hectare, or is there natural regeneration of the dominant over storey eucalypts.	No	No	No	No	No	No
Are occurrences of this zone part of a continuous area part of which meets the above criteria, comprising the larger of: ○ An area that contains five or more trees in which no tree is greater than 75 m from another tree, or ○ The area over which the understorey is predominantly native	Yes, all occurrences are part of continuous patch connected to areas of high diversity that meet the above criteria	Yes, all occurrences are part of continuous patch connected to areas of high diversity that meet the above criteria	Yes. Selected occurrences conforms where part of a continuous patch connected to areas of high diversity Only connected patches meet criteria	Yes. Selected occurrences conforms where part of a continuous patch connected to areas of high diversity Only connected patches meet criteria	Yes. Selected occurrences conforms where part of a continuous patch connected to areas of high diversity Only connected patches meet criteria	Yes, all occurrences are part of continuous patch connected to areas of high diversity that meet the above criteria

Criteria	Plot in PCT 654 (moderate- high)	Plot in 1330 (moderate – high)	Plot in 1330 (DNG moderate – high)	Plot in 1330 (low)	Plot in 1330 (DNG – low)	Plot in 1330 (native plantation)
EPBC Act listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Yes, all occurrences	Yes, all occurrences	Yes, selected occurrences where part of a larger patch Only connected patches meet criteria	Yes, selected occurrences where part of a larger patch Only connected patches meet criteria	Yes, selected occurrences where part of a larger patch Only connected patches meet criteria	Yes, all occurrences

umwelt



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)

Threatened Ecological Communities

- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)

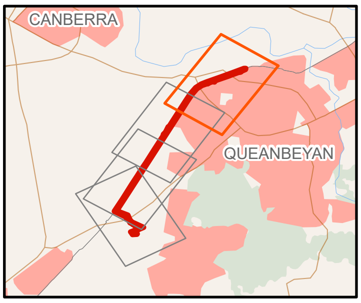


FIGURE 3.1-1

Distribution of BC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

Threatened Ecological Communities

- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)

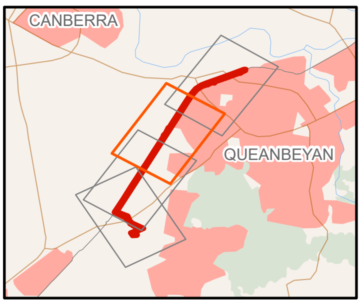


FIGURE 3.1-2

Distribution of BC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

Threatened Ecological Communities

- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions (critically endangered BC Act)

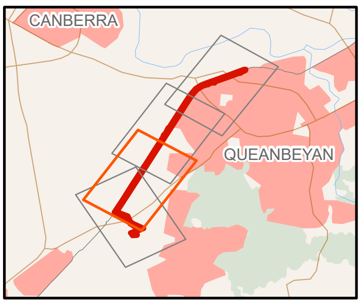
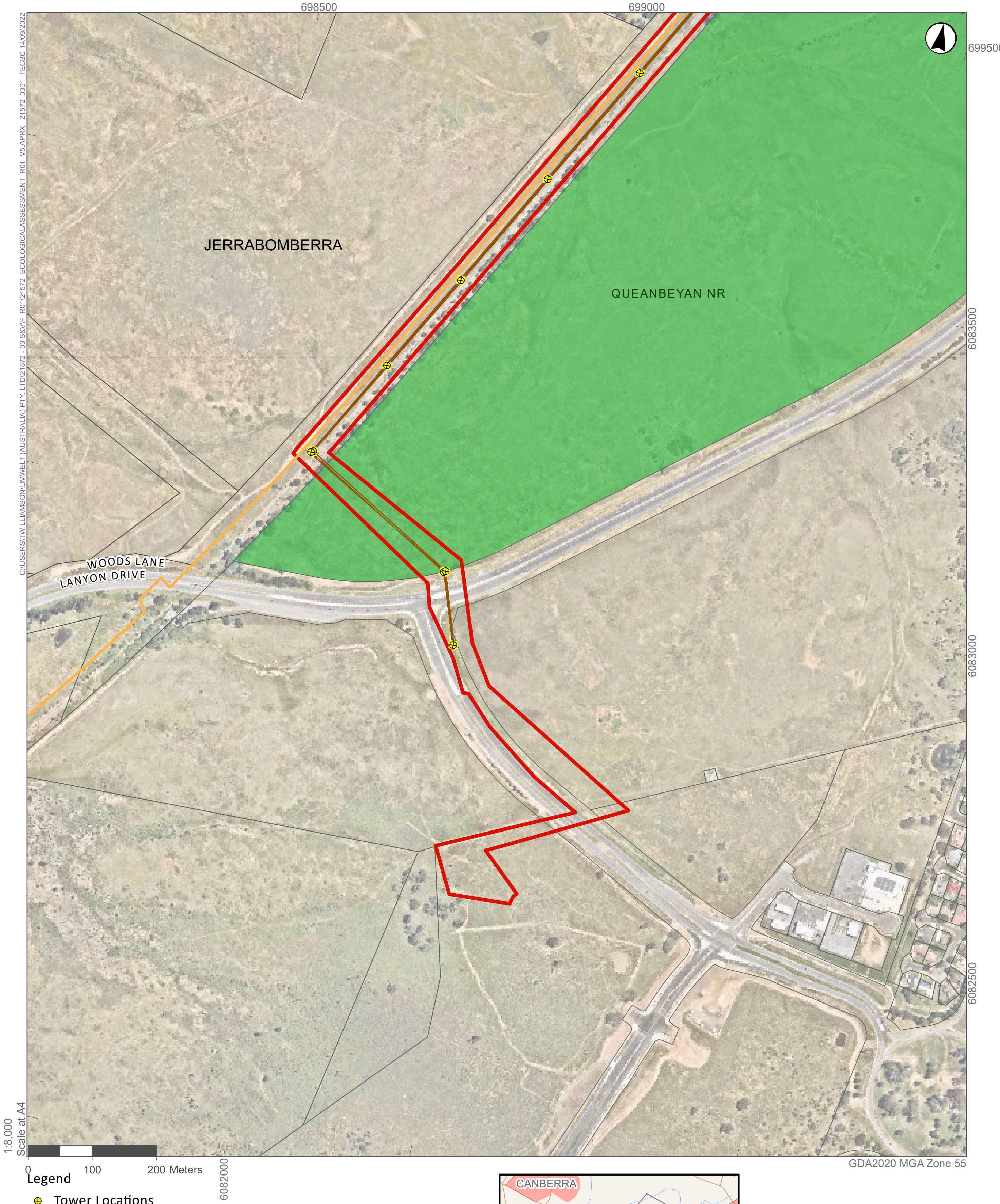


FIGURE 3.1-3

Distribution of BC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

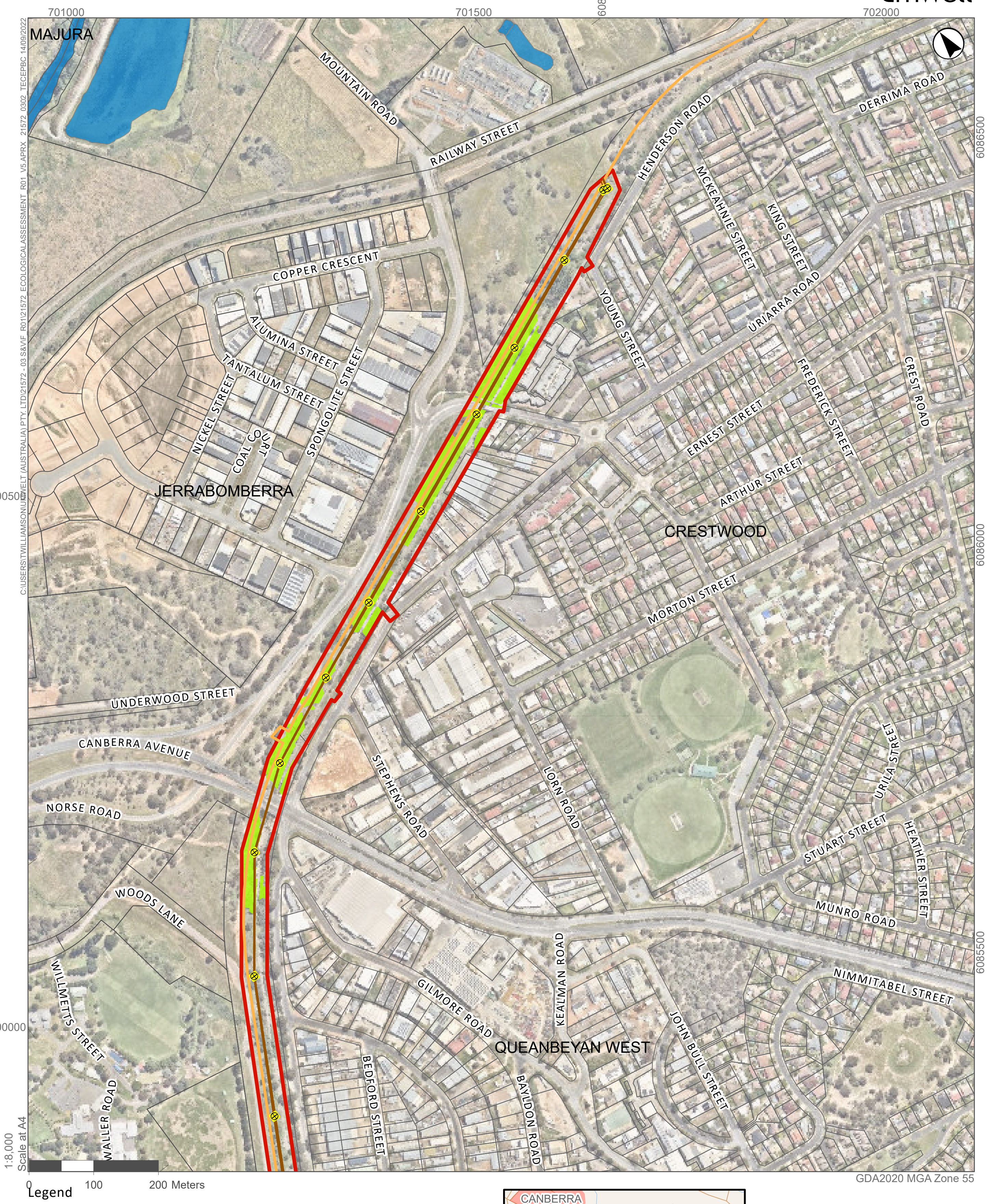


Legend
- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

FIGURE 3.1-4

Distribution of BC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)

Threatened Ecological Communities

- White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands (Critically Endangered)

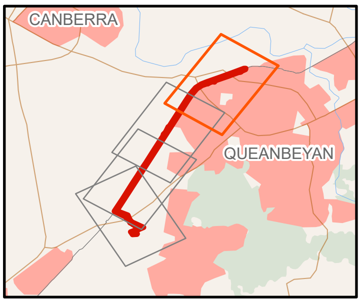


FIGURE 3.2-1

Distribution of EPBC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

Threatened Ecological Communities

- White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands (Critically Endangered)
- Natural Temperate Grassland of the South Eastern Highlands (Critically Endangered)

FIGURE 3.2-2

Distribution of EPBC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

Threatened Ecological Communities

- White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands (Critically Endangered)
- Natural Temperate Grassland of the South Eastern Highlands (Critically Endangered)

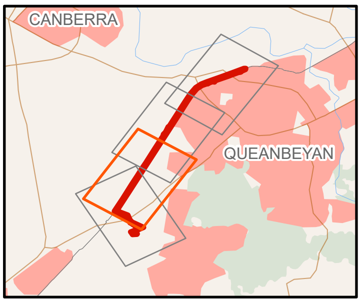
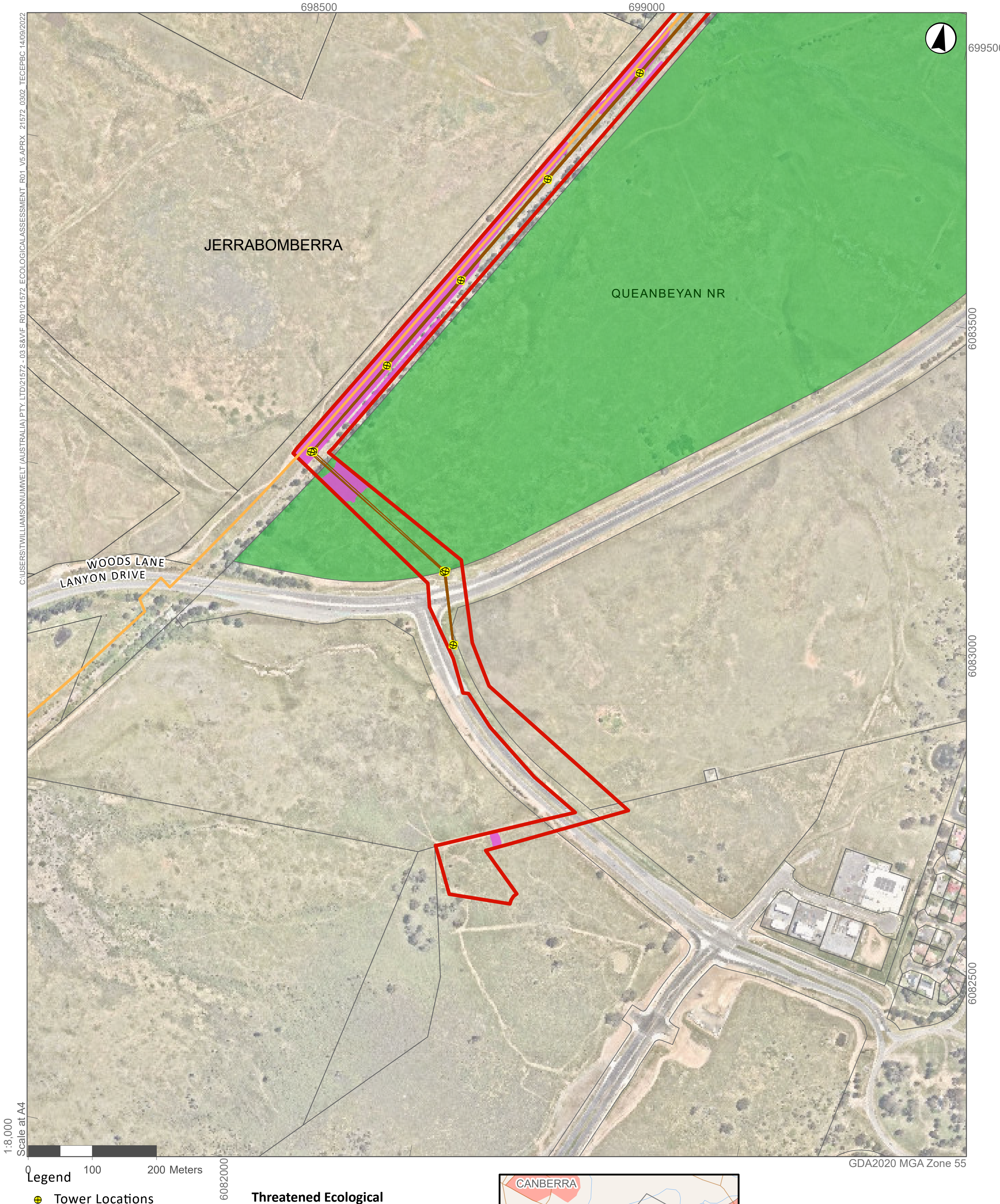


FIGURE 3.2-3

Distribution of EPBC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

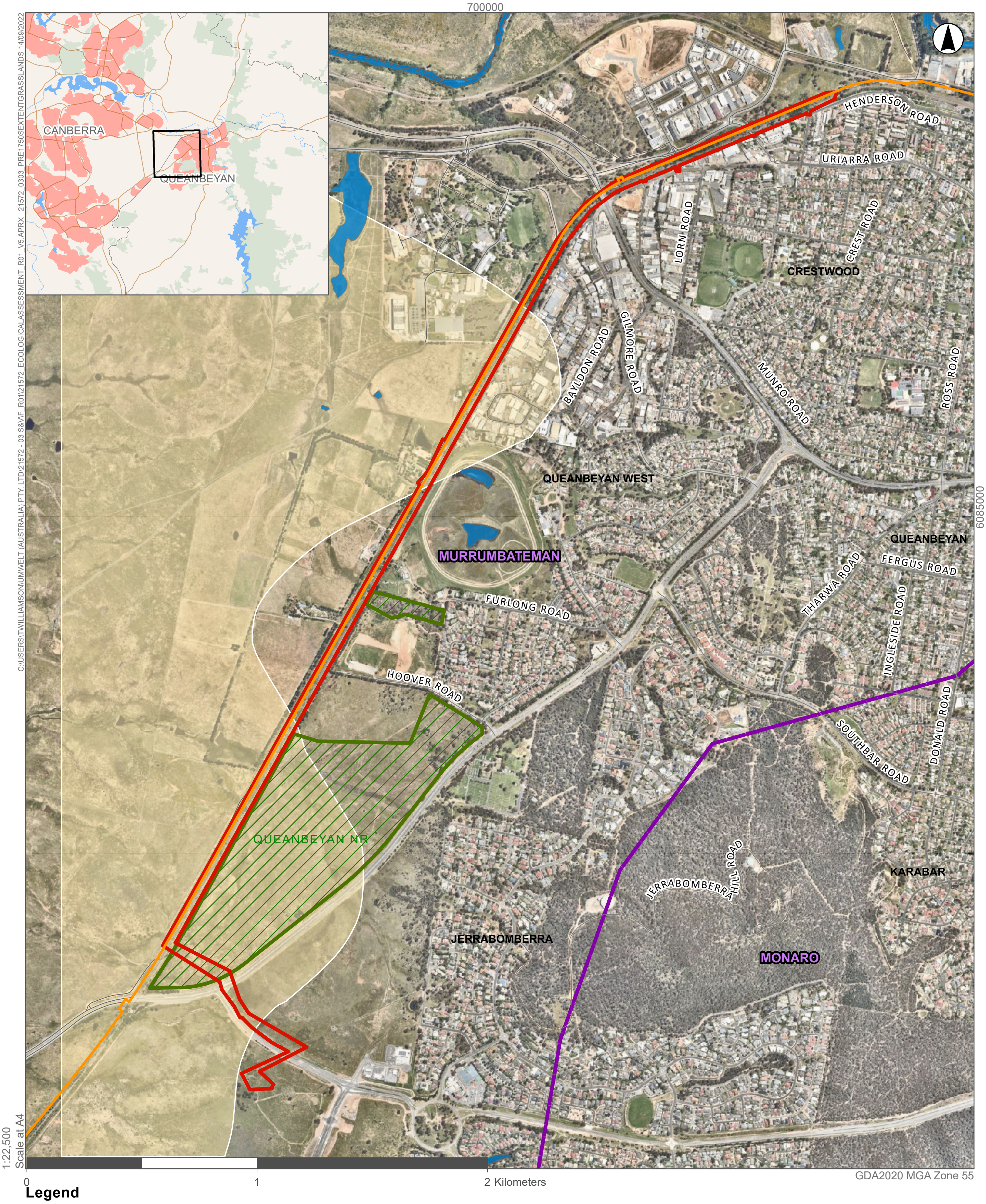
Threatened Ecological Communities

- Natural Temperate Grassland of the South Eastern Highlands (Critically Endangered)

FIGURE 3.2-4

Distribution of EPBC Act listed Threatened Ecological Communities in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Ibra-subregion
- Study Area
- ACT / NSW Boundary
- ACT Nature Reserves
- NSW NPWS Reserves
- Pre-1750s Extent of Natural Temperate Grassland (Modelled)

FIGURE 3.3

Pre-1750s Extent of Natural Temperate Grassland

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

3.4 Threatened species

3.4.1 Threatened Flora

Two threatened flora species were recorded in the Project Area (Table 3.11) (**Appendix A**):

- Hoary sunray (*Leucochrysum albicans var. tricolor)*, listed as endangered under the EPBC Act.
- Button wrinklewort (*Rutidosis leptorhynchoides*), listed as endangered under both the EPBC Act and the BC Act.

Following site inspection and based on the level of survey effort completed along the linear Project Area, no other threatened flora is likely to be present in the Project Area.

Hoary sunray (*Leucochrysum albicans var. tricolor*)

Hoary sunray were recorded at five discrete areas in the Project Area during the site assessment in September 2021. Abundance estimates for each of these areas are as follows:

- Hoary sunray is associated with each of the four PCTs present in the Project Area:
  - PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion
  - PCT 654 Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion
  - PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion
  - PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion.

Given the high detectability of the species during the month in which the site assessment was conducted (i.e., September) the actual mapped extent of occupancy in the Project Area is shown in **Figure 3.4**. The total area of hoary sunray habitat recorded in the project area is 1.10 ha.

Button wrinklewort (*Rutidosis leptorhynchoides*)

Button wrinklewort were recorded at two locations in the Project Area during the site assessment. Button wrinklewort is associated with two of the PCTs present in the Project Area:

- PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion
- PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion.

Given the high detectability of the species during the month in which the site assessment was conducted (i.e., September) the locations where this species is present in the Project Area is shown in **Figure 3.4**. The total area of button wrinklewort habitat recorded in the project area is 0.42 ha.

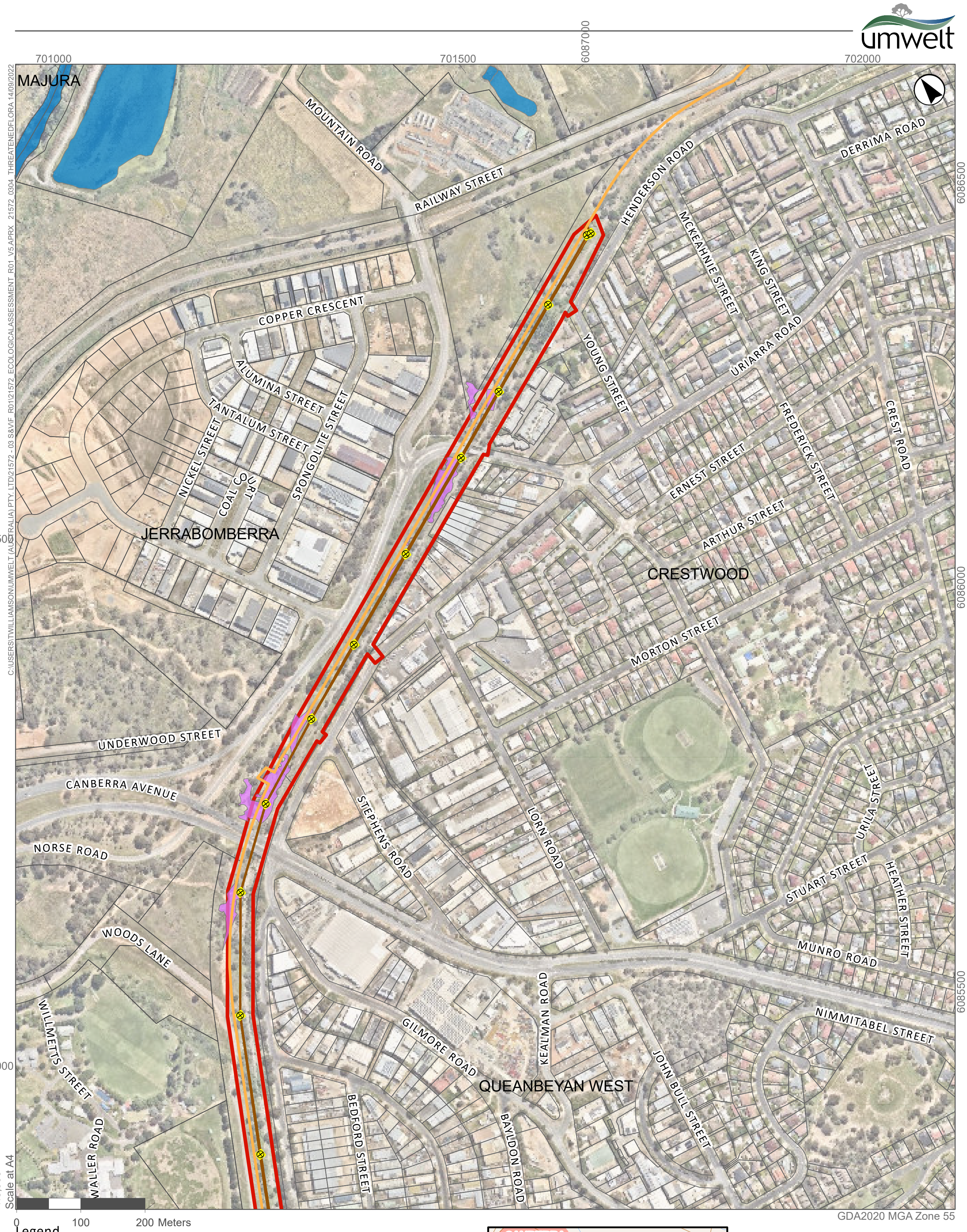
Table 3.11 Threatened flora species with a moderate or higher likelihood of occurrence

Species Name	Scientific Name	BC Act	EPBC Act	Likelihood of occurrence
hoary sunray	***Leucochrysum albicans* var. *tricolor***	Not listed	Endangered	**Known**. Button wrinklewort was recorded at two locations in the Project Area during the site assessment in September 2021.
button wrinklewort	***Rutidosis leptorhynchoides***	Endangered	Endangered	**Known**. Hoary sunray were recorded at five discrete areas in the Project Area during the site assessment. The extent of hoary sunray occupancy at these locations was recorded and mapped.

Table 3.12 Threatened flora in the Project Area

Species	Record type	Individuals recorded	Area of habitat (ha)
hoary sunray (*Leucochrysum albicans* var. *tricolor*)	Incidentally recorded	10,000+ individuals	1.10
button wrinklewort (*Rutidosis leptorhynchoides*)	Incidentally recorded	100+ individuals	0.42

The distribution of hoary sunray and button wrinklewort in the Project Area is shown in **Figure 3.4**.



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- *Leucochrysum albicans* Records

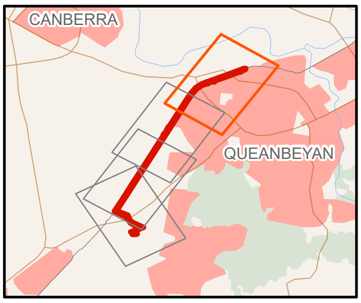
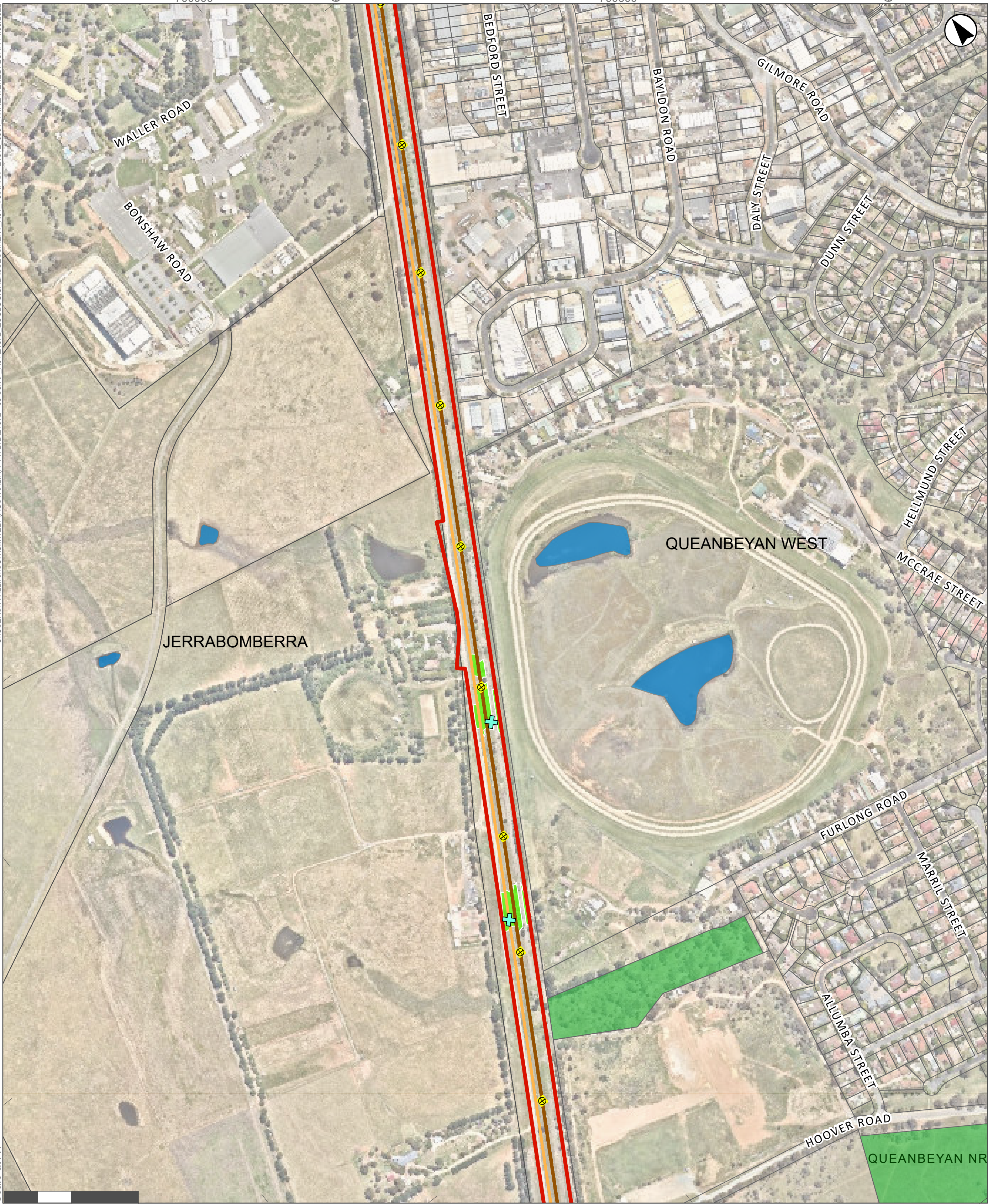


FIGURE 3.4-1

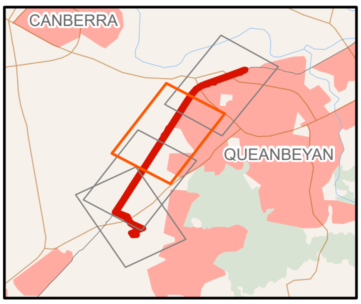
Distribution of Threatened Flora Records and Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- *Rutidosis leptorrhynchoides* Records
- *Rutidosis leptorrhynchoides* Habitat



umwelt

FIGURE 3.4-2

Distribution of Threatened Flora Records and Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- *Rutidosis leptorrhynchoides* Records
- *Rutidosis leptorrhynchoides* Habitat

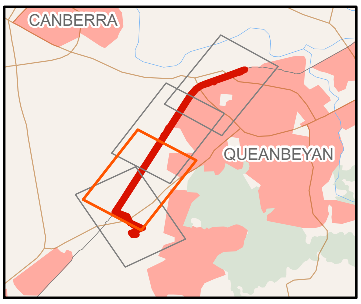


FIGURE 3.4-3

Distribution of Threatened Flora Records and Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend
- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

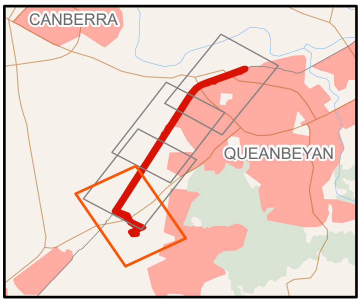


FIGURE 3.4-4

Distribution of Threatened Flora Records and Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

3.4.2 Threatened Fauna

A total 19 threatened fauna species comprising 12 bird species, one invertebrate, three mammal species and three reptile species have either been recorded in the Project Area or were assessed as having a moderate or higher likelihood of occurrence in the Project Area (**Table 3.13**) (**Appendix A**). No targeted threatened species surveys were completed for the purposes of this assessment. Relevant local survey data has been reviewed and included for the purposes of assessing species potential to occur.

Ecosystem credit species, or dual credit species for which key habitat constraints are absent, identified as having a moderate – high likelihood of occurrence are highly mobile species which may utilise habitat at the site, but for which the site does not support any specifically important habitat characteristics that distinguish it from habitat elsewhere in the landscape. Tests of significance for such species may be grouped and completed in summarised form. Species-specific consideration of potential impacts is recommended for the following species:

- Gang-gang cockatoo (*Callocephalon fimbriatum*), listed as vulnerable under the BC Act and endangered under the EPBC Act
- Golden sun moth (*Synemon plana*), listed as endangered under the BC Act and vulnerable under the EPBC Act
- Grassland earless dragon (*Tympanocryptis pinguicolla* / *lineata*) listed as critically endangered under the BC Act and endangered under the EPBC Act
- Pink-tailed worm-lizard (*Aprasia parapulchella*) listed as vulnerable under both the BC Act and the EPBC Act
- Striped legless lizard (Delma impar) listed as vulnerable under both the BC Act and the EPBC Act.

Aerial species are unlikely to interact with the development.

Table 3.13 Threatened fauna species with a moderate or higher likelihood of occurrence

Species Name	Scientific Name	BC Act	EPBC Act	Candidate Species Type	Likelihood of occurrence	Record type	Individuals or area of habitat (ha) recorded in the Project Area
Birds							
spotted harrier	***Circus assimilis***	Vulnerable	Not listed	Ecosystem	**Moderate**	Habitat assessment	N/A
little eagle	***Hieraaetus morphnoides***	Vulnerable	Not listed	Species/ Ecosystem	**High**	Habitat assessment	N/A
gang-gang cockatoo	***Callocephalon fimbriatum***	Vulnerable	Endangered	Species/ Ecosystem	**High**	Habitat assessment	2.37 hectares of foraging habitat which meets criteria for classification as critical habitat under the EPBC Act listing advice. No breeding habitat identified.
superb parrot	***Polytelis swainsonii***	Vulnerable	Vulnerable	Species/ Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of foraging habitat only. No breeding habitat identified.
swift parrot	***Lathamus discolor***	Endangered	Critically endangered	Species/ Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential foraging habitat.
white-throated needletail	***Hirundapus caudacutus***	Not listed	Vulnerable	Ecosystem	**High**	Habitat assessment	NA. May use aerial habitat above the site.
speckled warbler	***Chthonicola sagittata***	Vulnerable	Not listed	Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential habitat.
flame robin	***Petroica phoenicea***	Vulnerable	Not listed	Ecosystem	**High**	Habitat assessment	2.37 hectares of potential habitat.
scarlet robin	***Petroica boodang***	Vulnerable	Not listed	Ecosystem	**High**	Habitat assessment	2.37 hectares of potential habitat.
varied sittella	***Daphoenositta chrysoptera***	Vulnerable	Not listed	Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential habitat.
dusky woodswallow	***Artamus cyanopterus cyanopterus***	Vulnerable	Not listed	Ecosystem	**Known**	Incidentally recorded	1 individual, 2.37 hectares of potential habitat.
diamond firetail	***Stagonopleura guttata***	Vulnerable	Not listed	Ecosystem	**High**	Habitat assessment	2.37 hectares of potential habitat.

Species Name	Scientific Name	BC Act	EPBC Act	Candidate Species Type	Likelihood of occurrence	Record type	Individuals or area of habitat (ha) recorded in the Project Area
Invertebrates							
golden sun moth	***Synemon plana***	Endangered	Vulnerable*	Species	**High**	Habitat assessment	8.11 hectares of habitat, species assumed present due to adjacent confirmed habitat.
Mammals							
grey-headed flying-fox	***Pteropus poliocephalus***	Vulnerable	Not listed	Species/ Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential habitat.
eastern false pipistrelle	***Falsistrellus tasmaniensis***	Vulnerable	Not listed	Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential foraging habitat, potential roosting in hollow bearing trees.
large bent-winged bat	***Miniopterus orianae oceanensis***	Vulnerable	Not listed	Species/ Ecosystem	**Moderate**	Habitat assessment	2.37 hectares of potential foraging habitat. Potential roosting habitat recorded (rail-road underpass). No breeding habitat present.
Reptiles							
grassland earless dragon	***Tympanocryptis pinguicolla / lineata***	Critically Endangered#	Endangered@	Species	**High**	Habitat assessment	6.95 hectares of habitat in which the species is assumed present due to adjacent records.
pink-tailed worm-lizard	***Aprasia parapulchella***	Vulnerable	Vulnerable	Species	**Moderate**	Habitat assessment	0.08 hectares which the species is assumed present due to presence in surrounding landscape.
striped legless lizard	***Delma impar***	Vulnerable	Vulnerable	Species	**High**	Habitat assessment	12.42 hectares of habitat in which the species is assumed present due to adjacent records.

**Commonwealth listing status updated from critically endangered to vulnerable under the EPBC Act effective 07 December 2021.*

#Tympancryptis lineata provisionally listed as critically endangered under the BC Act effective 10 June 2022.

@Typmanocryptis pinguicolla listed as endangered under the EPBC Act. Taxonomic revisions not yet reflected in listing.

3.4.2.1 Threatened reptiles

Habitat for three threatened reptiles has been assessed as present in the Project Area: the grassland earless dragon (*Tympanocryptis lineata*), the pink-tailed worm-lizard (*Aprasia parapulchella*) and the striped legless lizard (*Delma impar*). Threatened reptile habitat is displayed in **Figure 3.7**.

Native grasslands on both sides of the alignment in East Jerrabomberra Grasslands Reserve and Queanbeyan Nature Reserve is known to support habitat for grassland earless dragon and striped legless lizard. Native grasslands which support surface rock in the landscape are known to support pink-tailed worm lizard in these areas.

Grassland earless dragon (*Tympanocryptis lineata*)

Following a comprehensive taxonomic review of *Tympanocryptis* in south-eastern Australia by Melville *et al.* 2019, *Tympanocryptis lineata* (the oldest specific name assignable to the genus), was assigned to the grassland earless dragon that occur in the ACT and neighbouring NSW in Queanbeyan Nature Reserve. Extant populations that are present on the Monaro Plains near Cooma and at Bathurst were named as two new species (*T. osborni* and *T. mccartneyi* respectively). The distribution of *T. pinguicolla* was restricted to Victoria, where there is particular concern regarding the species' status considering the last record was in the state was in 1969.

The grassland earless dragon that occurs in the ACT and Queanbeyan (*T. lineata*) has been provisionally listed on 10 June 2022 as a critically endangered species on an emergency basis. In the future, a preliminary determination will be made regarding the complete assessment of eligibility for listing as a threatened species is currently in the process of being listed under the BC Act following the taxonomic changes within the *Tympanocryptis* group noted above. It is currently subject to a provisional listing as Critically Endangered dated 10 June 2022.

The grassland earless dragon is listed as endangered under the EPBC Act as 'grassland earless dragon (*Tympanocryptis pinguicolla*)'. At the time of writing the current listing under the EPBC Act has not been updated to reflect taxonomic change.

Potential habitat for grassland earless dragon corresponds to the native grassland PCTs (320 and 1289) (**Figure 3.7**). The species is known to occur in Queanbeyan Nature Reserve to the east and in East Jerrabomberra Grassland Reserve to the west, with ACT Government habitat mapping extending to Woods Lane along the western boundary of the assessment area. ACT Government have an ongoing monitoring location 150 m from the Project Area where the species has been regularly detected. No other permanent monitoring plots have been established closer to the project area. The species has been detected (2017 - 2018) within 50 m of the assessment area during several active searches. The closest record from 2018, is less than 10 m west of the Project area, and confirms species occupancy east of Woods Lane. Based on the proximity of this record to the Project Area, and location west of Woods Land, this provides confirmation that the species is likely present in the Project Area.

No targeted grassland earless dragon surveys were conducted in the Project Area as part of this current ecological assessment. For the purpose of this assessment grassland earless dragon have been assumed present in suitable habitat in the Project Area given the proximity to recent records adjacent Woods Lane in the ACT and adjacent the Project Area in QNR continuous nature of suitable habitat between these specific locations and the Project Area. The Project Area is separated from known habitat in the ACT by a dirt track (Woods Lane) which is unlikely to be a barrier to species movement but may increase exposure of individuals in the area. Genetic analysis indicates low levels of gene flow between populations in QNR and ACT.

A total of 6.95 ha of habitat for grassland earless dragon is present in the Project Area.

Pink-tailed worm-lizard (*Aprasia parapulchella*)

Pink-tailed worm lizard is restricted to areas of rocky habitat which is essential for breeding and foraging (DPIE 2017). The nearest record is 800 m south-west of the Project Area. There are many records along the Jerrabomberra Creek corridor south and south-west of Jerrabomberra between 2.3–4 km south of the Project Area and several records south of Hume approximately 3.8 km south-west of the Project Area.

Restricted areas of suitable rocky habitat were identified in the south of the alignment. Due to the presence of records in rock outcrops in the surrounding landscape, continuity with adjacent areas and the good condition of habitat, and the proximity of records described above there is a high likelihood of pink-tailed worm-lizard utilising these restricted areas of habitat in the project area. For the purposes of this assessment, pink-tailed worm-lizard are assumed present in identified areas of potential habitat. Habitat for the pink-tailed worm-lizard was identified as small patches of rocky outcrops (0.08 hectares) in the southern quarter of the Project Area (**Figure 3.7**).

A total of 0.08 ha of habitat for pink-tailed worm-lizard is present in the Project Area.

Striped legless lizard (*Delma impar*)

The striped legless lizard is a small legless lizard that inhabits natural temperate grasslands dominated by kangaroo grass, wallaby grasses and/or spear grasses. They shelter among rocks and grass tussocks as they forage for small invertebrates. Striped legless lizard is known to occur in adjacent grassland habitat including the Jerrabomberra East Grasslands Nature Reserve.

There is suitable habitat in the form of native grassland, exotic grassland and derived native grassland present in the Project Area. Habitat for the striped legless lizard corresponds to native grassland PCTs (320 and 1289) and the DNG condition classes of PCTs 654 and 1330, excluding small patches of grassland within the woodland areas. Grassland in portions of Jerrabomberra East Grasslands N.R adjacent Woods Lane and grassland in the south-eastern portion of Block 2236 adjacent Woods Lane comprises mapped striped legless lizard habitat (ACTmapi 2022) in which the species is confirmed present by ACT Government ecologists. Due to the mobility of striped legless lizard, and presence of primary habitat for the species in the south of the site, and confirmed records of the species in adjacent habitat, this species has a high likelihood of being present in identified habitat areas. For the purposes of this assessment, striped legless lizard is assumed present in identified areas of potential habitat.

A total of 12.42 ha of habitat for striped legless lizard is present in the Project Area.

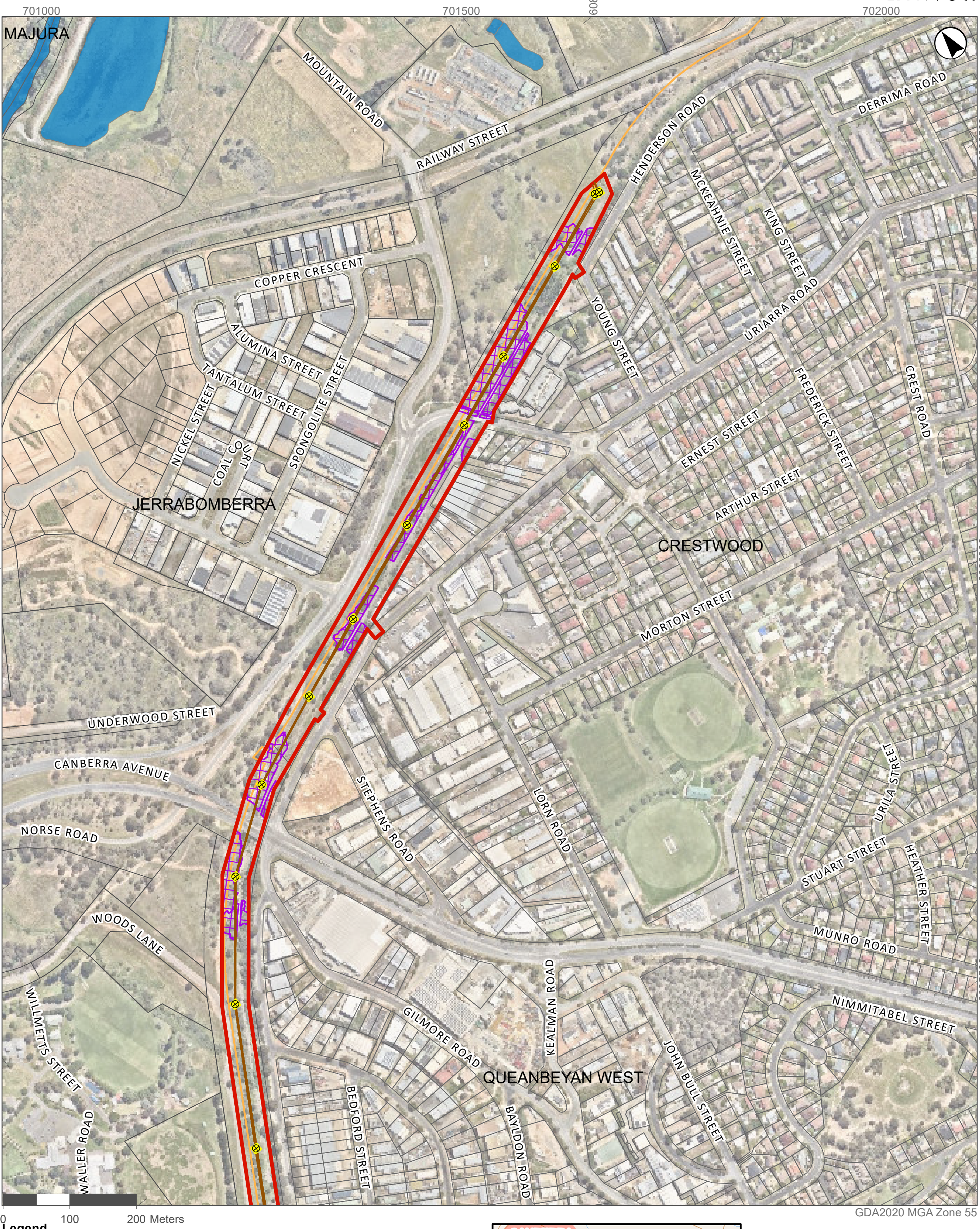
3.4.2.2 Threatened invertebrates

Golden sun moth (*Synemon plana*)

The golden sun moth occurs on the Southern Tablelands of NSW and the ACT in areas of open grassland. Confirmed golden sun moth habitat is present in immediately adjacent areas in ACT. Due to the presence of suitable habitat within the Project Area, and the proximity to nearby confirmed habitat, the golden sun moth has been assumed to be present within the Project Area.

Habitat for golden sun moth within the Project Area comprises the native grassland PCTs (320 and 1289) and the derived native grassland condition classes of PCTs 654 and 1330, except where small patches are unconnected to other grassland areas.

A total of 8.11 hectares of golden sun moth habitat has been mapped in the Project Area (**Figure 3.8**). Golden sun moth is present at multiple locations adjacent the Project Area. Golden sun moth has been recorded in the south-eastern corner of Harman (most recently in 2021), in woodland in the small section of Queanbeyan N.R just south of the Queanbeyan Race Club (2008), at multiple locations elsewhere in Queanbeyan N.R south of Hoover Road (across multiple years) and Jerrabomberra East Grasslands N.R (across multiple years) and immediately north and south of Tompsitt Drive (2019). A large area of suitable habitat is mapped in ACTmapi adjacent the Project Area at Jerrabomberra East Grasslands N.R.



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- Threatened Microbat Habitat

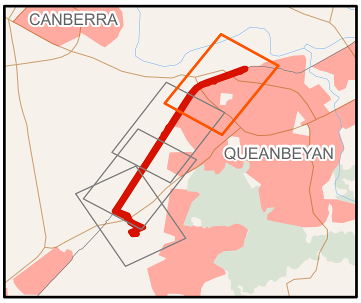


FIGURE 3.5-1

Distribution of Threatened Mammal Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

umwelt

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Threatened Microbat Habitat

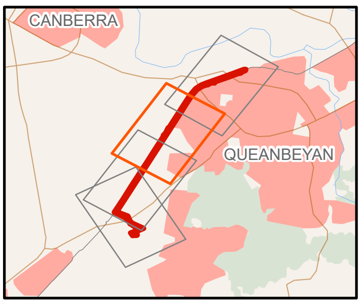


FIGURE 3.5-2

Distribution of Threatened Mammal Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

umwelt

C:\USERS\TWILLIAMSON\UMWELT (AUSTRALIA) PTY LTD\21572 - 03 S&VF R01\21572 ECOLOGICALASSESSMENT R01 V5.APRX 21572 0305 THREATENEDMAMMALHABITATS 14/09/2022

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Threatened Microbat Habitat

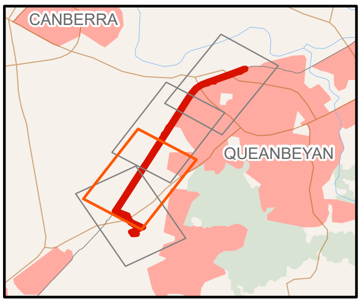


FIGURE 3.5-3

Distribution of Threatened Mammal Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

C:\USERS\TWILLIAMSON\UMWELT (AUSTRALIA) PTY LTD\21572 - 03 S&VF_R01\21572_ECOLOGICALASSESSMENT_R01_V5.APRX_21572_0305_THREATENEDMAMMALHABITATS 14/09/2022

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

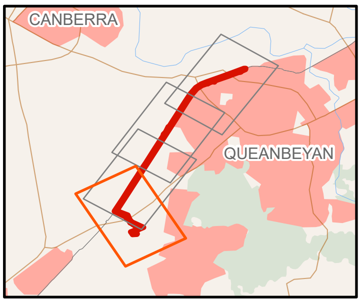
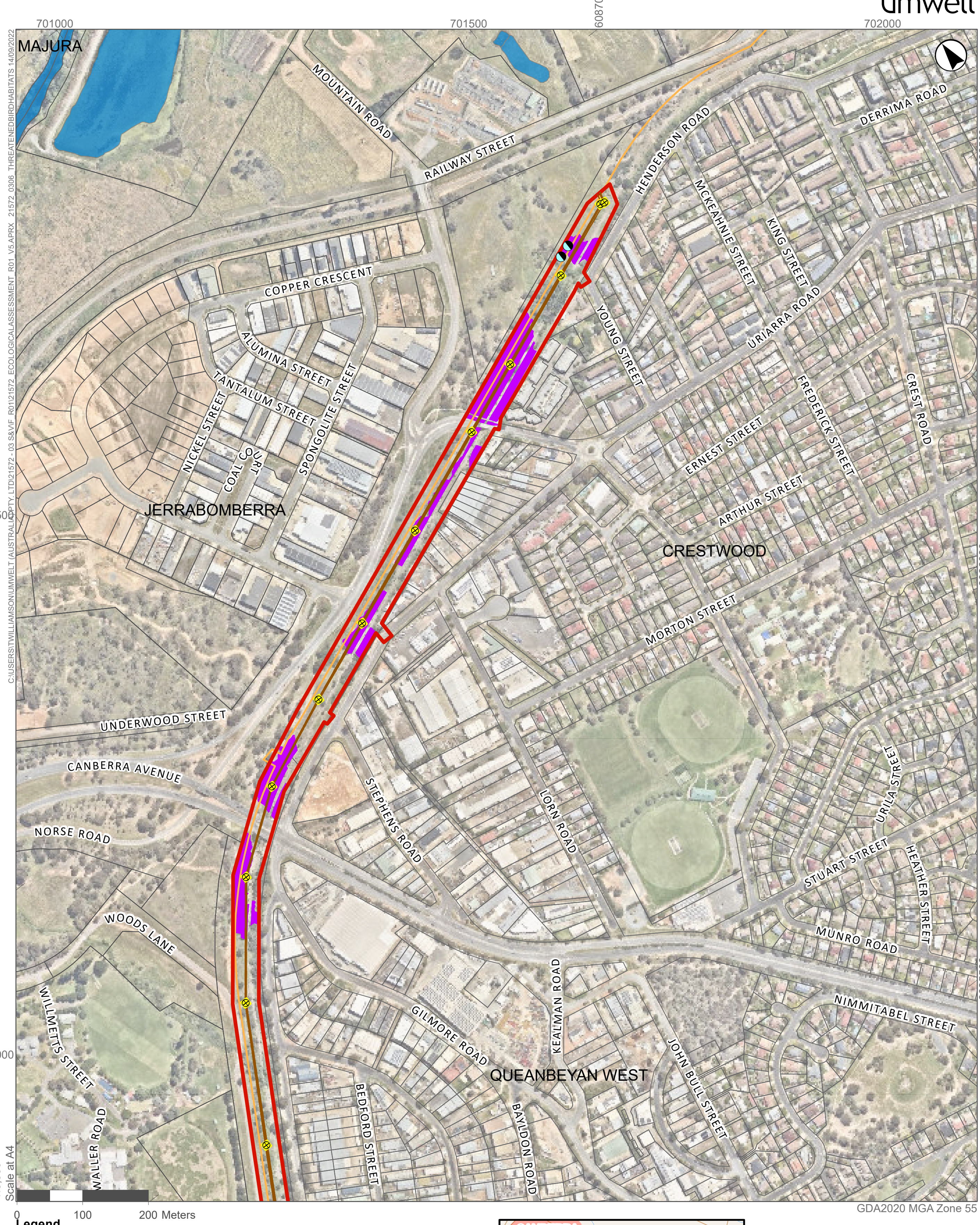


FIGURE 3.5-4

Distribution of Threatened Mammal Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

umwelt



Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Hollow-bearing Trees
- Threatened Bird Habitat

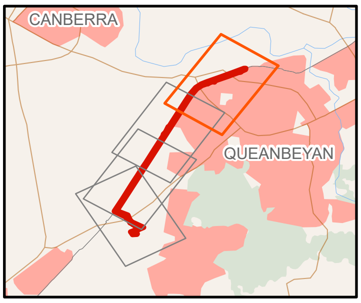


FIGURE 3.6-1

Distribution of Threatened Bird Habitat and Records in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Hollow-bearing Trees
- Threatened Bird Habitat

FIGURE 3.6-2

Distribution of Threatened Bird Habitat and Records in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Hollow-bearing Trees
- Threatened Bird Habitat

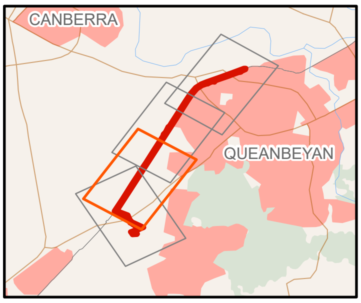


FIGURE 3.6-3

Distribution of Threatened Bird Habitat and Records in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

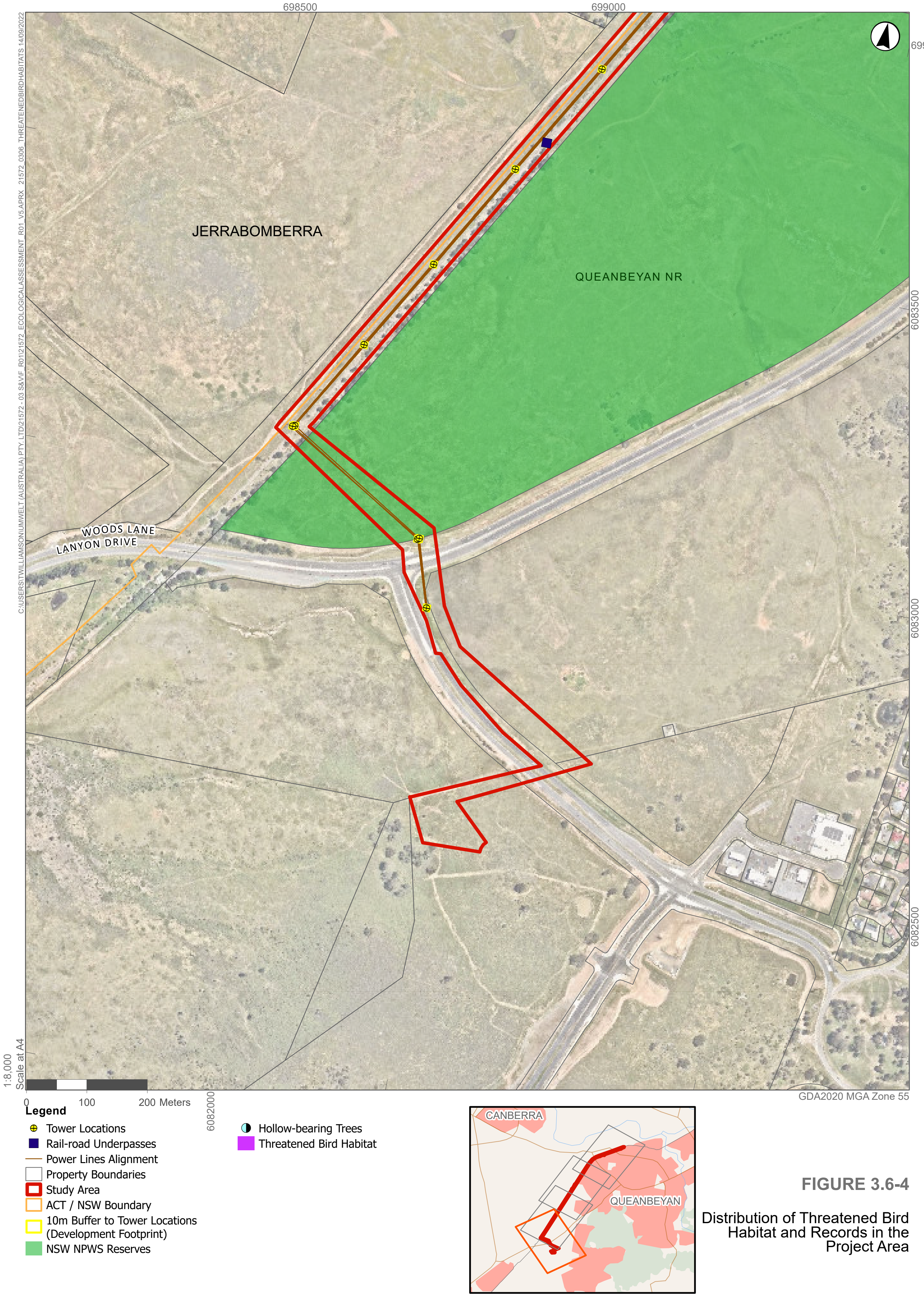
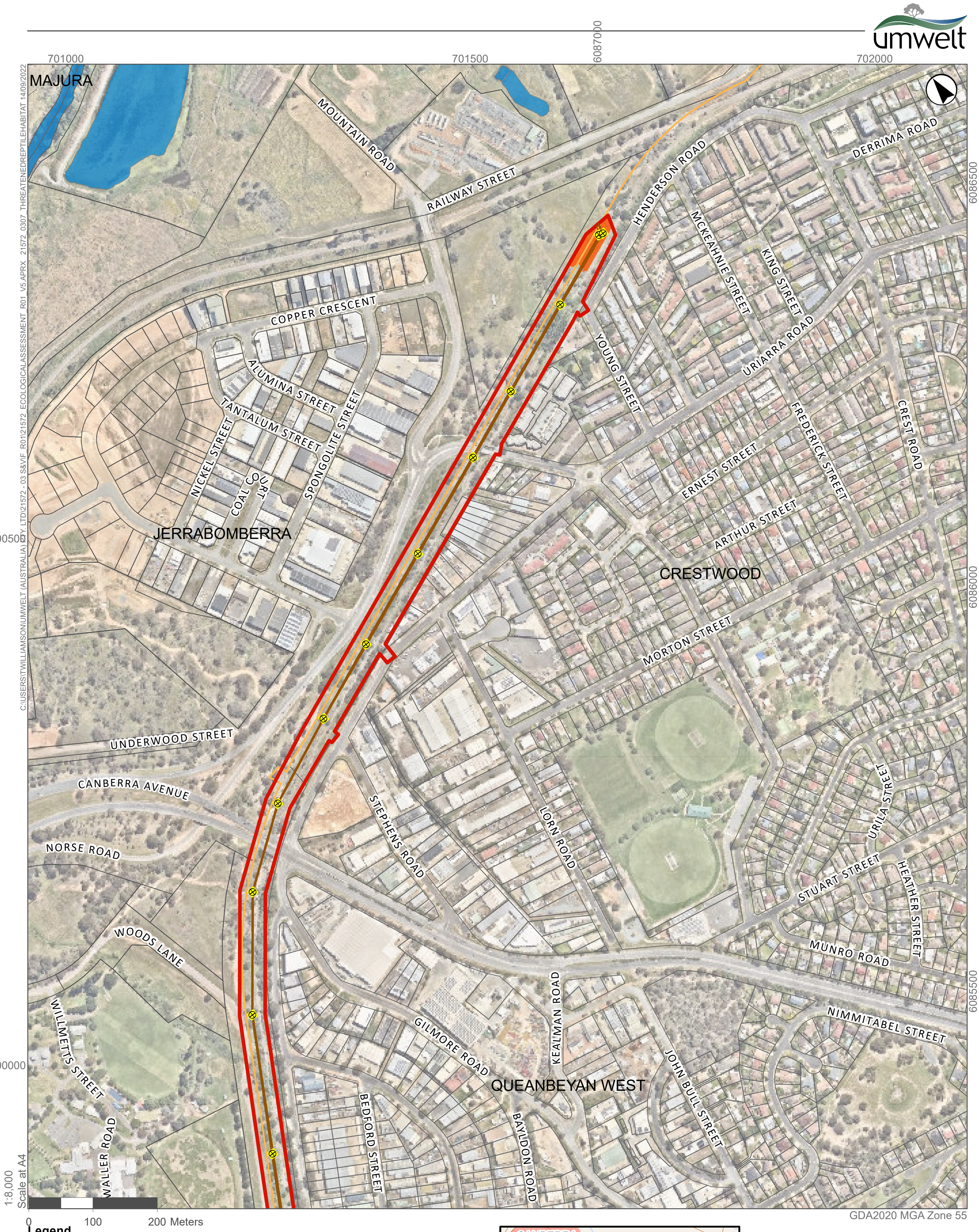


FIGURE 3.6-4

Distribution of Threatened Bird Habitat and Records in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- Striped Legless Lizard Habitat

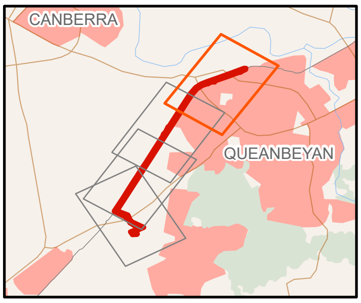


FIGURE 3.7-1

Distribution of Threatened Reptile Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Grassland Earless Dragon Habitat
- Striped Legless Lizard Habitat

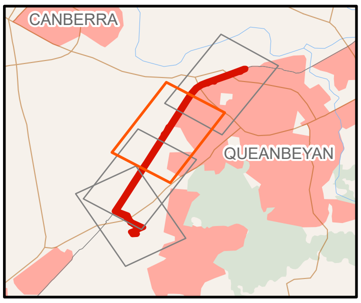


FIGURE 3.7-2

Distribution of Threatened Reptile Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Pink-tailed Worm Lizard Habitat
- Grassland Earless Dragon Habitat
- Striped Legless Lizard Habitat

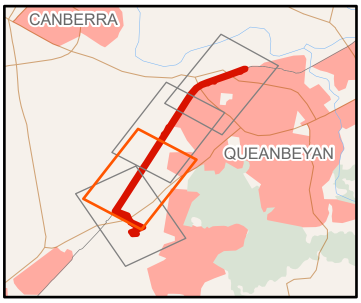


FIGURE 3.7-3

Distribution of Threatened Reptile Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Rail-road Underpasses
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Pink-tailed Worm Lizard Habitat
- Grassland Earless Dragon Habitat
- Striped Legless Lizard Habitat

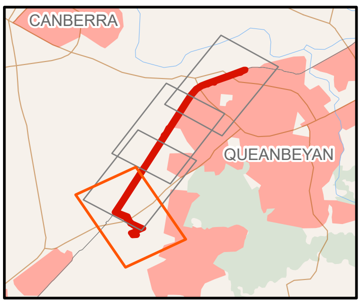
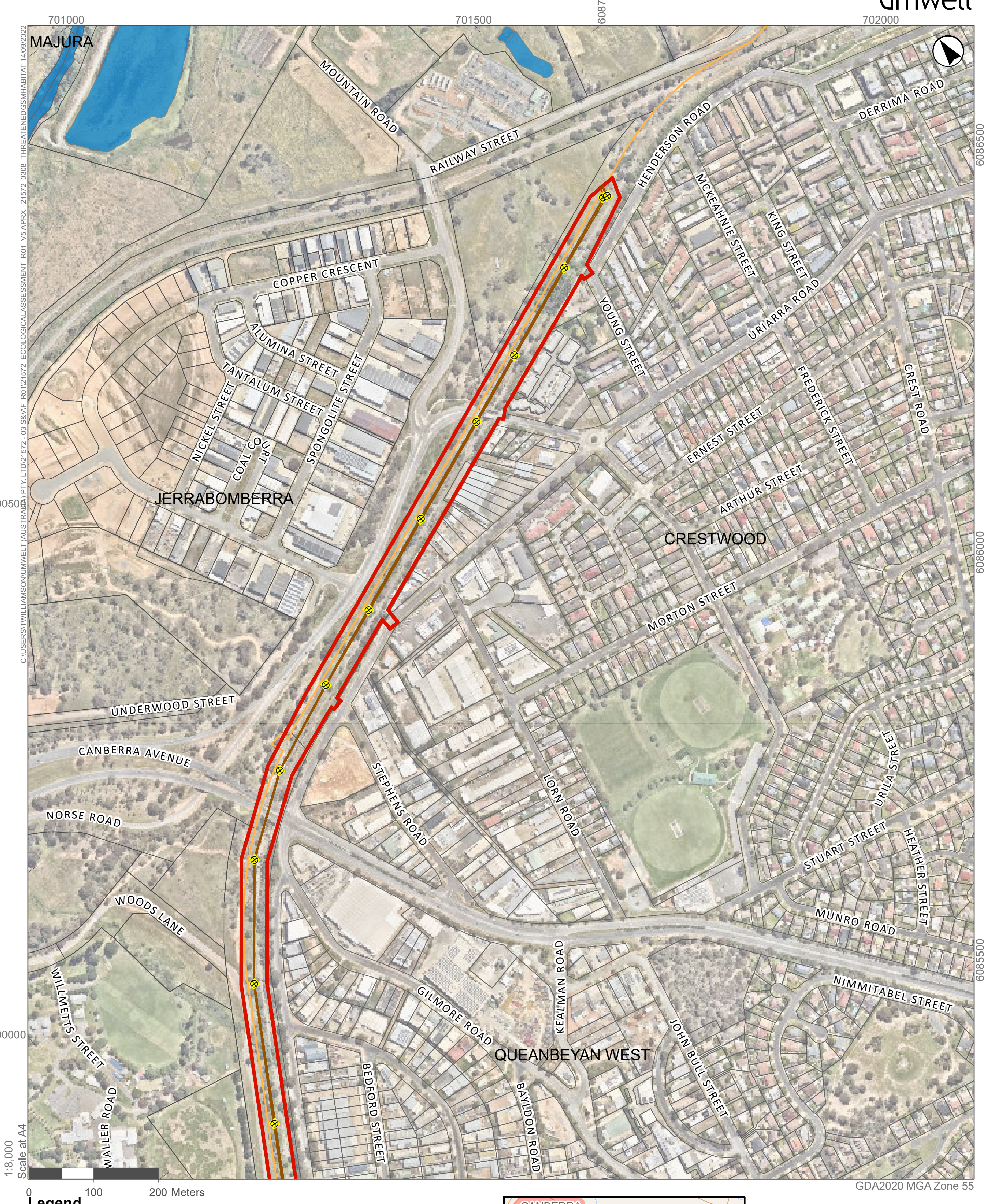
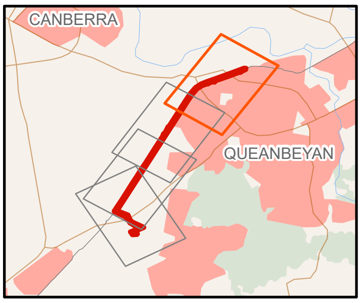


FIGURE 3.7-4

Distribution of Threatened Reptile Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)





Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves

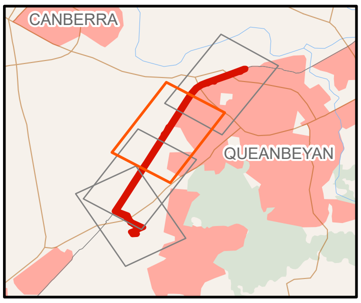
FIGURE 3.8-1

Distribution of Golden Sun Moth Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Golden Sun Moth Habitat



umwelt

FIGURE 3.8-2

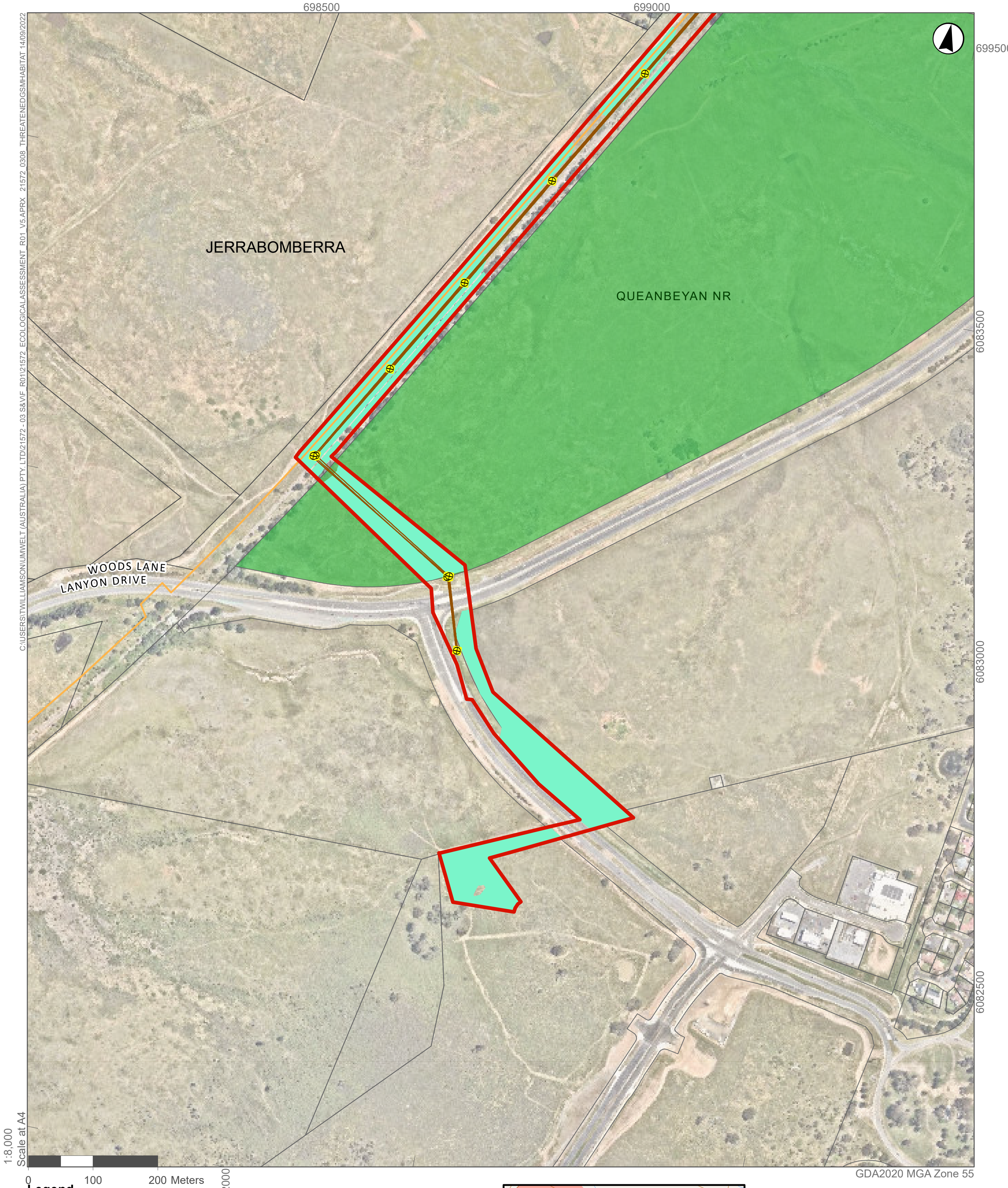
Distribution of Golden Sun Moth Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

FIGURE 3.8-3

Distribution of Golden Sun Moth Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)



Legend

- Tower Locations
- Power Lines Alignment
- Property Boundaries
- Study Area
- ACT / NSW Boundary
- 10m Buffer to Tower Locations (Development Footprint)
- NSW NPWS Reserves
- Golden Sun Moth Habitat

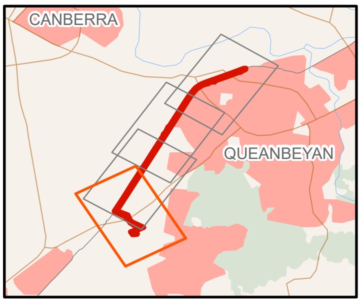


FIGURE 3.8-4

Distribution of Golden Sun Moth Habitat in the Project Area

Image Source: Nearmap (2022) **Data source:** NSW DSFI (2021); ACTMapi (2021)

3.4.2.3 Threatened birds

Habitat for twelve threatened birds has been assessed as present in the Project Area. All grassland and box-gum woodland areas constitute foraging habitat for spotted harrier (*Circus assimilis*) and little eagle (*Hieraaetus morphonoides*) which are likely to occasionally forage over the Project Area as they forage over the greater landscape, however they are unlikely to breed in the Project Area. White-throated needletail (*Hirundapus caudacutus*) may utilise the airspace over the entire Project Area as they forage and migrate through the area.

The gang-gang cockatoo (*Callocephalon fimbriatum*), superb parrot (*Polytelis swainsonii*), swift parrot (*Lathamus discolor*) and the woodland bird species speckled warbler (*Chthonicola sagittata*), flame robin (*Petroica phoenicea*), scarlet robin (*Petroica boodang*), varied sittella (*Daphoenositta chrysoptera*), dusky woodswallow (*Artamus cyanopterus cyanopterus*) and diamond firetail (*Stagonopleura guttata*) are all likely to forage occasionally in the mapped box-gum woodland habitat within the Project Area (**Figure 3.6**). Six tree hollows occur in the Project Area (**Figure 3.6**), however they are unlikely to constitute breeding habitat for gang-gang cockatoo and superb parrot. Superb parrot breeding is well documented within the Canberra region, with breeding locations at Mulligans Flat and Goorooyarroo Nature Reserves along with the Molonglo Valley (EPSD 2019). Gang-gang cockatoo require old growth forest and woodland for breeding so unlikely to breed within the Project Area (DoE 2022b). Given the habitat preferences and location of known breeding locations for superb parrot and gang-gang cockatoo, breeding habitat has not been mapped within the Project Area.

Spotted harrier (*Circus assimilis*)

There is suitable habitat present in the Project Area. The nearest records are from Jerrabomberra West Grasslands Nature Reserve (2013), approximately 2 km west of the Project Area and Jerrabomberra Creek (2012), approximately 3.5 km west of the Project Area. Spotted harrier may occasionally forage over any areas of grassland or box-gum woodland in the Project Area particularly in the Queanbeyan N.R and adjacent Jerrabomberra East Grasslands Nature Reserve. Spotted harrier foraging habitat conforms to all vegetated areas in the Project Area including PCTs 320, 654, 1289, 1330 and exotic. Foraging habitat has not been mapped for spotted habitat.

Little eagle (*Hieraaetus morphnoides*)

The little eagle is a large predatory bird that inhabits open forests and woodlands across Australia. Little eagles hunt over a large home range, feeding on birds, reptiles and mammals (DPE 2021). No little eagles or signs of their nests were observed within the Project Area; however, they are likely to utilise the airspace above the Project Area as they hunt and move through the landscape.

There is suitable foraging habitat present in the Project Area. Little eagle has been recorded on several occasions within 2 km of the Project Area at locations in Queanbeyan N.R, Jerrabomberra West Grasslands N.R and Jerrabomberra East Grasslands N.R (the nearest record being approximately 500 m east of the Project Area). The nearest records to the Study Area are from Newline Quarry and in Queanbeyan, however advice from ACT Government indicates that individuals are regularly observed in Fyshwick, approximately 2.5 km west of the Study Area. Little eagle forage has a large home range and forage over a variety of grassland and woodland habitat.

This species may occasionally hunt over any vegetation present in the Project Area. Little eagle foraging habitat conforms to all vegetated areas in the Project Area including PCTs 320, 654, 1289, 1330 and exotic. No stick nests were observed in or adjacent to the Project Area and considering the restricted extent of woody vegetation in the Study Area little eagle nesting habitat is absent from the Project Area. Foraging habitat has not been mapped for little eagle.

Gang-gang cockatoo (*Callocephalon fimbriatum*)

The gang-gang cockatoo inhabits upland areas of tall mountain forest and woodlands during spring and summer, where it most often breeds. During autumn and winter gang-gang cockatoos migrate to lower altitudes of open eucalypt forests and woodlands (DPE 2022b). No gang-gang cockatoos were observed within the Project Area however potential foraging habitat for the species for the species has been assessed as present based on the presence of suitable eucalypts and the presence of known records in the surrounding landscape.

Suitable foraging habitat for gang-gang cockatoo comprises both areas of exotic shrubs and native woody vegetation. The species is widespread and mobile in the landscape and is known to forage within urban areas. foraging habitat is likely to be intermittently utilised by gang-gang cockatoo for foraging. Areas without woody vegetation do not comprise habitat for the species.

This species has been recorded at several locations in Queanbeyan and Jerrabomberra within 1 km of the Project Area. All areas of native woody vegetation would conform to the definition of critical foraging habitat for gang-gang cockatoo under the EPBC Act listing advice. Within the Project Area gang-gang cockatoo critical foraging habitat conforms to the woodland PCTs (PCT 654 and PCT 1330), excluding derived native grasslands. A total of 2.37 ha of critical foraging habitat is present in the project area.

Gang-gang cockatoo depend on large stands of old growth forest and woodland to breed. While gang-gang cockatoo is known to nest in remnant trees in the urban context in ACT, breeding areas are connected to large stands of remnant and regenerating woodland. As the woodland habitat within the Project Area is isolated and poorly connected to old growth forest, and contains few mature trees, Gang-gang cockatoo are unlikely to breed in the Project Area.

Superb parrot (*Polytelis swainsonii*)

Superb parrots inhabit open forest and woodland habitat where they breed and forage (DPIE 2017). No superb parrots were observed within the Project Area however the species has been assessed as potentially being an occasional visitor occurring based on the presence of suitable foraging habitat.

Box-gum woodland present in the Project Area comprises suitable potential foraging habitat. The nearest record is from Kendall Avenue, Queanbeyan, immediately adjacent the Project Area. Other bird records are from Crestwood in 2018 (0.8 km west of the Study Area), Newline in 2014 (2 km north of the Study Area) and Greenleigh in 2016 (3.8 km south-east of the Project Area). Levels of superb parrot activity have been consistently increasing in the ACT in recent years, and areas of high utilisation are well documented. Locations of superb parrot breeding in ACT are well documented and located distant from the Study Area. Similarly, areas of high foraging utilisation are located distant from the Study Area. The species' southward range extension in Canberra over the past decade does not appear to have resulted in a substantial increase in the prevalence of superb parrot in the Queanbeyan area.

Superb parrot is not known to regularly forage within the Queanbeyan / Jerrabomberra area, with few records of the species from the area. Given the quality and extent of the habitat present and the species' use of the Queanbeyan / Jerrabomberra area superb parrot are likely to only occasionally occur in the Project Area. Breeding within and adjacent to the ACT are well documented, with known breeding locations restricted to Gungahlin and the Molonglo Valley. Consequently, the species is highly unlikely to breed in the Project Area and no breeding habitat has been mapped.

Nonetheless, the likelihood of occurrence of superb parrot in the Study Area is moderate due to the chance of individuals flying through and occasionally foraging in, the Study Area. Breeding habitat is absent, but potential foraging is present in PCT 654 and PCT 1330, excluding derived native grassland zones. A total of 2.37 ha of potential foraging habitat is present. The value of potential foraging habitat in the Study Area is likely to be low due to the location, extent, composition and condition of habitat present.

Swift parrot (*Lathamus discolor*)

Swift parrot is a migratory species that breeds in Tasmania, and migrates overwinter to mainland Australia where they forage in coastal NSW, typically north of Sydney. In the local region the species is usually detected in large woodland patches where they rest and forage during migration.

There is marginal foraging habitat in the form of box-gum woodland present in the Project Area which swift parrot may occasionally use during migration. A total of 2.37 ha of potential foraging habitat is present. No breeding habitat is present, as that is restricted to Tasmania, and the location of the project is south of core foraging habitat on the mainland. Typically, during migration, swift parrot are observed in or adjacent to large woodland reserves that form part of north-south landscape connectivity. The woodland in the project area is not in or adjacent to a larger woodland area and has relatively poor connectivity of woody vegetation.

Given the quality and extent of the habitat present and the species' use of the Queanbeyan / Jerrabomberra area swift parrot is likely to only very rarely occur in the Project Area. The nearest record is from Newline Quarry (2010), approximately 2 km north of the Project Area. This species has also been recorded at Molonglo Gorge, Symonston, Callum Brae N.R (where up to 65 individuals were recorded in 2021) and Jerrabomberra Wetlands N.R. The identified areas of potential foraging habitat are unlikely to be important for the species during migration.

Woodland birds (Ecosystem credit species)

Six woodland birds which are ecosystem species were identified as potentially occurring in the project area: speckled warbler (*Chthonicola sagittata*), flame robin (*Petroica phoenicea*), scarlet robin (P*etroica boodang*), varied sittella (*Daphoenositta chrysoptera*), dusky woodswallow (*Artamus cyanopterus cyanopterus*), diamond firetail (*Stagonopleura guttata*). One of these, dusky woodswallow, has been recored in the Project Area. All other woodland bird species have all been recorded as occurring within woodland and grassland habitat within 2.5 km of the Project Area.

There is suitable habitat in the form of box-gum woodland present in the Project Area which is likely to be occasionally utilised by woodland bird species dispersing to and from larger patches of woodland in the Queanbeyan / Jerrabomberra area. Woodland bird habitat is displayed in **Figure 3.6**. All species are likely to move through the Project Area as they disperse through the landscape, however due to the linear nature of habitat, and lack of direct connectivity to larger woodland areas species other than dusky woodswallow are unlikely to be resident or breeding in the Project Area. Each of these species are ecosystem credit species and are assumed present within the Project Area.

2.37 ha of habitat for these threatened birds is identified, comprising of the woodland PCTs (PCT 654 and PCT 1330) excluding derived native grasslands. While grassland areas may occasionally be utilised as foraging habitat and during dispersal, these areas have been excluded from consideration as core habitat.

Aerial birds (*Hirundapus caudacutus* and *Apus pacificus*)

Two aerial species, white-throated needletail (*Hirundapus caudacutus*) and pacific swift (*Apus pacificus*) were identified as having a moderate or high likelihood of occurrence. While potentially utilising airspace above the project area on an occasional basis, there is no suitable terrestrial habitat for white-throated needletail, or pacific swift are present in the Project Area. Habitat is not considered further for these species

3.4.2.4 Threatened mammals

Microbats: (Large-bent-winged bat (*Miniopterus orianae oceanensis*) and eastern false pipistrelle (*Falsistrellus tasmaniensis*)).

Roosting habitat for eastern false pipistrelle is poorly known, however they are thought to roost in tree hollows, under loose bark and in suitable anthropogenic structures (DPIE 2017). Large bent-winged bat roosting and breeding habitat is restricted to caves, tunnels, culverts and mines (DPIE 2017). Populations of large bent-winged bat are centered around a maternity cave, with resident bats dispersing up to 300 km away.

Potential foraging and roosting habitat were recorded for both microbat species. Medium (5–15 cm wide) to large (15-30 cm wide) sized tree hollows and the railroad underpass supports both temporary roosting and breeding habitat for the eastern false pipistrelle. One railroad underpass provides potential non-breeding roosting habitat for the large bent-wing bat (**Plate 3.7**). No targeted survey was completed and no evidence of occupancy was recorded.

2.37 ha of woodland have been identified as potential foraging habitat for microbats. Eastern false pipistrelle may utilise these woodland areas for roosting also. No breeding habitat for large-bent-winged bat is present although the railroad under-pass may provide incidental non-breeding roosting habitat.

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

Consistent with all vegetation in the surrounding landscape, grey-headed flying-fox likely to occasionally disperse through, or forage in, the Study Area. The majority of instances of occurrence of this species in the Study Area are likely to involve individuals flying through (or over) the Study Area from roosts around Lake Burley Griffin (10 km north-west) and a recently recorded roost on Queanbeyan River (3 km south-east). However, there is no potential roosting or breeding habitat in or adjacent to the Study Area and due to the extent and nature of vegetation in the Study Area is not likely to be regularly used or important foraging habitat.

Given that the Project Area is located within 20 km of known roosting sites in ACT and Queanbeyan, all flowering eucalypts in the landscape have the potential to be foraging habitat by grey-headed flying-fox. No roosting habitat is present. The nearest records are from Bedford Street in Queanbeyan (2017 & 2018), approximately 100 m and 200 m east of the Project Area. There are several other records within 2 km of the Project Area in Queanbeyan and Jerrabomberra. 2.37 ha of woodland in the Project Area (PCT 652 and PCT 133) excluding derived native grasslands have the potential to be utilised as foraging habitat by grey-headed flying fox. However, as roosting locations are not present, habitat present is consistent with that throughout the landscape.

Plate 3.7. The railroad under-pass providing potential roosting habitat for the large bent-winged bat (*Miniopterus orianae oceanensis*) and the eastern false pipistrelle (*Falsistrellus tasmaniensis*)

3.4.3 Migratory Species

No important habitat for migratory species was identified in the Project Area. Aerial species may utilise the airspace above the Project Area.

3.5 Threatened fish and aquatic ecology

No threatened aquatic species or communities listed under the FM Act were identified within the Project Area. The Queanbeyan River is listed as habitat for the Macquarie Perch, Endangered EPBC and FM (*Environmental Protection and Biodiversity Act 1999* and *Fisheries Management Act*) but is outside the study area and unlikely to be influenced from indirect impacts associated with the activity. Additionally, the desktop assessment identified the freshwater fish community status of Jerrabomberra Creek as listed as poor.

3.6 Areas of outstanding biodiversity value

No areas of outstanding biodiversity value occur within the Project Area.

3.7 Wildlife connectivity corridors

A wildlife corridor is a link of habitat, generally native vegetation, which joins two or more areas of similar wildlife habitat (DEC 2004). Corridors are critical for the maintenance of ecological processes including facilitating the movement of genes, individuals, species and populations and enabling the continuation of viable populations (DEC 2004; OEH 2011).

The Project Area is located between Jerrabomberra East Grasslands Nature Reserve and Queanbeyan Nature Reserve. The grassland earless dragon that occurs in Jerrabomberra East Nature Reserve (JENR) and Queanbeyan Nature Reserve (QNR) are considered as a belonging to a 'local population' as there are no impermeable barriers between these locations, noting that connectivity is disrupted by both Woods Lane, rail infrastructure and tree plantings. Genetic analysis indicates low levels of gene flow between populations in QNR and ACT. Maintaining or improving connectivity between these areas is likely to be important for the protection of this population of grassland earless dragon.

Queanbeyan Nature Reserve is mapped as part of a biodiversity corridor in DPIE's *South East and Tablelands Region Plan Corridors* map (DPIE 2017). This mapping identifies Queanbeyan Nature Reserve as a part of a larger network of reserves that stretch across the Southern Highlands and South Easter Tablelands. The network of nature reserves in the ACT likely add to this corridor and extend its function through to the system of national parks southwest of Canberra.

3.8 State Environmental Planning Policies

No State Environmental Planning Policies were identified as being potentially applicable to the biodiversity occurring in the Project Area.

3.9 Matters of National Environmental Significance

Table 3.14 identifies the matters of national environmental significance (MNES) assessed as likely to occur in the Project Area. With the exception of migratory species, a description of these MNES has been provided **Sections 3.3** and **3.4**. The extent of mapped threatened ecological communities is provided in **Figure 3.2**, threatened flora habitat and records in **Figure 3.4**, and threatened fauna habitat and records in **Figure 3.5**, **Figure 3.6**, **Figure 3.7** and **Figure 3.8**.

Table 3.14 Matters of national environmental significance in the Project Area

Species/ecological community	Status – EPBC Act	Occurrence
Threatened ecological communities		
Natural Temperate Grassland of the South Eastern Highlands	Critically endangered	Confirmed present (3.90 ha).
White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands	Critically endangered	Confirmed present (2.76 ha).
Threatened flora		
hoary sunray (*Leucochrysum albicans* var. *tricolor*)	Endangered	10,000+ individuals detected (1.09 ha presence).
button wrinklewort (*Rutidosis leptorhynchoides*)	Endangered	100+ individuals detected (0.42 ha).
Threatened fauna		
golden sun moth (*Synemon plana*)	Critically endangered	Confirmed habitat adjacent to site. 8.11 ha of habitat assumed present.
grassland earless dragon (*Tympanocryptis pinguicolla*)	Endangered	Confirmed habitat adjacent to site. 6.95 ha of habitat assumed present
pink-tailed worm-lizard (*Aprasia parapulchella*)	Vulnerable	Confirmed habitat adjacent to site. 0.08 ha of habitat assumed present
striped legless lizard (*Delma impar*)	Vulnerable	Confirmed habitat adjacent to site. 12.42 ha of habitat assumed present.
gang-gang cockatoo (*Callocephalon fimriatum*)	Endangered	2.37 ha of critical foraging habitat present.
superb parrot (*Polytelis swainsonii*)	Vulnerable	2.37 ha of potential foraging habitat present.
white-throated needletail (*Hirundapus caudacutus*)	Vulnerable, migratory	N/A
Migratory species – terrestrial		
white-throated needletail (*Hirundapus caudacutus*)	Vulnerable, migratory	N/A
pacific swift (*Apus pacificus*)	Migratory	N/A

** Foraging habitat only.*

4.0 Conclusion

A field based ecological assessment comprising vegetation community and zone mapping, vegetation condition assessment, threatened ecological community assessment and threatened species habitat assessment was completed. No targeted threatened fauna surveys were completed.

This ecological assessment identified 11.09 ha of native vegetation comprising:

- 3.09 ha of PCT 320 Kangaroo Grass - Redleg Grass forb-rich temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion in low and moderate-high condition
- 4.09 ha of PCT 1289 Wallaby Grass - Red-grass - Tall Speargrass - Kangaroo Grass dry tussock grassland of the North-western and Eastern Southern Tablelands in the South Eastern Highlands Bioregion in low and moderate-high condition
- 0.21 ha of PCT 654 Apple Box - Yellow Box dry grassy woodland of the South Eastern Highlands Bioregion in moderate-high condition
- 3.66 ha of PCT 1330 Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion in low, moderate-high, derived native grassland (low) and derived native grassland (moderate-high) condition.

The remainder of the Project Area supported exotic vegetation, bare ground or infrastructure such as roads or rail infrastructure.

Areas meeting diagnostic criteria for one BC Act listed threatened ecological communities was confirmed present in the Project Area:

- 3.91 ha of native vegetation conforming to diagnostic criteria for BC Act listed White Box - Yellow Box - Blakely’s Red Gum Grassy Woodland and Derived Native Grassland critically endangered ecological community.

Two EPBC Act listed threatened ecological communities were confirmed in the Project Area, with condition thresholds met as follows:

- 2.76 ha of native vegetation conforming to diagnostic criteria and condition thresholds for EPBC Act listed White Box – Yellow Box – Blakely’s Red Gum grassy woodlands and derived native grasslands critically endangered ecological community
- 3.90 ha of native grassland conforming to diagnostic criteria and condition thresholds EPBC Act listed Natural Temperate Grassland of the South Eastern Highlands critically endangered ecological community.

A total 19 threatened fauna species comprising 12 bird species, one invertebrate, three mammal species and three reptile species have either been recorded in the Project Area or were assessed as having a moderate or higher likelihood of occurrence in the Project Area. No targeted threatened species surveys were completed for the purposes of this assessment. Relevant local survey data has been reviewed and included for the purposes of assessing species potential to occur.

The following fauna habitat was identified in the project area:

- 2.37 ha of woodland foraging habitat for Gang-gang cockatoo (*Callocephalon fimbriatum*), listed as vulnerable under the BC Act and endangered under the EPBC Act; while no breeding habitat was detected foraging habitat would meet criteria for classification as critical habitat under the Commonwealth listing advice

- 8.11 ha of grassland habitat for golden sun moth (*Synemon plana*), listed as endangered under the BC Act and vulnerable under the EPBC Act

- 6.95 ha of grassland habitat for grassland earless dragon (*Tympanocryptis pinguicolla / lineata*) listed as critically endangered under the BC Act and endangered under the EPBC Act

- 0.08 ha of rocky grassland habitat for pink-tailed worm-lizard (*Aprasia parapulchella*) listed as vulnerable under both the BC Act and the EPBC Act

- 12.42 ha of grassland habitat for striped legless lizard (*Delma impar*) listed as vulnerable under both the BC Act and the EPBC Act.

Targeted surveys for the above species were not completed. However, on the basis of records in adjacent and continuous habitat areas, there is a high likelihood of these species occurring in identified habitat. Species-specific test of significance are recommended for the above species.

Breeding habitat for bird species dependent on large hollows, primarily gang-gang cockatoo and superb parrot is absent, as were large stick nests suitable for little eagle.

Highly mobile species with a moderate to high – likelihood of utilising the site, but for which the site does not support any specifically important habitat characteristics that distinguish it from habitat elsewhere in the landscape. Tests of significance for the following species may be grouped and completed in summarised form:

- 2.37 ha of potential foraging habitat for threatened mammal species large bent-winged bat, eastern false pipistrelle and grey-headed flying fox, as well as potential roosting habitat eastern false pipistrelle. A single wooden railroad underpass was assessed as potential non-breeding roosting location for large bent-winged bat, however no targeted survey was completed and no evidence of occupancy was recorded. No breeding habitat was present for large bent-winged bat.

- 2.37 ha of suitable habitat for threatened woodland birds.

Targeted surveys were not completed hence potential for occurrence is assumed only. It is unlikely that development in the project area would adversely impact the availability of habitat in the landscape for these species. Grouped tests of significance are recommended for these species.

Two threatened flora species were confirmed present in the Project Area:

- 1.10 ha supporting hoary sunray (*Leucochrysum albicans var. tricolor)*, listed as endangered under the EPBC Act

- 0.42 ha supporting button wrinklewort (*Rutidosis leptorhynchoides*), listed as endangered under both the EPBC Act and the BC Act.

Following site inspection and based on the level of survey effort completed along the linear Project Area, no other threatened flora is likely to be present in the Project Area.

Following confirmation of the proposed alignment, impact footprint and the nature of indirect impacts, the potential significance of impacts on NSW BC Act listed and EPBC Act listed entities should be assessed as follows:

- 5-part tests under the NSW BC Act are required to determine the significance of impact, and
- EPBC Act Assessment of Significance in accordance with Significant Impact Guidelines 1.1, including consideration of species or community specific guidelines and listing advice to ascertain if referral to the Minister of the Environment is warranted to determine if the proposed powerline would be a controlled action.

5.0 References

Capital Ecology 2020. Poplars Innovation Precinct (Stage 1) Jerrabomberra, NSW. Biodiversity Development Assessment Report.

Department of Agriculture, Water and the Environment (DoAWE) 2016. *Approved Conservation Advice (including listing advice) for Natural Temperate Grassland of the South Eastern Highlands* (EC 152). Canberra: Department of the Environment.

Department of the Environment (DoE) 2013. Matters of National Environmental Significance; Significant impact guidelines 1.1. Canberra: Department of the Environment.

Department of the Environment (DoE) Threatened Species Scientific Committee 2016. *Approved Conservation Advice (including listing advice) for Natural Temperate Grassland of the South Eastern Highlands* (EC 152). Canberra: Department of the Environment.

Department of the Environment (DoE) 2021. *Little Eagle* – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20131 on 27/03/2022.

Department of the Environment (DoE) 2021b. *Small Purple-pea* – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10782 on 27/03/2022.

Department of the Environment (DoE) 2021c. *Button Wrinklewort* – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10739#:~:text=The%20Button%20Wrinklewort%20is%20a,like%2C%20to%202%20cm%20wide on 27/03/2022.

Department of the Environment (DoE) 2021c. *White-throated Needletail* – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20354 on 27/03/2022.

Department of the Environment (DoE) 2022a. BioNet Vegetation Classification Database.

Department of the Environment (DoE) 2022b. *Gang-gang Cockatoo* – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10975 on 27/03/2022.

Department of the Environment (DoE) 2022. White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions – profile. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10837 on 27/03/2022.

Department of the Environment and Energy (DoEE) 2016. Natural Temperate Grassland of the South Eastern Highlands: a nationally protected ecological community. Canberra: Australian Government.

Department of Environmental and Climate Change (DoECC) 2007. Identification guidelines for endangered ecological communities: White box - yellow box – Blakely's red gum woodland.

Department of Environment and Conservation (DEC) 2004. *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft*. NSW Department of Environment and Conservation, NSW.

Department of Planning, Industry and Environment (DPIE) 2022. Biodiversity Assessment Method 2022. 1st ed. NSW: Environment, Energy and Science.

Department of Planning, Industry and the Environment (DPIE) 2017. *South East and Tablelands Region Plan Corridors*.

Department of Planning, Industry and the Environment (DPIE) 2020. White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions - Threatened species profile.

Environment, Planning and Sustainable Development (EPSD) 2019. *Superb Parrot Action Plan*. ACT Government, Canberra.

Jenkins, B.R. (2000) *Soil Landscapes of the Canberra 1:100 000 Sheet*. Department of Land and Water Conservation, Sydney.

Office of Environment and Heritage (OEH) 2011. *Corridors and connectivity: Conservation management note*. Office of Environment and Heritage, Sydney.

Department of Planning, Industry and the Environment (DPIE) 2017. *Threatened Species Profiles*. Obtained from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx

Department of Planning, Industry and the Environment (DPIE) 2018. Threatened Species Test of Significance Guidelines. Office of Environment and Heritage, Sydney.

Umwelt Australia 2021. Overview of Potential Ecological Constraints: Oaks Estate ACT and Environa NSW. Prepared for Essential Energy, Canberra ACT.

APPENDIX A

Likelihood of Occurrence Assessment

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Birds				
Oxyura australis	blue-billed duck	Vulnerable	-	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R (where the species is a rare / occasional visitor), approximately 4.5 km north-west of the Project Area.
Stictonetta naevosa	freckled duck	Vulnerable	-	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from ponds adjacent the Molonglo River approximately 800 m north of the Project Area, where the species is a very rare visitor (i.e., freckled duck has only been recorded in 2016 at this location). Freckled duck are also occasionally recorded at Jerrabomberra Wetlands N.R., approximately 4.5 km north-west of the Project.
Botaurus poiciloptilus	Australasian bittern	Endangered	Endangered	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R (2021), approximately 4.5 km north-west of the Project.
Circus assimilis	spotted harrier	Vulnerable	-	**Moderate**. There is suitable habitat present in the Project Area. The nearest records are from Jerrabomberra West Grasslands Nature Reserve (2013), approximately 2 km west of the Project Area and Jerrabomberra Creek (2012), approximately 3.5 km west of the Project Area. Spotted harrier may occasionally forage over any areas of grassland or derived native grassland in the Project Area particularly in the Queanbeyan N.R and adjacent Jerrabomberra East Grasslands Nature Reserve.
Haliaeetus leucogaster	white-bellied sea-eagle	Vulnerable	-	**Low**. There is no suitable habitat present in the Project Area. The nearest record is from 1 km east of the Project Area adjacent the Queanbeyan Lawn Cemetery in 2021. There is also a record 1 km south of the Project Area at Lake Jerrabomberra.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Hieraaetus morphnoides	little eagle	Vulnerable	-	**High**. There is suitable foraging habitat present in the Project Area. Little eagle have been recorded on several occasions within 2 km of the Project Area at locations in Queanbeyan N.R, Jerrabomberra West Grasslands N.R and Jerrabomberra East Grasslands N.R (the nearest record being approximately 500 m east of the Project Area). This species may hunt over any vegetation present in the Project Area but is highly unlikely to breed in the Project Area.
Falco hypoleucos	grey falcon	Endangered	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. This species is a vagrant in the south-east NSW / ACT region.
Falco subniger	black falcon	Vulnerable	-	**Low**. There is suitable foraging habitat in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R, approximately 4.5 km north-west of the Project Area (where the species is occasionally recorded) and from Newline Quarry (2021), approximately 2 km north of the Project Area. This species may hunt over any vegetation present in the Project Area but is highly unlikely to breed or be a regular visitor in the Project Area.
Limosa lapponica	bar -tailed godwit	-	Vulnerable	**Nil**. There is no suitable habitat present in the Project Area. The nearest record is from Jerrabomberra Wetlands N.R (2007), approximately 4.5 km north-west of the Project Area (where the species is a rare vagrant).
Calidris ferruginea	curlew sandpiper	-	Critically Endangered	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R, approximately 4.5 km north-west of the Project Area (where the species is occasionally recorded).
Numenius madagascariensis	far eastern curlew	-	Critically Endangered	**Nil**. There is no suitable habitat present in the Project Area. The nearest record is from Jerrabomberra Wetlands N.R (1989), approximately 4.5 km north-west of the Project Area (where the species is a rare vagrant).
Rostratula australis	Australian painted snipe	Endangered	Endangered	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R, approximately 4.5 km north-west of the Project Area (where the species is occasionally recorded).

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Callocephalon fimbriatum	gang-gang cockatoo	Vulnerable	Endangered	**High**. Box-gum woodland present in the Project Area comprises suitable foraging habitat. This species has been recorded at several locations in Queanbeyan and Jerrabomberra within 1 km of the Project Area. Gang-gang cockatoo are unlikely to breed in the Project Area.
Calyptorhynchus lathami	glossy black-cockatoo	Vulnerable	Endangered	**Low**. There is no suitable habitat present in the Project Area. Glossy black-cockatoo is a rare visitor to the Queanbeyan / Jerrabomberra area The nearest record is from Mt Jerrabomberra (2020) approximately 2 km east of the Project Area.
Glossopsitta pusilla	little lorikeet	Vulnerable	-	**Low**. There is suitable habitat present in the Project Area. The nearest record is from Newline Quarry (2012), approximately 2 km north of the Project Area. This species is an occasional visitor to the ACT and a rare visitor to the Queanbeyan / Jerrabomberra area. Given the quality and extent of the habitat present and the species' use of the Queanbeyan / Jerrabomberra area little lorikeet are unlikely to occur in the Project Area.
Polytelis swainsonii	superb parrot	Vulnerable	Vulnerable	**Moderate**. Box-gum woodland present in the Project Area comprises suitable foraging habitat. The nearest record is from Kendall Avenue, Queanbeyan, immediately adjacent the Project Area. Otherwise, there are few records in the Queanbeyan / Jerrabomberra area. Given the quality and extent of the habitat present and the species' use of the Queanbeyan / Jerrabomberra area superb parrot are likely to only rarely occur in the Project Area. Superb parrot is highly unlikely to breed in the Project Area.
Lathamus discolor	swift parrot	Endangered	Critically Endangered	**Moderate**. There is suitable habitat in the form of box-gum woodland present in the Project Area though given the quality and extent of the habitat present and the species' use of the Queanbeyan / Jerrabomberra area swift parrot is likely to only very rarely occur in the Project Area. The nearest record is from Newline Quarry (2010), approximately 2 km north of the Project Area. This species has also been recorded at Molonglo Gorge, Symonston, Callum Brae N.R (where up to 65 individuals were recorded in 2021) and Jerrabomberra Wetlands N.R.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Neophema pulchella	turquoise parrot	Vulnerable	-	**Low**. There is marginal habitat present in the Project Area though this species is unlikely to occur in the Project Area given its status in the Queanbeyan / Jerrabomberra area and the extent and quality of marginal habitat present. The nearest records are from Jerrabomberra Wetlands N.R, approximately 4.5 km north-west of the Project Area (where the species is occasionally recorded). During the past five years this species has also been recorded just east of Queanbeyan at Cuumbeun N.R (2021) and south of Queanbeyan at Googong Dam (2018).
Hirundapus caudacutus	white-throated needletail	-	Vulnerable, Migratory	**High**. White-throated needletail are likely to occur in the airspace of the Project Area regardless of the vegetation type present. The nearest records are approximately 700 m east of the Project Area in Queanbeyan (2009) and 800 m south of the Project Area in Jerrabomberra (2013). This species has also been recorded at Newline Quarry (2011, 2012), approximately 2 km north of the Project Area and at several locations within 2 km of the Project Area in central Queanbeyan.
Climacteris picumnus victoriae	brown treecreeper (eastern subspecies)	Vulnerable	-	**Low**. There is marginal habitat present in the Project Area. Due to the extent and quality of habitat present combined with the species' status in the Queanbeyan / Jerrabomberra area brown treecreeper are unlikely to occur in the Project Area. Brown treecreeper was resident (and regularly recorded) at Newline Quarry, approximately 2 km north of the Project Area, until about 2013. Similarly, this species was formerly fairly regularly recorded at Callum Brae N.R until the late 2000s.
Chthonicola sagittata	speckled warbler	Vulnerable	-	**Moderate**. There is suitable habitat in the form of box-gum woodland present in the Project Area which is likely to be occasionally utilised by speckled warbler dispersing to and from larger patches of woodland in the Queanbeyan / Jerrabomberra area. The nearest records are from Jerrabomberra (2011), approximately 800 m south of the Project Area; Newline Quarry (where the species is resident), approximately 2 km north of the Project Area; and at Jerrabomberra West Grasslands N.R (where the species is also resident), approximately 2.3 km west of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Melithreptus gularis gularis	black-chinned honeyeater (eastern subspecies)	Vulnerable	-	**Low**. There is marginal habitat present in the Project Area. Given the species' status as a vagrant in the ACT black-chinned honeyeater are highly unlikely to occur in the Project Area. The nearest records are from Newline Quarry, approximately 2 km north of the Project Area where a single flock was observed during June and July 2007. The only other record in the ACT is from Campbell Park, adjacent Mt Ainslie, also in June 2007.
Grantiella picta	painted honeyeater	Vulnerable	Vulnerable	**Low**. There is suitable habitat in the form of box-gum woodland present in the Project Area though given the quality and extent of the habitat present and the species' status in the Queanbeyan / Jerrabomberra area painted honeyeater are unlikely to occur in the Project Area. The nearest records are from near Googong Dam (1977) approximately 6 km south-east of the Project Area; and from Campbell Park (recorded during several years, most recently in 2020), approximately 8 km north-west pf the Project Area.
Anthochaera phrygia	regent honeyeater	Endangered	Critically Endangered	**Low**. There is suitable habitat in the form of box-gum woodland present in the Project Area though given the quality and extent of the habitat present and the species' status in the Queanbeyan / Jerrabomberra area regent honeyeater are unlikely to occur in the Project Area. The nearest records are from Symonston (2019), approximately 4 km west of the Project Area and from Callum Brae (1976 and 2004), approximately 5 km west of the Project Area.
Petroica boodang	scarlet robin	Vulnerable	-	**High**. There is suitable habitat in the form of box-gum woodland present in the Project Area. Given the species' status in the Queanbeyan / Jerrabomberra area scarlet robin are likely to occasionally occur in the Project Area especially during periods when individuals are dispersing through the region. The nearest records are from Queanbeyan Cemetery (2016), approximately 1 km east of the Project Area; Jerrabomberra Mountain Reserve (several records across multiple years), approximately 2 km east of the Project Area; Jerrabomberra West Grasslands Nature Reserve (2007, 2017 & 2019), approximately 2 km west of the Project Area and Jerrabomberra (2014), approximately 800 m south of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Petroica phoenicea	flame robin	Vulnerable	-	**High**. There is suitable habitat in the form of box-gum woodland, derived native grassland and native and exotic grassland present in the Project Area. Given the species' status in the Queanbeyan / Jerrabomberra area flame robin are likely to occasionally occur in the Project Area especially during periods when individuals are dispersing through the region. Flame robin has been recorded immediately adjacent the Project Area (i.e., within 200 m) on Wood's Lane in 2017 and in Queanbeyan N.R in 2019.
Melanodryas cucullata cucullata	hooded robin (south-eastern form)	Vulnerable	-	**Low**. There is marginal habitat present in the Project Area though due to the extent and quality of habitat present combined with the species' status in the Queanbeyan / Jerrabomberra area hooded robin is unlikely to occur in the Project Area. The nearest record is from Queanbeyan N.R, adjacent the Project Area in 1998 at a time when the species was more prevalent in the Canberra / Queanbeyan area. The next closest record is from Newline Quarry (2005), approximately 2 km north of the Project Area. The nearest location where this species is still occasionally recorded is the western foreshore of Googong Dam, approximately 8 km south-east of the Project Area.
Daphoenositta chrysoptera	varied sittella	Vulnerable	-	**Moderate**. There is suitable habitat in the form of box-gum woodland present in the Project Area. Given the species' status in the Queanbeyan / Jerrabomberra area varied sittella are likely to occasionally occur in the Project Area especially whilst individuals / groups are dispersing between larger habitat patches such as those mentioned below. The nearest records are from Newline Quarry (where the species is resident), approximately 2 km north of the Project Area; Jerrabomberra Mountain Reserve (1998, 2006 & 2007), approximately 1.5 km east of the Project Area; Jerrabomberra West Grasslands N.R (2005, 2017), approximately 2 km west of the Project Area and Callum Brae N.R (where the species is resident), approximately 4 km west of the Project Area.
Pachycephala olivacea	olive whistler	Vulnerable	-	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from Griffith (1962), approximately 8 km north-west of the Project Area and from the Australian National Botanic Gardens (the most reliable site for the species in Canberra where it has been recorded during at least 1976, 2008, 2015 & 2017), approximately 11.5 km north-west of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Artamus cyanopterus cyanopterus	dusky woodswallow	Vulnerable	-	**Known**. There is suitable habitat in the form of box-gum woodland and grassland present in the Project Area. Dusky woodswallow was recorded in the Project Area adjacent Wood's Lane during the site assessment in September 2021. This species has also been recorded on several occasions within 500 m of the Project Area at Mike's Hill, in Jerrabomberra East Grasslands N.R in 2015 and 2021, at Queanbeyan N.R in 1998, 2013 & 2014 and in woodland in the small section of Queanbeyan N.R just south of the Queanbeyan Race Club in 2016.
Stagonopleura guttata	diamond firetail	Vulnerable	-	**High**. There is suitable habitat in the form of box-gum woodland and grassland present in the Project Area. Given the extent and quality of habitat present in the Project Area combined with the status of this species in the Queanbeyan / Jerrabomberra area diamond firetail are highly likely to occur in the Project Area. The nearest record is from Oaks Estate (2018), approximately 600 m north of the Project Area. Diamond firetail have also been recorded at Newline Quarry (recorded across multiple years), approximately 2 km north of the Project Area and at Jerrabomberra West Grasslands N.R (recorded across multiple years), approximately 2 km west of the Project Area.
Pycnoptilus floccosus	pilotbird	-	Vulnerable	**Low**. There is no suitable habitat present within the Project Area. Pilotbird very rarely occur in urban and peri-urban areas of Canberra and Queanbeyan. The nearest records are from Kingston and Parkes (2007 & 1984), approximately 6 km north-west of the Project Area, and another 13 km north-west at Black Mountain (2014).
Fish				
Bidyanus bidyanus	silver perch	-	Critically Endangered	**Nil**. There is no suitable habitat present in the Project Area.
Maccullochella macquariensis	trout cod	-	Endangered	**Nil**. There is no suitable habitat present in the Project Area.
Maccullochella peelii	Murray cod	-	Vulnerable	**Nil**. There is no suitable habitat present in the Project Area.
Macquaria australasica	Macquarie perch	-	Endangered	**Nil**. There is no suitable habitat present in the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Amphibians				
Litoria aurea	green and golden bell frog	Endangered	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. The nearest extant population is located in the Carwoola area, at least 15 km east of the Project Area. Closer records from the Queanbeyan and Canberra areas are historic.
Litoria booroolongensis	Booroolong frog	Endangered	Endangered	**Low**. There is no suitable habitat present in the Project Area. The nearest record is from Uriarra Crossing (1979) approximately 25 km north-west of the Project Area.
Litoria castanea	yellow-spotted tree frog,	Critically Endangered	Critically Endangered	**Low**. There is no suitable habitat present in the Project Area. There are no contemporary records of this species in the ACT or the Southern Tablelands. There is no known extant population of the yellow-spotted bell frog in the region.
Litoria raniformis	growling grass frog	Endangered	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There are no contemporary records of this species in the ACT or the Southern Tablelands aside from a record in the Yass area in 2009.
Invertebrates				
Synemon plana	golden sun moth	Endangered	Vulnerable	**High**. Suitable habitat in the form of native and exotic grassland containing feed species is present in the Project Area. Golden sun moth is present at multiple locations adjacent the Project Area. Golden sun moth has been recorded in the south-eastern corner of Harman (most recently in 2021), in woodland in the small section of Queanbeyan N.R just south of the Queanbeyan Race Club (2008), at multiple locations elsewhere in Queanbeyan N.R south of Hoover Road (across multiple years) and Jerrabomberra East Grasslands N.R (across multiple years) and immediately north and south of Tompsitt Drive (2019). A large area of suitable habitat is mapped in ACTmapi adjacent the Project Area at Jerrabomberra East Grasslands N.R.
Mammals				
Dasyurus maculatus maculatus (SE mainland population)	spot-tailed quoll	Vulnerable	Endangered	**Low**. There is no suitable habitat present in the Project Area. Spot-tailed quoll very rarely occur in urban and peri-urban areas of Canberra and Queanbeyan. The nearest records are from near Googong Dam (1984 & 1986), approximately 7 km south-east of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Petauroides volans	greater glider	-	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There are no historic or contemporary records of greater glider within 20 km of the Project Area.
Petaurus australis australis	yellow-bellied glider (south-eastern)	-	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There are no historic or contemporary records of greater glider within 20 km of the Project Area.
Petrogale penicillata	brush-tailed rock-wallaby	Endangered	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. The nearest record is from Kambah Pool in 1968, approximately 16 km west of the Project Area.
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)	koala	Vulnerable	Endangered	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from Cuumbeun N.R (several records in the 2010s) east of Queanbeyan, between 4 and 7 km east of the Project Area.
Pteropus poliocephalus	grey-headed flying-fox	Vulnerable	Vulnerable	**Moderate**. There is suitable foraging habitat in the form of box-gum woodland in the Project Area. The nearest records are from Bedford Street in Queanbeyan (2017 & 2018), approximately 100 m and 200 m east of the Project Area. There are several other records within 2 km of the Project Area in Queanbeyan and Jerrabomberra.
Chalinolobus dwyeri	large-eared pied bat	-	Vulnerable	**Low**. There is marginal habitat present in the Project Area. There are no records in the ACT or in the Queanbeyan area.
Falsistrellus tasmaniensis	eastern false pipistrelle	Vulnerable	-	**Moderate**. There is suitable habitat in the form of box-gum woodland in the Project Area. The nearest records are from Ellerton Drive (2019), approximately 5 km east of the Project Area and adjacent Hume (2020), approximately 4.5 km south-west of the Project Area.
Miniopterus orianae oceanensis	large bent-winged bat	Vulnerable	-	**Moderate**. There is suitable habitat in the form of box-gum woodland in the Project Area. The nearest records are from Queanbeyan (two historic records), approximately 2 km east of the Project Area, adjacent Hume (2020), approximately 4.5 km south-west of the Project Area and adjacent Jerrabomberra (2015), approximately 3 km south of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Reptiles				
Aprasia parapulchella	pink-tailed worm-lizard	Vulnerable	Vulnerable	**High**. There are restricted areas of suitable rocky habitat present in the Project Area. The nearest record is 800 m south-west of the Project Area. There are many records along the Jerrabomberra Creek corridor south and south-west of Jerrabomberra between 2.3 and 4 km south of the Project Area and several records south of Hume approximately 3.8 km south-west of the Project Area.
Delma impar	striped legless lizard	Vulnerable	Vulnerable	**High**. There is suitable habitat in the form of native grassland, exotic grassland and derived native grassland present in the Project Area. Grassland in portions of Jerrabomberra East Grasslands N.R adjacent Woods Lane and grassland in the south-eastern portion of Block 2236 adjacent Woods Lane comprises mapped striped legless lizard habitat (ACTmapi 2022).
Tympanocryptis pinguicolla	grassland earless dragon	Endangered	Endangered	**Known**. There is suitable habitat in the form of native grassland in the Project Area. Grassland earless dragon have been recorded at multiple locations within 200 m of the Project Area at Jerrabomberra East Grasslands N.R. The closest record, from 2018, is less than 10 m west of the Project Area (i.e., between Woods Lane and the western boundary of the Project Area). Grassland earless dragon also occur in Queanbeyan N.R and have been recorded during the 2000s in native grassland at locations north-east of Tompsitt Drive and south-east of Lanyon Drive.
Varanus rosenbergi	Rosenberg's goanna	Vulnerable	-	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from Karabar, Cuumbeun N.R and Greenleigh between 4 and 7 km east of the Project Area.
Flora				
Rutidosis leptorhynchoides	button wrinklewort	Endangered	Endangered	**Known.** Button wrinklewort was recorded at two locations in the Project Area during the site assessment in September 2022. This species is also known to occur adjacent the Project Area at Harman, on the Woods Lane verge adjacent Harman and Block 2236, in woodland in the small section of Queanbeyan N.R just south of the Queanbeyan Race Club, elsewhere at Queanbeyan N.R south of Hoover Road and at Jerrabomberra East Grasslands N.R.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Senecio macrocarpus	large-fruit fireweed	-	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There are no records in the Canberra / Queanbeyan area.
Leucochrysum albicans* subsp. *tricolor	hoary sunray	-	Endangered	**Known.** Hoary sunray were recorded at five discrete areas in the Project Area during the site assessment**.** The extent of hoary sunray occupancy at these locations was recorded and mapped. This species is also known to occur just north of the Project Area at Beard, in the small section of Queanbeyan N.R just south of the Queanbeyan Race Club, elsewhere at Queanbeyan N.R south of Hoover Road and in native grassland east of the intersection of Lanyon Drive and Tompsitt Drive.
Calotis glandulosa	mauve burr-daisy	Vulnerable	Vulnerable	**Low**. There is suitable habitat present in the Project Area. This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The sole record in the Queanbeyan / Jerrabomberra record is from Queanbeyan N.R (2019).
Lepidium aschersonii	Spiny Pepper-cress	-	Vulnerable	**Low**. The Project Area is outside the known range of the species. This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The nearest known occurrence of this species is in Temora 180 km north-west of the Project Area.
Lepidium ginninderrense	Ginninderra peppercress	-	Vulnerable	**Low**. There is marginal habitat present in the Project Area. This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The nearest known occurrence of this species is in Jerrabomberra East Grasslands N.R.
Lepidium hyssopifolium	basalt pepper-cress	Endangered	Endangered	**Low**. There is marginal habitat present in the Project Area. This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The nearest record is in the small section of Queanbeyan N.R south of the Queanbeyan Race Club approximately 250 m west of the Project Area.
Swainsona recta	small purple-pea	Endangered	Endangered	**Low**. There is suitable habitat present in the Project Area This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. Three historic records from Queanbeyan represent the only records from near the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Swainsona sericea	silky swainson-pea	Vulnerable	-	**Low**. There is suitable habitat present in the Project Area This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The nearest records are from Jerrabomberra West Grasslands N.R (2005, 2015) and adjacent the Monaro Highway (2020), approximately 2 km west of the Project Area.
Eucalyptus aggregata	black gum	Vulnerable	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There is marginal habitat present in the Project Area There is one record in the Queanbeyan / Jerrabomberra area from Greenleigh in 1999.
Caladenia actensis	Canberra spider orchid	-	Critically Endangered	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from Mt Ainslie and adjacent Sutton Road, approximately 10 km north-west and 8 north-east of the Project Area respectively.
Prasophyllum petilum	Tarengo leek orchid	Endangered	Endangered	**Low**. There is no suitable habitat present in the Project Area. There is marginal habitat present in the Project Area The nearest records are from Hall, more than 20 km north-west of the Project Area.
Amphibromus fluitans	river swamp wallaby-grass	-	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. There are no records in the Canberra / Queanbeyan area.
Muehlenbeckia tuggeranong	Tuggeranong lignum	-	Endangered	**Low**. There is no suitable habitat present in the Project Area. There is marginal habitat present in the Project Area. The nearest records are from the Murrumbidgee River corridor approximately 12 km south-west of the Project Area.
Pomaderris pallida	pale pomaderris	Vulnerable	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. The nearest records are from the Queanbeyan River above Queanbeyan approximately 6 km east of the Project Area.
Thesium australe	Austral toadflax	Vulnerable	Vulnerable	**Low**. There is marginal habitat present in the Project Area This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The nearest record is from the Murrumbidgee River corridor approximately 12 km south-west of the Project Area.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Dodonaea procumbens	trailing hop-bush	Vulnerable	Vulnerable	**Low**. There is no suitable habitat present in the Project Area. This species was not recorded during the vegetation assessment conducted in the Project Area in September 2021. The sole record in the Queanbeyan / Jerrabomberra area is from the southern section of Jerrabomberra East Grasslands N.R in 1999.
Migratory				
Pandion haliaetus	osprey		Migratory	**Nil.** There is no suitable habitat present in the Project Area. The nearest record is from Giralang Pond (2011), approximately 18 km north-west of the Project Area.
Actitis hypoleucos	common sandpiper	-	Migratory	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Lake Tuggeranong (where a single individual has been recorded regularly since 2019), approximately 10 km south-west of the Project Area.
Calidris acuminata	sharp-tailed sandpiper	-	Migratory	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R, approximately 4.5 km north-west of the Project Area where the species is a rare / occasional visitor.
Limosa lapponica	bar-tailed godwit	-	Migratory	**Nil**. There is no suitable habitat present in the Project Area. The nearest record is from Jerrabomberra Wetlands N.R (2007), approximately 4.5 km north-west of the Project Area (where the species is a rare vagrant).
Calidris melanotos	pectoral sandpiper	-	Migratory	**Nil**. There is no suitable habitat present in the Project Area. The nearest records are from Jerrabomberra Wetlands N.R (2007), approximately 4.5 km north-west of the Project Area (where the species is a rare visitor).
Gallinago hardwickii	Latham's snipe	-	Migratory	**Low**. There is marginal habitat present in the Project Area. The nearest record is from adjacent Railway Street, Oaks Estate (2021), approximately 300 m north of the Project Area. This species has also been recorded in Jerrabomberra East Grasslands N.R (2018).

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Likelihood of Occurrence
Hirundapus caudacutus	white-throated needletail	-	Vulnerable, Migratory	**High**. White-throated needletail are likely to occur in the airspace of the Project Area regardless of the vegetation type present. The nearest records are approximately 700 m east of the Project Area in Queanbeyan (2009) and 800 m south of the Project Area in Jerrabomberra (2013). This species has also been recorded at Newline Quarry (2011, 2012), approximately 2 km north of the Project Area and at several locations within 2 km of the Project Area in central Queanbeyan.
Apus pacificus	Pacific swift	-	Migratory	**Moderate**. Pacific swift is likely to occasionally occur in the airspace of the Project Area. The nearest records are from near Mt Jerrabomberra (2020), approximately 1.2 km east of the Project Area and Symonston (2019 & 2021), approximately 4 km west of the Project Area.
Rhipidura rufifrons	rufous fantail	-	Migratory	**Low**. There is marginal habitat present in the Project Area. The nearest records are from Mt Jerrabomberra (2018), approximately 2.2 km east of the Project Area and Callum Brae N.R (2018), approximately 5.5 km west of the Project Area.
Monarcha melanopsis	black-faced monarch	-	Migratory	**Low**. There is marginal habitat present in the Project Area. The nearest record is from Molonglo Gorge (2020), approximately 3.7 km north-east of the Project Area.
Myiagra cyanoleuca	satin flycatcher	-	Migratory	**Low**. There is marginal habitat present in the Project Area. The nearest record is from Lake Jerrabomberra (2017), approximately 1.2 km south of the Project Area and Callum Brae N.R (2016 & 2017), approximately 5.5 km west of the Project Area.
Motacilla flava	yellow wagtail	-	Migratory	**Nil.** There is no suitable habitat present in the Project Area. This species has not been recorded in the Canberra / Queanbeyan area.

gunninah

PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

ECOLOGICAL ISSUES & ASSESSMENT REPORT

ATTACHMENT C
AREA 2023 REPORT

F Dominic Fanning

May 2023

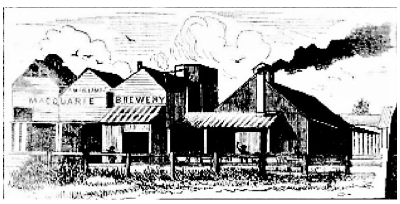
132 KV POWERLINE: ECOLOGICAL OBSERVATION OF / FOR:

Grassland Earless Dragon Potential Avian Predators
Golden Sun Moth
Pink-tailed Worm-lizard

ALONG THE SOUTH JERRABOMBERRA SECTION

South Jerrabomberra, NSW and ACT
Report to Essential Energy Pty Ltd

March 2023



AREA - Biodiversity | Heritage | Landscape Design
a: “The Old Macquarie Brewery” c1876, 72 Brisbane Street, Dubbo, NSW, 2830
e: phil@areaenv.com.au
w: www.areaenvironmental.com.au
Instagram: areaenvironmental

AREA Environmental & Heritage Consultants ABN:29 616 529 867

- Environmental impact assessment, auditing, and approvals
- High level preliminary environmental assessment (PEA)
- Review of environmental factors (REF)
- Peer review
- Community engagement
- Biobanking and biodiversity offsetting assessments
- Aboriginal heritage assessments and community walkovers
- Landscape architecture and design

AREA Environmental & Heritage Consultants acknowledge Traditional Custodians of the country on which we work.

Document controls

Proponent	Essential Energy
Client	Essential Energy
Project No / Purchase Order No	RE00049313
AREA Job No.	QU-0874
Document Description	132 KV POWERLINE: ECOLOGICAL OBSERVATION OF / FOR: - Grassland Earless Dragon Potential Avian Predators - Golden Sun Moth - Pink-tailed Worm-lizard ALONG THE SOUTH JERRABOMBERRA SECTION South Jerrabomberra, NSW and ACT Report to Essential Energy Pty Ltd February 2023
Clients Representative Managing this Document	Brett Hayward Environmental Services Manager
AREA Person(s) Managing this Document	Phil Cameron (PJC) Managing Director
Cover image	View west over Jerrabomberra East Grasslands Nature Reserve with kangaroo exclusion fencing

Document Status	Version	Date	Action
DRAFT (Internal document)	V1.0	22.03.2023	PJC to RM
DRAFT (AREA / Client)	V2.0 V2.1	23.03.2023	AREA to client Client Edits
FINAL	V3.0	7.05.2023	Final to Client
	V3.1		To Client

Prepared For	Brett Hayward Environmental Services Manager **Essential Energy** 0409 603 005
Prepared By	Phillip Cameron / Director **AREA Environmental & Heritage Consultants Pty Ltd** 72 Brisbane Street Dubbo NSW 2830 E: phil@areaenv.com.au ABN: 29 616 529 867

Executive summary

Essential Energy propose to construct a 132 kV powerline from the TransGrid Queanbeyan substation in Oaks Estate ACT along a disused railway corridor to a new substation in Environa, NSW (the proposal). Approximately eight kilometres of the proposal is in NSW and 300 metres is in the ACT.

This report provides additional information to supplement the Umwelt Environmental & Social Consultants (Umwelt) September 2022 ecology report for the proposal. Specifically, it considers potential harm to Grassland Earless Dragon (*Tympanocryptis lineata*) within habitat polygons mapped, and where uncertainty occurred with the proposal potentially enabling avian predators by providing additional perching / hunting platforms (Figures 1-1 to 1-4).

This report also provides additional survey effort results for Golden Sun Moth (*Synemon plana*) and Pink-tailed Worm-lizard (*Aprasia parapulchella*) within habitat polygons mapped by Umwelt (2022), (Figures 1-1 to 1-4).

The study area is along the Woods Lane to Environa (South Jerrabomberra) section.

AREA Environmental & Heritage Consultants (AREA) undertook the survey over two days in ideal species detection weather / season / times of day for all three species using a suitably qualified and experienced ecologist with a working knowledge of all three species in the locality, and an experienced assistant.

Potential harm to a viable local population of Grassland Earless Dragon by the proposal was considered a negligible risk.

This professional opinion is based on review of literature concerning powerline and bird interactions provided by Essential Energy, peer review scientific articles on potential predator candidates focusing on aspects of the behaviour, foraging and their habitat use, field observations and by considering the interrelationships between density of native Eastern Grey Kangaroos (*Macropus giganteus)*, and grass structure, and reptiles (i.e., abundance, richness, diversity and occurrence).

The ACT Government recognises and effectively manages this risk in the Jerrabomberra East Grasslands Nature Reserve by providing kangaroo exclusion fencing. This fencing provides grassland structural complexity needed by a viable local population of Grassland Earless Dragon to avoid aerial predators even though some aerial predators i.e., Australian Magpies (*Gymnorhina tibicen*) use it as perching habitat to hunt. Overall, the conservation benefit of the exclusion fencing to the population of Grassland Earless Dragon significantly outweighs risk to individuals.

Within the NSW Queanbeyan Nature Reserve, the same survey effort was applied as per the ACT areas. This reserve does not have the benefit of kangaroo exclusion fencing as its ACT counterpart. Street lighting along the Tompsitt Drive and Lanyon Drive intersections and roads on its eastern boundary provides structures upon which an Australian Kestrel (*Falco cenchroides*), a known lizard predator, uses as an elevated hunting platform in late afternoons. Observations / autecology of this Australian Kestrel showed while it uses elevated artificial structures for hunting, the majority of food taken (including a skink) was from short managed / mown grassland within the road reserve or within the immediate proximity in the same grassland.

In conclusion, while certain avian predators may hunt Grassland Earless Dragon and use artificial structures as hunting platforms, it is considered unlikely the proposal would alter the balance of nature to cause population decline.

The habitat in NSW and ACT areas of interest are managed for conservation, whereby the structural integrity and complexity of the grassland affords the most important attributes for predator evasion.

Table of Contents

Figures

Tables

1 Introduction

Essential Energy propose to construct a 132 kV powerline from the TransGrid Queanbeyan substation in Oaks Estate ACT along a disused railway corridor to a new substation in Environa NSW (The proposal). Approximately eight kilometres of the proposal is in NSW and 300 metres is in the ACT.

This report provides additional information to supplement the Umwelt Environmental & Social Consultants (Umwelt) September 2022 ecology report for the proposal. Specifically, it considers potential harm to Grassland Earless Dragon (*Tympanocryptis lineata*) from avian predators assuming the proposed powerline provides additional perching / hunting platforms. This report also provides additional opportunistic survey effort results for Golden Sun Moth (*Synemon plana*) and Pink-tailed Worm-lizard (*Aprasia parapulchella*) along the Woods Lane to Environa (South Jerrabomberra) section (Figures 1-1 to 1-4).

The habits, behaviour, habitat use and hunting behaviour of avian predators which may prey upon Grassland Earless Dragon have been described in general terms, but with little or no quantification of home-range size, detailed habitat use, or activity budgets of the sexes. Due to limitations of the contract; some aspects of the birds' habitat use and foraging behaviour, in terms of perching substrates, daily activity, diet was considered in the broadest sense and professional judgement has been applied.

To inform this report, dietary studies, quantified aspects of habitat use, foraging behaviour and daily activity for potential avian predators were reviewed and the relationship of how birds use powerlines was considered.

The survey season and times used to watch potential avian predators were also ideal for detecting Golden Sun Moth and Pink-tailed Worm-lizard, these species were also subject to targeted assessments.

The author of this report has completed another environmental impact project for the Grassland Earless Dragon in 2020 in the Jerrabomberra East Grasslands Nature Reserve specifically considering the risk of harm to this species, has undertaken substantive research and monitoring experience of the Barrier Range Dragon (*Ctenophorus mirrityana*) a comparable similar sized dragon species which has directly comparable avian predator risks, substantive and ongoing experience with Pink-tailed Worm-lizard research and monitoring from 2016 to now, and more general consulting environmental impact assessment experience for Golden Sun Moth. Recent survey experience includes two major assessments (about 200 kilometres long) in grasslands observing powerline and potential small lizard predator relationships.

2 Study area and method

Section 2.3.1 of Umwelts Environmental & Social Consultants in 2022 report provides detail and justification of habitat assessments for threatened species identified as having a moderate or higher likelihood of occurring in the Project Area. Habitats for Grasslands Earless Dragon, Pink-tailed Worm-lizard and for Golden Sun Moth were subsequently mapped as habitat polygons in their report reflecting consistency with the NSW Biodiversity Assessment Method (2020).

This report agrees Umwelt (2022) can be relied upon for their mapping and justification for each species likelihood of occurrence.

The environment of the Project Area and surrounds has been described elsewhere by Umwelt (2002) and by others in peer review papers and the national Recovery Plan for Grassland Earless Dragon mentioned in this report.

2.1 Desktop assessment

Umwelt (2022) was reviewed and considered.

Before the field assessment a review of an Essential Energy internal document '*Avian interaction with powerlines and potential consequences August 2022*' by Brett Hayward was undertaken and considered.

This document considers the influence of powerline structures on predation efficiency, location, perch availability, powerline design / operation, and predator height preference. The summary of this document is there are a number of factors which must be considered when assessing the potential impact of any development, and the influence they may have on natural predation processes.

For the current proposal, being a grassland, avian species best adapted to hunting Grassland Earless Dragon within it are pouncers (Magpies) who by default need to be closer to the ground i.e., on a fence post to negotiate grassy habitat complexities, rather than soaring (Birds of prey) risks.

The author read Essential Energy (2022) before assessing a proposed telecommunication cable within PCT52 – *Queensland Bluegrass +/- Mitchell Grass grassland on cracking clay floodplains and alluvial plains* which follows a 132kV powerline from Moree to Gurley NSW and used this insight to inform his opinion. The trip to and from Dubbo was also used opportunistically to make similar observations. Similarly other work to Ivanhoe in far western NSW and back was used to make the same opportunistic observations.

A review of the following scientific articles, publications / guidance material or reputable websites occurred. A synthesis of these resources or their executive summaries are provided below:

1. **National Recovery Plan for the Grassland Earless Dragon *Tympanocryptis pinguicolla.*** Robertson, P. and Evans, M. (2009/2012). National Recovery Plan for the Grassland Earless Dragon *Tympanocryptis pinguicolla*. As varied October 2012. ACT Department of Territory and Municipal Services, Canberra.
    a. Sustained high intensity grazing that leaves little or no ground cover is likely to be detrimental to Grassland Earless Dragons, particularly in areas with few surface rocks.
    b. Grassland Earless Dragons use grass tussocks for shelter (both diurnally and nocturnally), as a refuge from predators, and shady tussocks with open inter-tussock spaces are probably important for thermoregulation.

c. The impact of native predatory birds is not understood in areas where cover has been removed through overgrazing, slashing or burning, or where artificial perches (posts, fences, buildings) are present.
d. Fences and other structures (e.g., posts, antennas, marker stakes) should be minimised within Grassland Earless Dragon habitat to avoid providing perching sites for predatory birds. It noted that in some circumstances, fencing may be necessary for other recommended management of Grassland Earless Dragon habitat, in particular, grazing to maintain structural or floristic attributes of habitat.
e. Artificial perches (posts) for predatory birds in grasslands have been identified as a potential threat.
f. Currently, the best available information on managing habitat is to manage native grasslands to prevent further degradation (i.e., loss of plant species diversity, maintenance of tussock structure, control weeds) and to minimise the impacts of feral and native predators on Grassland Earless Dragons.

2. **Home ranges of, and habitat use by, the grassland earless dragon (*Tympanocryptis pinguicolla*) in remnant native grasslands near Canberra.** Toni A. Stevens, Murray C. Evans B , William S. Osborne and Stephen D. Sarre. Australian Journal of Zoology, 2010, **58,** 76–84.
   a. burrows excavated by arthropods are an important resource for grassland earless dragons, with individuals having one or two home burrows around which they maintained home ranges of between 925 m^2 and 4768 m^2
   b. Fidelity to these burrows increased with the onset of winter, indicating their importance as over-winter refuge sites.
   c. Within the native grasslands, grassland earless dragons were found to use a broad range of grassland structure as habitat. This result contrasts with the prevailing view that these dragons are confined to well drained, minimally disturbed areas, which include large patches of short grass dominated by *Austrodanthonia*.
   d. They concluded habitat management (i.e., grazing, mowing, burning) for this species should aim to retain structural heterogeneity of native grasslands rather than impose a uniform structure
3. **Eaten Out of House and Home: Impacts of Grazing on Ground-Dwelling Reptiles in Australian Grasslands and Grassy Woodlands.** Brett Howland, Dejan Stojanovic, Iain J. Gordon, Adrian D. Manning, Don Fletcher, David B. Lindenmayer. PLOS ONE | DOI:10.1371/journal.pone.0105966 1 / 25 December 11, 2014 December 11, 2014.
   a. Changes in grazing intensity (i.e., grass structure) significantly affected reptile abundance, reptile species richness, reptile species diversity, and the occurrence of several ground-dwelling reptiles.
   b. Reptile abundance, species richness and diversity were highest where grazing intensity was low.
   c. Importantly, no species of reptile was more likely to occur at high grazing intensities.
   d. Legless lizards (*Delma impar, D. inornata*) were more likely to be detected in areas subject to moderate grazing intensity, whereas one species (*Hemiergis talbingoensis*) was less likely to be detected in areas subject to intense grazing
   e. Three species (*Menetia greyii, Morethia boulengeri, and Lampropholis delicata*) did not appear to be affected by grazing intensity.
4. **Diet of Nankeen Kestrels *Falco cenchroides* at Brisbane Airport**. Elliot Leach, Darryl Jones, James McBroom and Rob Appleby. Australian Field Ornithology 2015, **32**, 15–25.

a. The majority of the prey items were orthopteran insects, which occurred in 94% of the sampled stomachs, and in greater numbers than any other prey taxon.
b. 1.7% of the sampled stomachs were reptiles (skink).
c. 0.6% of the sampled stomachs were house mouse.
d. In my opinion, Nankeen Kestrels is a candidate threat to Grassland Earless Dragon and needs to be considered. The Nankeen Kestrel is also a predator of Barrier Range Dragon which the author has extensive hands-on experience with.

5. **Breeding and Diet of the Little Eagle *Hieraaetus morphnoides* in Central Queensland** Keith D. Fisher. Australian Field Ornithology 2010, **27**, 119–127.
    a. The breeding diet was 80% lizards and 20% small birds by number (n = 10) at two nests in one year.
    b. The lizard was in the vast majority Bearded Dragons *Pogona* sp with one Pogona sp and one Gidgee Skink *Egernia stokesii.*
    c. In my opinion, Little Eagle is NOT a candidate threat to Grassland Earless Dragon due to its size / hunting reward for the predator.
6. **Breeding Biology and Diet of the Little Eagle *Hieraaetus morphnoides* in the New England Region of New South Wales**. S.J.S. Debus, T.S. Hatfield , A.J. Ley and A.B. Rose. Australian Field Ornithology 2007, **24**, 137–157.
    a. The breeding diet at three nests near Armidale (on the Northern Tablelands of NSW) was 78% mammals (70% Rabbits *Oryctolagus cuniculus*), 13% birds and 4% reptiles by number (plus 4% unidentified bird/mammal), and 94% mammals (80% Rabbits), 5% birds and 1% reptiles by biomass (n = 23 prey items).
    b. Tree Dragon *Amphibolurus muricatus* and Eastern Bearded Dragons *Pogona barbata* were the prey items.
    c. In my opinion, Little Eagle is NOT a candidate threat to Grassland Earless Dragon due to its size / hunting reward for the predator. Rabbit populations are important for this species.
7. **Breeding Diet at Two Whistling Kite Nests near Canberra.** Esteban Fuentes, Jerry Olsen and A.B. Rose. Australian Field Ornithology 2005, **22**, 122- 125.
    a. The Kites consumed animals of five different major taxa: mammals, birds, reptiles, fish and insects. Birds (43.6% by number and 33.3% of biomass) and mammals (41.0 and 57.4% respectively) dominated the diet, with the European Rabbit *Oryctolagus cuniculus* the most common prey item (25.6%, n = 10) as well as the one that contributed most to the dietary biomass (36.1%).
    b. Several large food items were identified, which indicates that either the local Whistling Kites rely heavily on carrion during the breeding season or that they hunt larger prey than previously thought; both possibilities contrast with what is currently reported for the species.
    c. Reptiles taken included Cunningham's Skink *Egemia cunninghamii*, Eastern Brown Snake *Pseudonaja textilis* and Eastern Blue-tongued Lizard *Tiliqua scincoides.*
8. In my opinion, Whistling Kite is NOT a candidate threat to Grassland Earless Dragon due to its size / hunting reward for the predator. Rabbit populations are important for this species.
9. **Foraging, Habitat Use and Nesting of the Black-shouldered Kite *Elanus axillaris* in the Australian Capital Territory**. Tanya Barnes. Australian Field Ornithology 2005, **22**, 58- 66.
    a. The male foraged hovering grassland with numerous perches, mostly by quartering and hovering, and caught only mice (presumably House Mice *Mus*

domesticus), captured by drop-attacks; he delivered 4-5 mice per day to the nest-building female.

   b. The male spent most of his time perching, on exposed perches, but foraged in bouts of about two hours morning and afternoon (for 4 h/day)
   c. The female spent most of her time on the nest.
   d. In my opinion, Black-shouldered Kite is NOT a candidate threat to Grassland Earless Dragon, as it prefers mice populations which are important for this species.

10. **A comparison of the diets of the Black-shouldered Kite *Elanus axillaris* and Nankeen Kestrel *Falco cenchroides* in the Canberra region**. Leah R. Tsang, A. B. Rose, Esteban J. Fuentes, Jerry Olsen, Susan Trost, Paul G. McDonald. Corella, 2017, **41**: 27-31.
    a. The kite's diet comprised mostly small mammals (93% by mass); the kestrel consumed mainly invertebrates (86.1% by number), as well as some mammals, birds and reptiles (collectively 94.8% by mass).
    b. Both species can coexist as the kite has a bigger tarsi therefore it can tackle larger prey and therefore does not really compete. Both prey upon mice.
    c. In my opinion, Black-shouldered Kite is NOT a candidate threat to Grassland Earless Dragon, but Nankeen Kestrel is. Mice populations are important for both species.
11. **Behaviour of the Little Raven *Corvus mellori* on Phillip Island Victoria**. Nora Swinburne and Rosalind Jessop. Australian Field Ornithology 2005, **22**, 137-145.
    a. Ravens forage mid-morning and mid-afternoon.
    b. Insects are 72% of the diet, berries 17%, carrion 16% and human related scrap 3%.
    c. In my opinion, Little Raven is a low-risk candidate threat to Grassland Earless Dragon. The risk is associated for Ravens are their ability to walk though grasslands and feed between tusks.
12. **Australian Magpie** *Gymnorhina tibicen.* (https://animalia.bio/australian-magpie)
    a. Australian magpies are omnivorous. They eat invertebrates, a wide variety of insects and other larvae. Their diet may also include skinks, frogs, mice, and other small animals as well as grain, tubers, figs, and walnuts.
    b. In my opinion, Australian Magpie is a risk candidate threat to Grassland Earless Dragon. The risk is associated with their ability to perch on low posts / fences and walk though grasslands and feed between tusks.
13. **Pied Butcher Bird** (https://australian.museum/learn/animals/birds/pied-butcherbird
    a. Butcherbirds are carnivorous, preying on small lizards and birds.
    b. It is an aggressive feeder, preying on small reptiles, mammals, frogs and birds, as well as large insects. Most food is caught on the ground. The birds sit on an exposed perch and swoop down on their prey. Hunting groups may consist of several birds from a large group or may also hunt alone or in pairs.
    c. In my opinion, Pied Butcher Bird is a risk candidate threat to Grassland Earless Dragon. The risk is associated with its ability to use perching habitat to predate on items between grass tusks.
14. **Brown Falcon** (https://australian.museum/learn/animals/birds/brown-falcon/)
    a. Brown Falcons are usually seen alone, searching for food from an exposed perch. When prey is sighted, the bird swoops down and grasps it in its claws (talons), killing the prey with a bite to the spine. The powerful bill has specialised 'tomial' teeth and matching notches for this purpose. Less often the species will hunt by hovering or gliding over the ground, often at great heights.

Brown Falcons feed on small mammals, insects, reptiles and, less often, small birds.

b. In my opinion, Brown Falcon is a NOT risk candidate threat to Grassland Earless Dragon because there is very little risk / reward for a bird of this size (mice provide better rewards).

15. **Pied Currawong** (https://australian.museum/learn/animals/birds/pied-currawong/) feed on a variety of foods including small lizards, insects, caterpillars and berries. They also take a large number of small and young birds, especially around urban areas where suitable cover is scarce.
    a. In my opinion, Pied Currawong is a risk candidate threat to Grassland Earless Dragon because of its versatile ability to use habitats in the area.

2.2 Field assessment

Observations of potential avian predators of Grassland Earless Dragon were conducted from an unconcealed position on the ground by walking up the two kilometre long unsealed section of Woods Lane between Jerrabomberra East Grasslands Reserve and the Queanbeyan Nature Reserve and back again on 6 and 7 February 2023. The transect followed the alignment of the Proposal. Once this transect was complete a second viewing event occurred along Tompsitt Drive to undertake further observations.

Three 4km transects (two km each way) were walked a day, followed by stationary vehicle based observations at Tompsitt Drive. Each observation event was repeated and occurred at:

1. Dawn to 1130am (5 hours) – the morning assessment
2. 1pm to 3pm (2 hours) – mid-afternoon assessment
3. 4pm to dusk (3.5 hours) – late afternoon assessment

The assessment times were developed to be as consistent with those undertaken in peer review bird related literature reviewed for this project and from personal experience to allow effective surveying in peak bird detecting times (dawn) and during suitable ambient temperatures between 16 and 45°C in Canberra (Nelson 2004). The temperature consideration was linked to Grassland Earless Dragon activity i.e., if they are active then aerial predators of interest should be also active and observed. Similarly, the same temperature rule of thumb applies to Pink-tailed Worm-lizard (with a cut off about 35 degrees) but the hottest part of the day applies to the Golden Sun Moth.

10x42 Binoculars were used for the assessment and two suitably qualified and / or experienced assessors did the assessments.

The observation occurred recording the species, what it was doing when first observed i.e., fly over, perching or hunting and what it was perching on and at the time of the day. Regular ambient temperatures were noted so the assessor could be consistently aware of the activity periods of the Grassland Earless Dragon. Each observation was essentially capturing a moment in time. A new observation record would only occur when the species being observed moved to a new location doing another activity. For example, an Australian Magpie perching in an exotic pine tree was one record but when it flew to the kangaroo exclusion fence to perch it was another record and when it pounced on prey or walked though grassland to hunt it was another record.

The Tompsitt Drive viewing point was selected as built infrastructure (streetlights) occurred immediately adjacent to native grassland habitats and areas of potential occupancy mapped by Umwelt (2022) for the Grasslands Earless Dragon. This assessment occurred from within a parked car as walking in this area was ‘not normal’ and altered the behaviour of the resident kestrel. The vehicle was placed to have a good field of vision and was moved occasionally as required to increase the effectiveness of the survey without changing the bird's behaviour[1].

The transect was walked along the unsealed section of Woods Lane on the eastern boundary of Jerrabomberra East Grasslands Reserve was used to consider any interaction of potential predatory birds with grassland habitats. This track is publicly accessible and people on foot or on bicycles were commonly encountered. Being on foot did not alter animal (bird) behaviours.

Collectively two 10.5 hours days' worth of observations were made in areas mapped by Umwelt as candidate habitat for the three target species. Suitable rocks for Pink-tailed Worm-lizard were looked under during the assessment.

[1] About no less than 100m was the 'safe distance'

Figure 2-1: Location of mapped Grassland Earless Dragon habitat along the subject land

Image source: Essential Energy 2023

Figure 2-2: Location of mapped Grassland Earless Dragon habitat along the subject land

Image source: Essential Energy 2023

Figure 2-3: Location of mapped Grassland Earless Dragon habitat along the subject land

Image source: Essential Energy 2023

Figure 2-4: Location of mapped Grassland Earless Dragon habitat along the subject land

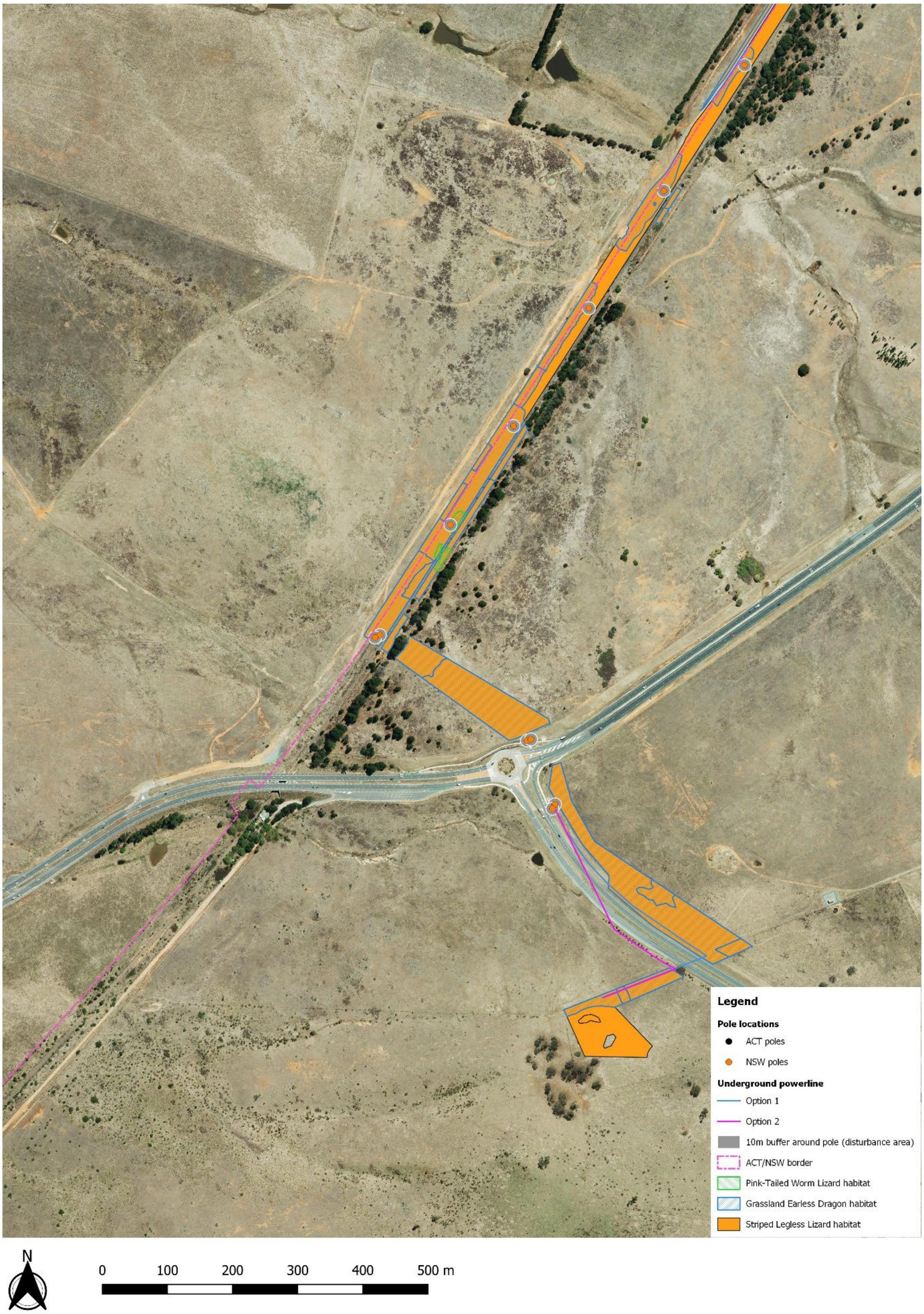


Image source: Essential Energy 2023

3 Results

3.1 Species of birds observed

20 species of birds were observed over two days between dawn and dusk, of which four have potential to predate upon Grassland Earless Dragon (Table 1).

Table 1: Diurnal species observed showing potential aerial predators

Common name	Scientific name	Predation risk to Grassland Earless Dragon?
Australian Raven	*Corvus coronoides*	Yes
Galah	*Eolophus roseicapilla*	No
Australian Magpie	*Gymnorhina tibicen*	Yes
Crested Pigeon	*Ocyphaps lophotes*	No
Starlings (feral sp)	*Sturnus vulgaris*	No
Wedge-tailed Eagle	*Aquila audax*	No
Australian Kestrel	*Falco cenchroides*	Yes
Eastern (Green-headed) Rosella	*Platycercus eximius*	No
Spotted Pardalote	*Platycerys elegans*	No
Double-barred Finch	*Taeniopygia bichenovii*	No
Superb Fairywren	*Malurus cyaneus*	No
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	No
Black-shouldered Kite	*Elanus axillaris*	No
Black-faced cuckooshrike	*Black-faced cuckooshrike*	No
Magpie-lark	*Grallina cyanoleuca*	No
Crimson Rosella	*Platycerys elegans*	No
Willy Wagtail	*Rhipidura leucophrys*	No
Rufus Whistler	*Pachycephala rufiventris*	No
Grey Fantail	*Rhipidura albiscapa*	No
Black-faced Woodswallow	*Artamus cinereus*	No
Pied Currawong	*Strepera graculina*	Yes

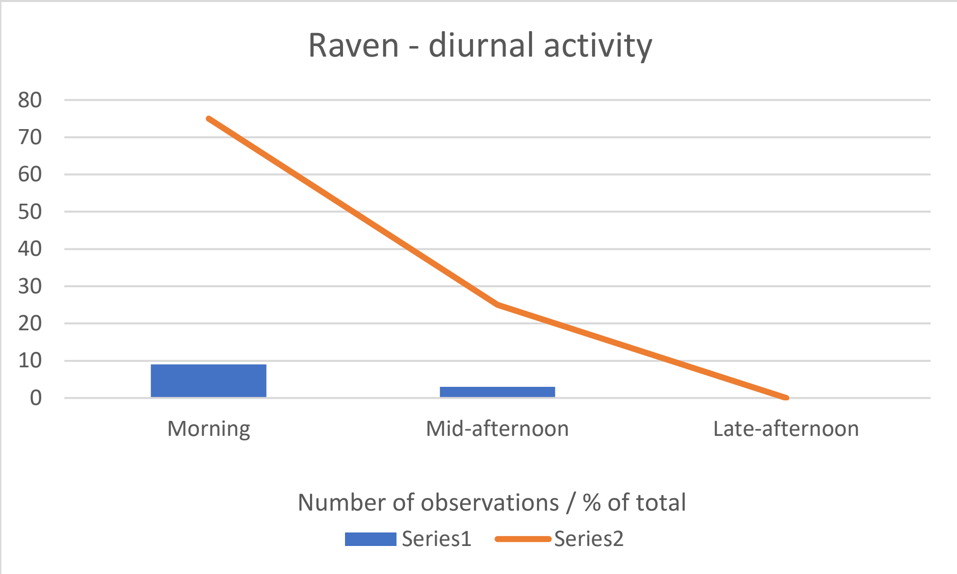
Additional information of the Australian Raven, Australian Magpie and Australian Kestrel have been provided in following sections.

3.2 Australian Raven

3.2.1 Diurnal activity

In total the Australian Raven was observed on 12 occasions (some individuals but mostly as groups) over two days. 75 per cent of the observations were in the morning and the remaining 25 per cent were mid-afternoon (Table 2).

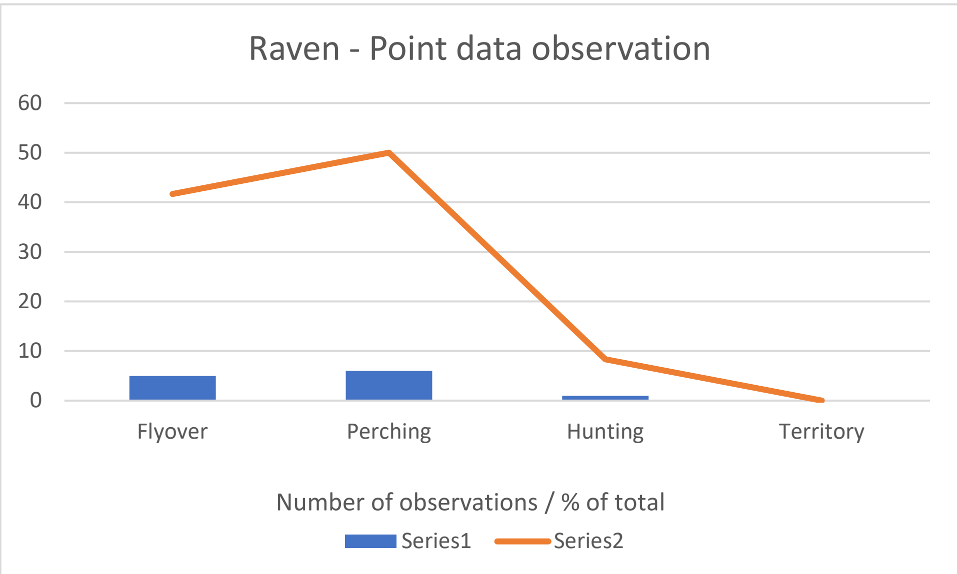
Table 2: Australian Raven diurnal activity



3.2.2 Activity being undertaken when observed

50 per cent of all observation were Australian Ravens perching, 41.7 per cent flying over the study area and 8.3 per cent hunting / foraging for food (Table 3).

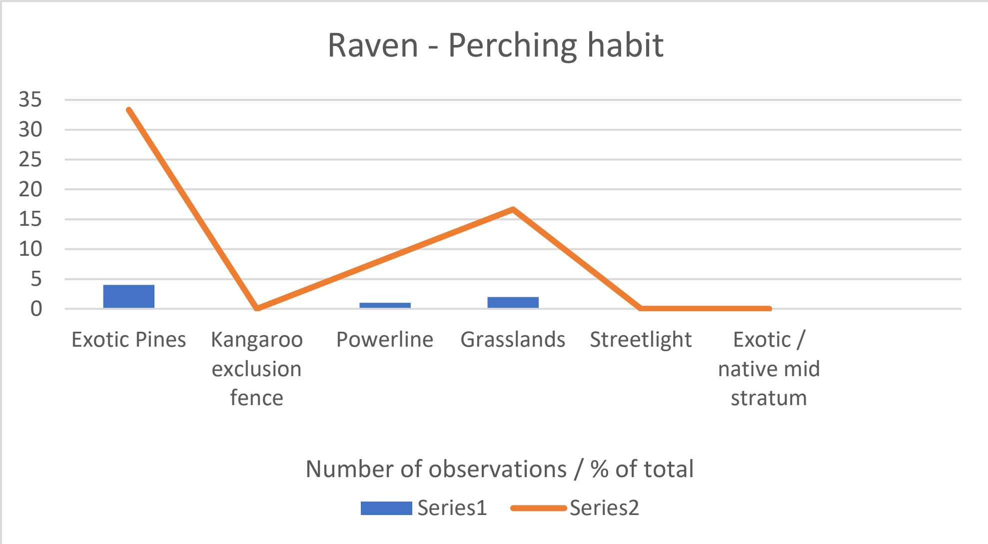
Table 3: Australian Raven behaviour activity



3.2.3 Perching habits when observed

Australian Raven was most often observed perching in exotic pine trees (*Pinus radiata*) being 33.3 per cent of perching habitat recorded. Walking through or standing in grasslands was the next most frequent perching platform (16.7 per cent) and powerlines least most frequently observed (8.3 per cent), Table 4.

Table 4: Australian Raven perching habits

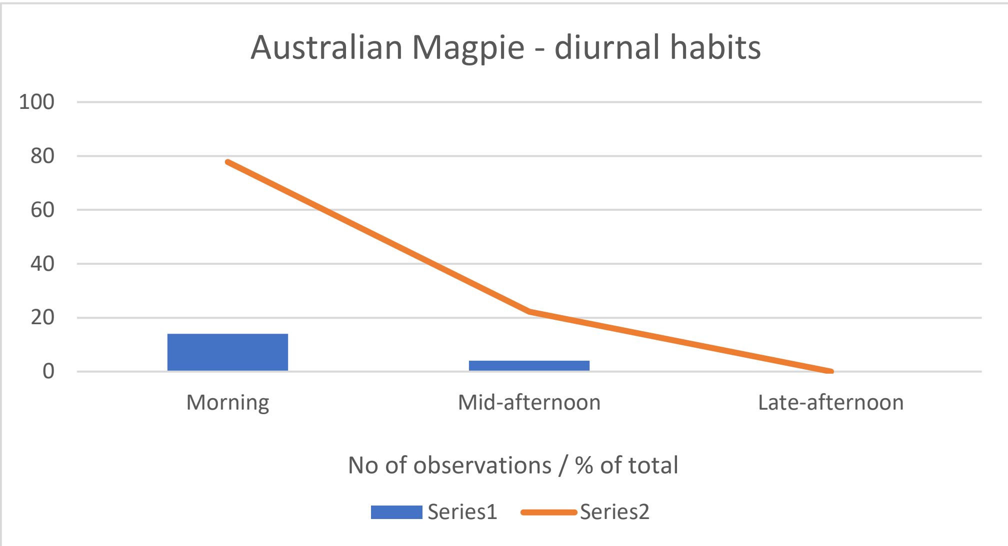


3.3 Australian Magpie

3.3.1 Diurnal activity

In total the Australian Magpie was observed on 18 occasions (some individuals but mostly as family groups or in pairs) over two days. 77.8 per cent of the observations were in the morning and the remaining 22.2 per cent were mid-afternoon (Table 5).

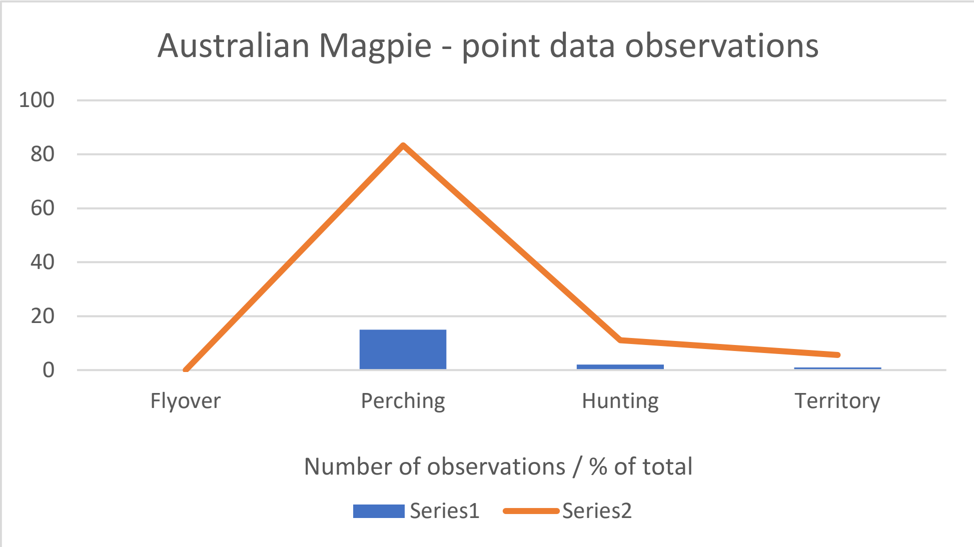
Table 5: Australian Magpie diurnal activity



3.3.2 Activity being undertaken when observed

Australian Magpies were perching in 83.3 per cent of all observations. They were hunting / foraging for food 11.1 per cent and instigating territorial disputes on 5.6 per cent of all observations (Table 3).

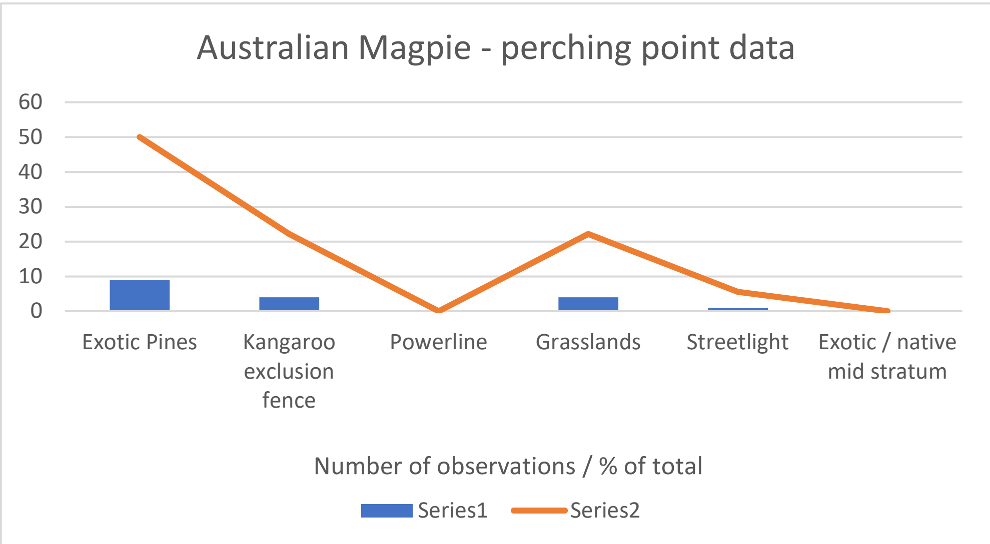
Table 6: Australian Magpie behaviour activity



3.3.3 Perching habits when observed

Australian Magpies were most often observed perching in exotic pine trees (*Pinus radiata*) being 50 per cent of perching habitat recorded. Perching upon the Kangaroo exclusion fence occurred in 22.2 per cent of all observations which directly preceded walking through or standing within native grasslands on 22.2 per cent of all occasions, Table 7. The Australian Magpie was observed perching on a street light on one occasion.

Table 7: Australian Magpie perching habits

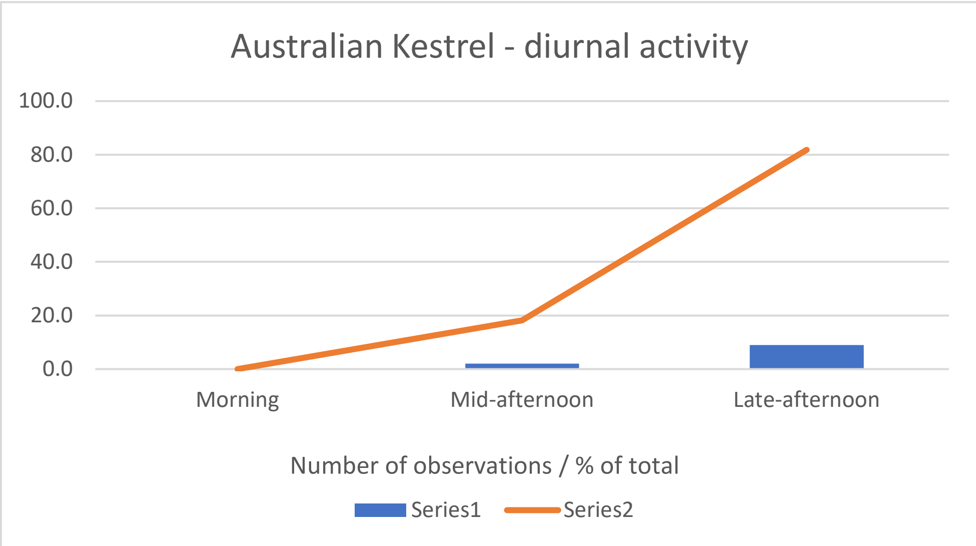


3.4 Australian Kestrel

3.4.1 Diurnal activity

In total the Australian Kestrel were observed on 11 occasions (two individuals, both in distinctly separate territories) over two days. They were not observed in the morning, infrequently during the mid-afternoon (18.2 per cent) and most commonly in the late-afternoon (81.8 per cent), Table 8.

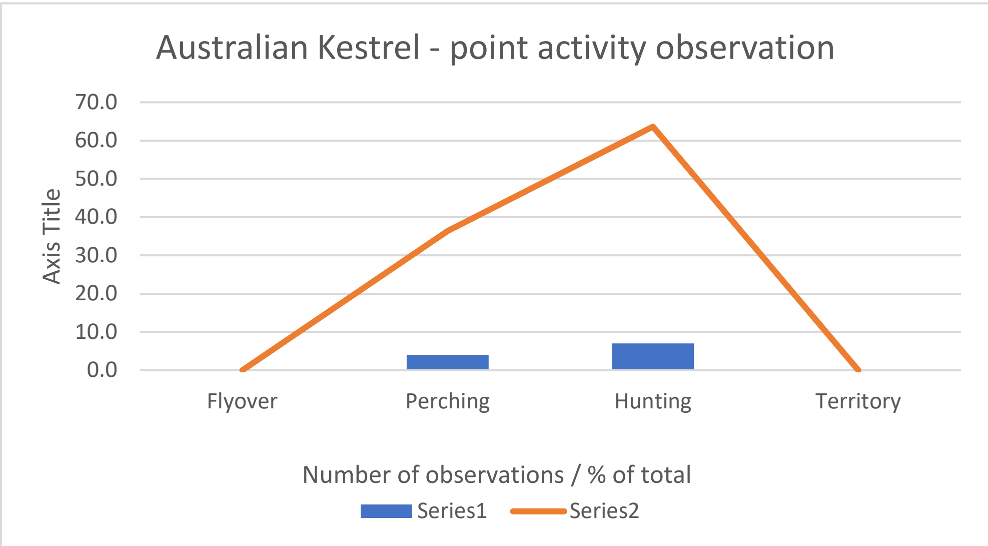
Table 8: Australian Kestrel diurnal activity



3.4.2 Activity being undertaken when observed

Australian Kestrel was actively hunting in 63.6 per cent of all observations. They were perching in 36.4 per cent of all observations with their hunting grounds (Table 9).

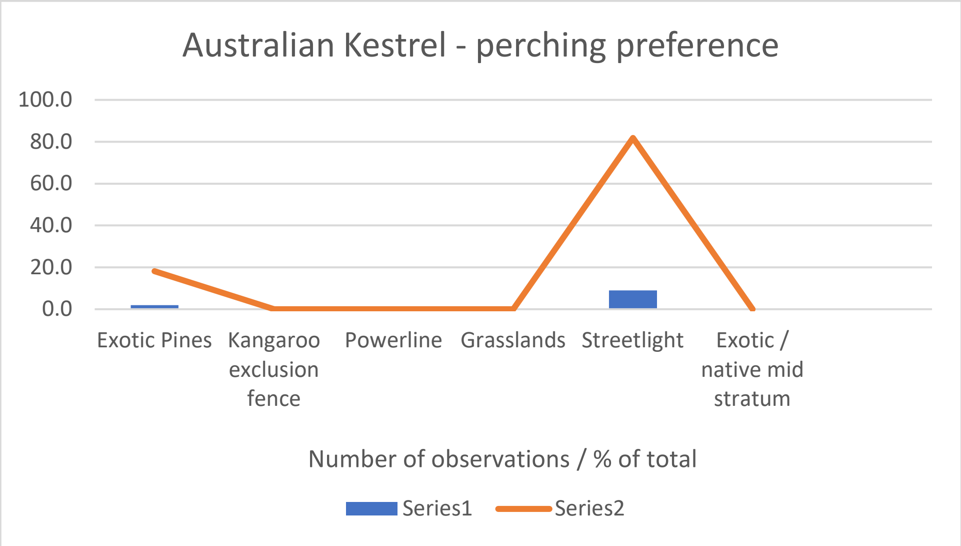
Table 9: Australian Kestrel behaviour activity



3.4.3 Perching habits when observed

The Australian Kestrel was most often observed perching on the headlamp of street lights along Tompsitt Drive (81.8 per cent) and within exotic pine trees (*Pinus radiata*) being 18.2 per cent of perching habitat recorded. Perching upon the street lights was directly related to hunting within native grasslands, Table 10.

Table 10: Australian Kestrel perching habits



3.5 Pied Currawong

3.5.1 Diurnal activity

In total one individual Pied Currawong was seen once over two days in the mid-afternoon.

3.5.2 Activity being undertaken when observed

The Pied Currawong was harassing an Australian Kestrel who abandoned its prey (likely a house mouse) and took it.

3.5.3 Perching habits when observed

The Pied Currawong was observed leaving exotic pine trees (*Pinus radiata*) and taking the prey from an Australian Kestrel within another stand of exotic pine trees.

3.6 Pink-tailed worm-lizard

No Pink-tailed worm-lizards were recorded under suitable rocks within the proposal along the Woods Lane to Environa (South Jerrabomberra) section.

3.7 Golden Sun Moth

No Golden Sun Moths were recorded within the proposal along the Woods Lane to Environa (South Jerrabomberra) section.

4 Discussion

4.1 Personal potential bird predator observations with respect to Essential Energy (2022)

Essential Energy (2022) considered the influence of powerline structures on predation efficiency, location, perch availability, powerline design / operation, and predator height preference. In this document Essential Energy stated there were a number of factors which must be considered when assessing the potential impact of any development, and the influence they may have on natural predation processes.

Before mobilising to do the field assessment for this job the author read Essential Energy (2022) before assessing a proposed telecommunication cable within PCT52 – *Queensland Bluegrass +/- Mitchell Grass grassland on cracking clay floodplains and alluvial plains* which follows a 132kV powerline from Moree to Gurley NSW and used this insight to inform his opinion. The proposed telecommunications cable assessment was undertaken three weeks before this assessment. The assessor travelled to Ivanhoe in far western NSW (Dubbo – Hay – Ivanhoe due to localised flooding) before returning two days before this assessment (Ivanhoe - Cobar – Dubbo) and used all desktop knowledge to consider powerline and bird interactions along these routes.

The author of this report agrees with Essential Energy (2022) that 'pouncers' especially the Australian Magpie are the most likely risks to Earless Grassland Dragon and adds Australian Kestrel is an ever-present risk for small dragon type lizards within native grasslands and more broadly open woodland communities. Neither Australian Magpie nor Australian Kestrel were observed using the powerline as a hunting platform, the Australian Kestrel favoured trees and lower artificial platforms (road signs, posts etc) and the Australian Magpie favoured lower trees, shrubs, farming infrastructure such as fence posts / stockyards, low outcropping rock etc.

With respect to Australian Kestrel and Australian Magpie, they are collectively the most likely predators of Earless Grasslands Dragon and construction of a powerline adjacent to its habitat is unlikely to result in a significant impact to a viable local population as a number of factors need to be considered when assessing the potential impact of any development, and the influence they may have on natural predation processes. The powerline is merely one factor to consider but it is not "the factor" likely to change the balance of nature when assessing the potential impact of the development.

4.2 Grassland complexity

Howland, Stojanovic, Gordon, Manning, Fletcher, and Lindenmayer (2014) studied Eucalyptus woodland communities across south-eastern Australia in 18 properties across the Australian Capital Territory, two in New South Wales and two in Victoria where temperate grassland and grassy Eucalyptus woodland communities remain. Their study is therefore directly comparable for the current matter. The understorey they assessed was largely dominated by native perennial grasses (e.g., *Austrostipa* spp., *Bothriochloa macra*, *Rytidosperma* spp., *Themeda triandra*), and exotic perennial grasses were locally abundant at some locations (e.g. *Eragrostis curvula, Phalaris aquatica*). The species mix of grasses in their study areas are directly comparable to this proposal.

They concluded changes in grazing intensity (i.e., grass structure) significantly affected reptile abundance, reptile species richness, reptile species diversity, and the occurrence of several ground-dwelling reptiles and reptile abundance. Species richness and diversity were highest where grazing intensity was low. Importantly, no species of reptile was more likely to occur at high grazing intensities.

The National Recovery Plan for the Grassland Earless Dragon states sustained high intensity grazing leaving little or no ground cover is likely to be detrimental to Grassland Earless Dragons, particularly in areas with few surface rocks. This is consistent with Howland, Stojanovic, Gordon, Manning, Fletcher, and Lindenmayer (2014) and adds Grassland Earless Dragons use grass tussocks for shelter (both diurnally and nocturnally), as a refuge from predators, and shady tussocks with open inter-tussock spaces are probably important for thermoregulation. In my opinion both documents provide evidence showing structural complexity of the grassland is a key attribute or “the factor” needed for the survival of a locally viable population of Grassland Earless Dragon.

The National Recovery Plan for the Grassland Earless Dragon highlights the impact of native predatory birds is not understood in areas where cover has been removed through overgrazing, slashing or burning, or where artificial perches (posts, fences, buildings) are present. The key issues here are the words *’where cover has been removed’* therefore supporting structural complexity of the grassland is “the factor” needed for the survival of a locally viable population of Grassland Earless Dragon.

The National Recovery Plan for the Grassland Earless Dragon also states fences and other structures (e.g., posts, antennas, marker stakes) should be minimised within Grassland Earless Dragon habitat to avoid providing perching sites for predatory birds. This was observed to be true especially for the Australian Magpie who used either kangaroo exclusion fence or other similar structures within the grasslands as hunting platforms.

The National Recovery Plan for the Grassland Earless Dragon stated (at the time) the best available information on managing habitat is to manage native grasslands to prevent further degradation (i.e., loss of plant species diversity, maintenance of tussock structure, control weeds) and to minimise the impacts of feral and native predators on Grassland Earless Dragons. This also supports structural complexity of the grassland is a key attribute needed for the survival of a locally viable population of Grassland Earless Dragon.

4.3 Locally occurring observed birds which are likely Grassland Earless Dragon predators

Four locally occurring bird species observed during this assessment were considered likely to Grassland Earless Dragon predators, being Australian Raven, Australian Magpie, Australian Kestrel and Pied Currawong. Collectively exotic pine trees were more commonly used as perching habitat than any other substrate.

The active period for all birds in summer overlaps with the Grassland Earless Dragon activity period between 16 and 45°C in Canberra (Nelson 2004). The nuances of reptile thermoregulation introduce a range of variables but in the broadest sense during summer all four bird species and the Grassland Earless Dragon may be present and active at the same time. It is unlikely the Grassland Earless Dragon activity would occur from dusk to dawn in any other season of the year therefore their exposure to potential bird predators would be those active in the warmest parts of the day (mid-afternoon). All four species of potential avian predators were observed mid-afternoon.

All four species were observed hunting in grasslands;

- Australian Kestrel was actively hunting 63 per cent of all observations with the remaining 36.4 per cent was them perching while hunting.

- Australian Magpie actively hunted 11.1 per cent of all observations but perching on the Kangaroo exclusion fence or within grasslands occurred 44.4 per cent of the time, presumably passively hunting (i.e., also preening, sunning themselves etc. at the same time).
- Australian Raven actively hunted in 8.3 per cent of all observations. The relatively low amount of actively time hunting may indicate ease of obtaining other food i.e., blackberries locally and carrion (Kangaroo road kill) along the road.
- The Pied Currawong was only seen once when it took prey (likely a house mouse) from an Australian Kestrel. Overall, the Kangaroo exclusion fence, posts etc. would be more suited for Grassland Earless Dragon hunting for this species than a powerline.

The Australian Magpie is the most likely / consistent Grassland Earless Dragon predator of all those assessed in this report.

The only species of potential bird predator observed using a powerline was the Australian Raven. When hunting in an environment where Grassland Earless Dragon could be taken, this species was observed walking though native grassland, therefore powerlines are an unlikely hunting platform for this species. Overall, the Kangaroo exclusion fence, posts etc. would be more suited for hunting Grassland Earless Dragon than a powerline.

The Australian Kestrel, a prolific hunter, predominately used street lights along Tompsitt Drive as hunting platforms but was not observed using powerline infrastructure in any other observations related to this or the telecommunications cable assessment by the author in the preceding weeks. When observed hunting in grasslands, the Australian Kestrel was most commonly observed in trees, on posts, road signs or other rural infrastructure. Within the Essential Energy study area for this matter the Australian Kestrel predominantly divebombed prey within maintained grass areas within or immediately next to the road corridor. The Australian Kestrel was also occasionally observed in this matter hunting over areas of grassland in its natural state. In the area of native grasslands associated with the telecommunications cable the Australian Kestrel has similar perch, watch, hover, then dive bomb hunting behaviour but within areas with less grassland structural complexity. Overall, the existing streetlights are a known hunting platform potentially for hunting Grassland Earless Dragon and the variables, if a power line was constructed, would be:

- reptiles are not a major component of their diet,
- they are territorial and will maintain the territory (the powerline is unlike to result in more Kestrel per hectare),
- the species is less of a risk to a local viable population of Grassland Earless Dragon than Australian Magpie; and
- structural complexity of the grassland is “the factor” needed for the survival of a locally viable population of Grassland Earless Dragon.

4.4 Pink-tailed worm-lizard

No Pink-tailed worm-lizards were recorded from personal experience locally (Googong) and further afield (the Toongi meta population south of Dubbo) there was a scarcity of suitable rocks to be assessed indicating an overall paucity of suitable habitat.

4.5 Golden Sun Moth

No Golden Sun Moths were recorded within the proposal despite ideal seasonal and microclimate timing of the assessment. On the balance of probability there is not a Golden Sun Moth local viable population at risk of harm by the proposal.

5 Conclusion

Desktop assessment, peer review and field assessment was used to consider if construction of a 132 kV powerline from the TransGrid Queanbeyan substation in Oaks Estate ACT along a disused railway corridor to a new substation in Environa NSW along the Woods Lane to Environa (South Jerrabomberra) section would result in a significant impact to a known viable local population of Grassland Earless Dragon.

The assessment identified four species of locally occurring birds likely to opportunistically prey upon Grassland Earless Dragon with Australian Magpie and the Austrian Kestrel considered as the most likely avian predator.

This assessment found Essential Energy (2022) had correctly and succinctly stated there were a number of factors which must be considered when assessing the potential impact of any development, and the influence they may have on natural predation processes, and also supports structural complexity of the grassland is “the factor” needed for the survival of a locally viable population of Grassland Earless Dragon.

In my opinion, construction of the proposal is unlikely to result in a significant impact to Grassland Earless Dragon because:

a. All native grasslands possessing a viable local population of Grassland Earless Dragon which could be used by locally occurring aerial predators is managed for conservation. This ensures structural complexity of the grassland will be maintained resulting in the overall protection of the population.
b. The cost of this protection native grassland via a kangaroo exclusion fence is it enables the Australian Magpie as a potential predator. An Australian Magpie is highly unlikely to use a powerline as a hunting platform for Grassland Earless Dragon.
c. The Australian Kestrel is known to use elevated manmade infrastructure but was not observed using powerline infrastructure as a hunting platform. Peer reviewed literature and personal observations show the majority of their diet are insects with an occasional reptile being taken. During the observations all prey except on two occasions were insects (beetles) with a suspected mouse and definite grassland skink being preyed upon during the assessment.

6 References

Barnes 2005. Foraging, Habitat Use and Nesting of the Black-shouldered Kite *Elanus axillaris* in the Australian Capital Territory. Australian Field Ornithology 2005, 22, 58- 66.

Debus, S.J.S. Hatfield, T.S. Ley A.J. and Rose A.B. 2007. Breeding Biology and Diet of the Little Eagle *Hieraaetus morphnoides* in the New England Region of New South Wales. Australian Field Ornithology 2007, 24, 137–157.

Elliot Leach, Darryl Jones, James McBroom and Rob Appleby 2015. Diet of Nankeen Kestrels *Falco cenchroides* at Brisbane Airport.. Australian Field Ornithology 2015, 32, 15–25.

Elliot Leach, Darryl Jones, James McBroom and Rob Appleby 2015. Diet of Nankeen Kestrels *Falco cenchroides* at Brisbane Airport.. Australian Field Ornithology 2015, 32, 15–25.

Fisher, K (2010). Breeding and Diet of the Little Eagle *Hieraaetus morphnoides* in Central Queensland. Australian Field Ornithology 2010, 27, 119–127.

Howland, B. Stojanovic, D. Gordon, I. Manning, Fletcher, D. Lindenmayer, D. 2014. Eaten Out of House and Home: Impacts of Grazing on Ground-Dwelling Reptiles in Australian Grasslands and Grassy Woodlands. PLOS ONE | DOI:10.1371/journal.pone.0105966 1 / 25 December 11, 2014 December 11, 2014.

Nelson, L. 2004. Thermal ecology and implications for life history variation in Tympanocryptis pinguicolla (Grassland Earless Dragon). Division of Botany and Zoology (Ecology, Evolution and Systematics). The Australian National University PhD thesis June 2004.

Olsen, J. and Rose, A. Breeding Diet at Two Whistling Kite Nests near Canberra. Esteban Fuentes,. Australian Field Ornithology 2005, 22, 122- 125.

Robertson, P. and Evans, M. (2009/2012). National Recovery Plan for the Grassland Earless Dragon *Tympanocryptis pinguicolla.* As varied October 2012. ACT Department of Territory and Municipal Services, Canberra.

Stevens, T. Evans, M. Osborne, W. and Sarre, S. Home ranges of, and habitat use by, the grassland earless dragon (*Tympanocryptis pinguicolla*) in remnant native grasslands near Canberra. Australian Journal of Zoology, 2010, 58, 76–84.

Swinburne, N. Jessop, R. 2005. Behaviour of the Little Raven *Corvus mellori* on Phillip Island Victoria. Australian Field Ornithology 2005, 22, 137-145.

Tsang, L. Rose, A. Fuentes, E. Olsen, J. Trost, S. McDonald, P. 2017. A comparison of the diets of the Black-shouldered Kite *Elanus axillaris* and Nankeen Kestrel *Falco cenchroides* in the Canberra region.. Corella, 2017, 41: 27-31.

Websites:

Australian Magpie *Gymnorhina tibicen.* (https://animalia.bio/australian-magpie)

Pied Butcher Bird (https://australian.museum/learn/animals/birds/pied-butcherbird

Brown Falcon (https://australian.museum/learn/animals/birds/brown-falcon/)

Pied Currawong (https://australian.museum/learn/animals/birds/pied-currawong/)

gunninah

PROPOSED 132kV POWERLINE
QUEANBEYAN to ENVIRONA

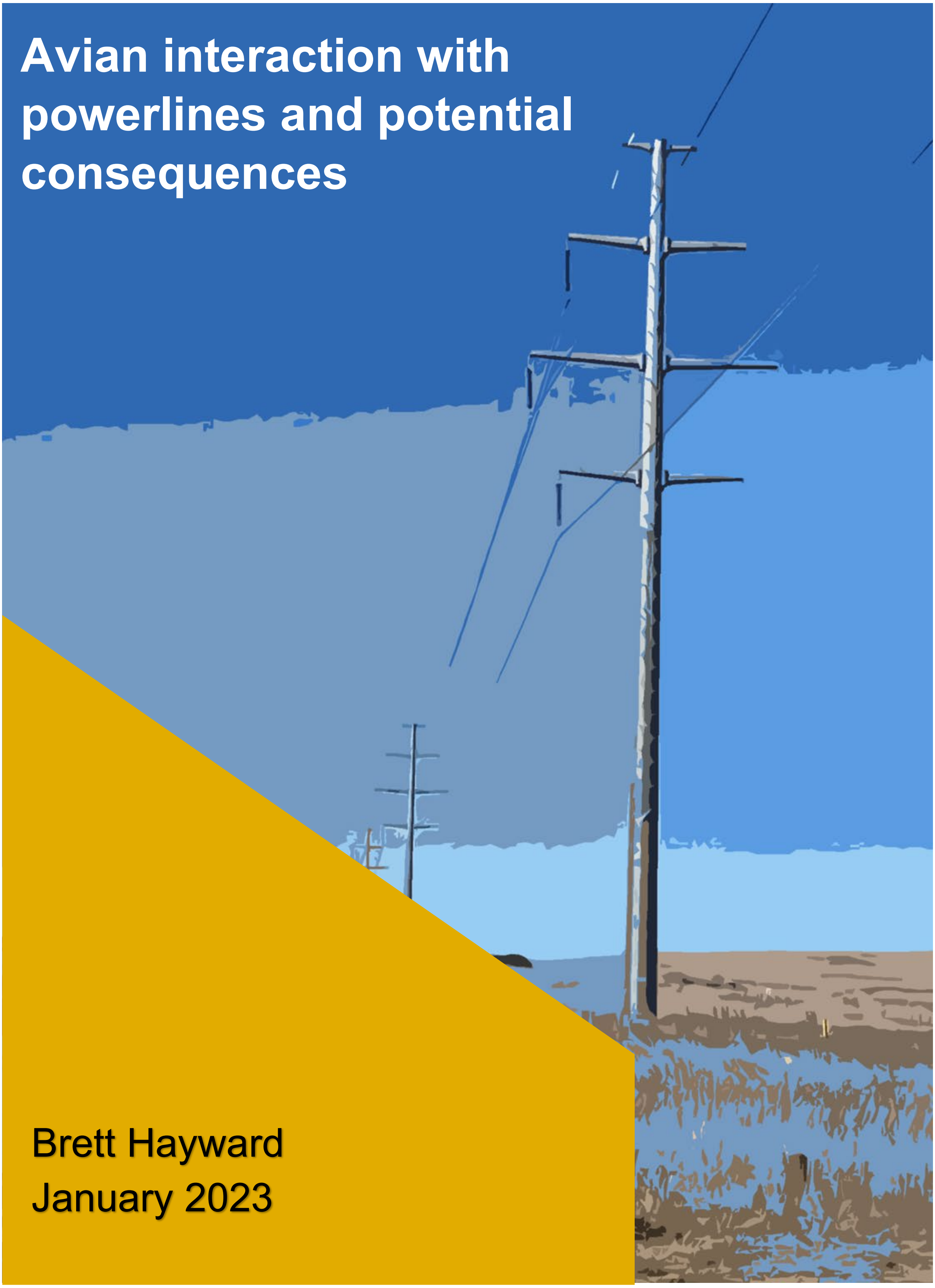
ECOLOGICAL ISSUES & ASSESSMENT REPORT

ATTACHMENT D
HAYWARD 2023 REPORT

F Dominic Fanning

May 2023

Avian interaction with powerlines and potential consequences



Brett Hayward

January 2023

Table of Contents

Abstract

The influence of artificial structures on increasing bird predation efficiency has been noted as being a poorly understood aspect of threatened species conservation and management. The co-habitation of avian wildlife on structures, such as power poles, is well known and documented. However, the influence of such structures on predation efficiency needs to consider the location, perch availability, powerline design and operation, and predator height preference. This paper examines the potential influence of a proposed 132,000 volt dual circuit powerline adjacent to grasslands on increasing predation efficiency and predator abundance, as well as increased mortality of birds due to collisions with the powerline.

This paper will specifically respond to the following:

> **Australian Capital Territory (ACT) Environmental Impact Statement (EIS) scoping document issued under Division 8.2.2 of the *Planning and Development Act 2007* for the South Jerrabomberra high voltage power supply**
>
> The purpose of the scoping document is to outline the matters to be addressed as part of the development of the EIS.
>
> Clause 8.2.5 of the scoping document specifies the following requirements, amongst other things, which are the matters specifically addressed in this paper:
>
> *Consider the indirect impacts of the development on fauna species listed above (threatened species) with particular consideration of the following:*
>
> - *Increased predation efficiency and predator abundance due to the erection of poles and lines adjacent to grasslands*
> - *Increased mortality of birds due to collisions with power lines, particular consideration for Little Eagles and other avian species known to occur in the area*

About the author

Brett Hayward holds a Master of Environmental Law (with Merit) from the Australian National University, and a Bachelor of Environmental Science from the University of Newcastle. Brett is a highly respected and experienced environmental practitioner with over 20 years' experience across a number of industries in environmental planning, approvals and management. Brett is also a published author, in the November 2012 edition of the Environmental and Planning Law Journal.

Background

Essential Energy has identified a need to augment the electricity supply network in the South Jerrabomberra region to continue to foster and encourage economic development and increase electricity supply reliability through the installation of a new dual circuit 132,000 volt powerline.

The South Jerrabomberra development, south of Queanbeyan in New South Wales (NSW), is identified as a project enabling regional growth and the Innovation Precinct is the State's third Regional Jobs Precinct. The NSW Government and the Queanbeyan-Palerang Regional Council are making significant contributions to the development, including from the Regional Growth Fund / Growing Local Economies Fund, for construction of road, sewer, and electricity infrastructure.

Strategic development of electricity supply to the South Jerrabomberra development area in NSW is required over at least the next 10 years to support the forecasted growth of multiple time-staged real estate developments. These developments are proposed to service a broad mix of precincts, including residential, retail, business, industrial, education, sporting, community and open space precincts.

An upgrade and augmentation of the high voltage electricity supply will cater for future uses and increase reliability to existing uses, future proofing essential infrastructure services to the broader region.

Essential Energy examined a number of potential high voltage supply options originating from the Transgrid Oaks Estate substation located within the Australian Capital Territory (ACT). The proposal is to connect into an existing Essential Energy 132,000 volt powerline, No. 975, that exits the Oaks Estate substation immediately to the east of the substation. The powerline would then head in a southerly direction directly towards the ACT/NSW border and ultimately continue into NSW. This connection point would facilitate the high voltage supply to a proposed new substation in the NSW suburb of Jerrabomberra. A connection into the powerline, No. 975 near the Transgrid substation within the ACT is a critical component of the high voltage supply.

Approximately 230 metres of the proposed powerline will be within the ACT with the majority of the remaining portion of the powerline in NSW. The alignment of the powerline will largely extend along a currently disused railway corridor, which is also the edge of the ACT/NSW border with the powerline being on the NSW side of the border. Refer to **Figure 1** and **Figure 2**.

The objectives of the project will be to:

- Increase electricity supply reliability of the broader Queanbeyan region
- Future proof ongoing supply needs over the next ten years based on current and proposed developments
- Provide a cost-effective solution to drive down the price of electricity
- Minimise environmental impacts by utilising existing disturbed corridors

As the proposed powerline within the ACT is 132,000 volt and outside an existing easement, Part 4.2 item 2, of the ACT *Planning and Development Act 2007* is triggered. Triggering Part 4.2 requires the small 230 metre section of the powerline to go through the Impact Track assessment pathway and the preparation of an environmental impact statement (EIS).

In NSW, the powerline (and substation) is considered development permissible without consent and will be approved by a public authority. As such, the activity will be considered in accordance with Part 5, Division 5.1 of the NSW *Environmental Planning and Assessment Act 1979*.

Figure 1: Overview of proposed electricity upgrade works

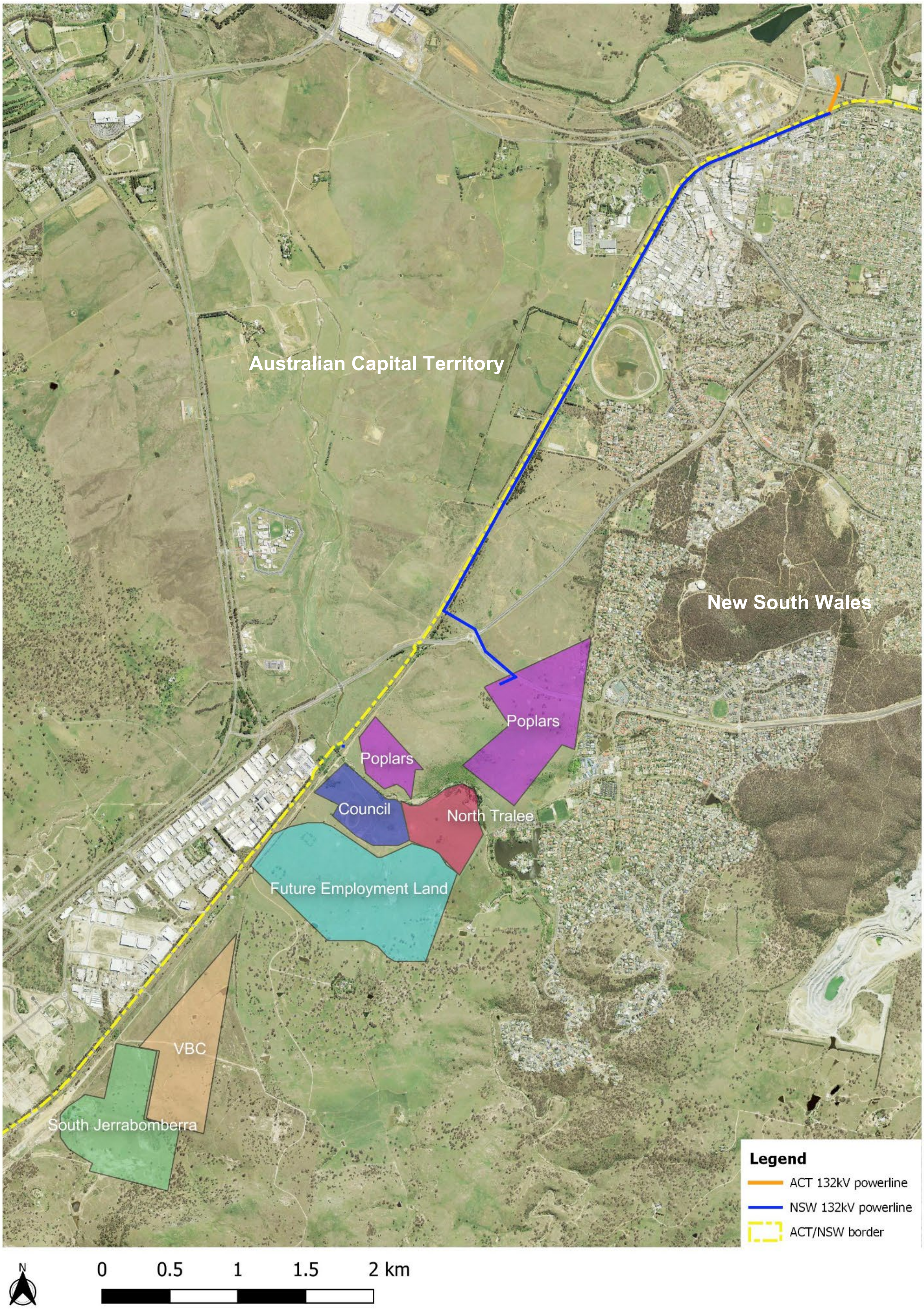


Figure 2: Overview of proposed electricity upgrade and developments

Introduction

The purpose of this paper is to document Essential Energy's consideration of the matters raised within the Environmental Impact Statement Scoping Document issued as part of the ACT assessment process for a proposed dual circuit 132,000 volt powerline. This paper considers the potential impact of the development on increasing predation efficiency and predator abundance due to the erection of poles and lines adjacent to grasslands and the potential impacts of increasing mortality of birds due to collisions with powerlines, particularly for Little Eagles (*Hieraaetus morphnoides*).

This paper examines a range of literature on bird predation, including the optimal search height, recorded prey attack perch levels, bird morphology, powerline designs (and how they can encourage or deter perching) and operations, and Essential Energy's experience with birds roosting on its assets. The paper also includes an overview of the existing natural and artificial structures in close proximity to the proposed powerline, the behavioural characteristics of the Grassland Earless Dragon (*Tympanocryptis pinguicolla)* (**Dragon**), and the threat posed by birds in a low density, open landscape where the Dragon is substantially smaller than the surrounding vegetation. Consideration of the potential for an increase in bird mortality due to the development is also explored.

There are many factors that can influence the choice of perch for a predator, being for example, the height and design of the structure. Powerline designs vary quite substantially with some designs offering more appealing perching opportunities than others. Local and international publications have been reviewed to consider the potential and extent of impact posed by the development.

The design of this potential powerline development is a dual circuit 132,000 volt powerline with horizontal insulators, and poles ranging in height from 21 to 28 metres. Horizontal insulators extend out from the pole itself, compared to vertical insulators that extend along a vertical axis from a horizontal cross arm. Cross arms can provide more suitable perching opportunities due to their ability to function as a platform to roost from, as is experienced in coastal areas of NSW with the Eastern Osprey (*Pandion cristatus*) regularly co-habituating with Essential Energy structures. The proposed development involves poles considerably higher than other artificial perches in the local area that have been identified as potential prey perches, for example, fence posts, fences and buildings.

Powerline designs

A major influencing factor in the facilitation or deterrence of birds perching on powerlines is the design of the powerline itself. Powerline design vary significantly with some designs being more attractive to birds than others. Some of the design factors that could influence the attractiveness of the infrastructure to birds include the separation distance between conductors (wires), the offset of conductors from the poles, whether the conductors are arranged vertically or horizontally, and the structure type (e.g., steel lattice tower or poles).

Distribution powerlines are those at the end of the electricity supply grid that distribute electricity to homes, industry and other end users or provide smaller length distribution of electricity between suburbs. In Essential Energy's network they generally comprise of a wooden pole with either a composite or wooden cross arm supporting insulators that extend vertically from the cross arm. The conductors are attached to the insulator from above the cross arm.

Distribution powerlines typically contain three phases, with two close together on one side with an offset distance to the furthest phase on the other side to provide separation and prevent conductor slap. Some distribution powerlines may be arranged in a more equal separation distance with the middle conductor and insulator sitting above the pole and the two other conductors sitting on a cross arm. Both of these distribution designs contain a cross arm which provides a horizontal surface for perching. Pole height for distribution poles is normally approximately 12 metres.

Distribution powerline design. Normally on a pole approximately 12m high and contains a cross arm supporting insulators.

Conductors (wires) aligned along a horizontal plane.

Picture shown below and to the right depicts the typical style of a distribution design in an urban environment. Pole shown with 11,000 volts towards the top of the pole with three conductors. Pole also contains a low voltage (415 volts) premise supply circuit (four conductors).

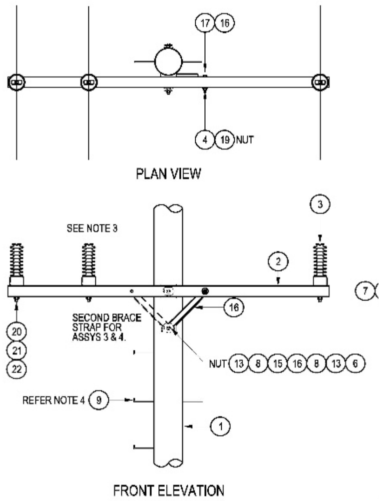


Figure 3: Detailed elevation and plan view of an 11,000 volt distribution design in theory and practice

Distribution powerlines generally emanate from zone substations where higher voltage electricity that has been transmitted across large distances via the sub-transmission network is then transformed down to lower voltages for distribution to end users. The sub-transmission powerlines extend from larger transmission substations, with a typical range of between 33,000 volts and 132,000 volts and are comprised of a heavier and thicker conductor requiring a different design and engineering philosophy to distribution powerlines.

Moving into sub-transmission powerline design, there are a number of different variations. One includes a H-pole arrangement (two pole suspension design) whereby the weight of the conductors is supported by two poles with a large cross arm connecting the two poles, which provides a substantial flat-topped surface upon which birds can potentially perch. Insulators extend down from the cross arm to support the (heavier) conductor.

Typically, a H-pole constructed powerline will require poles of approximately 16 metres in height to provide the necessary clearance and sag allowance over larger distances. Sub-transmission powerlines generally include longer spans (between pole structures) compared to distribution powerlines.

Two pole suspension powerline or H-pole arrangement. Two wooden poles are required to hold the weight of a heavier conductor used in sub-transmission (greater than 11,000 volts). Insulators are suspended from a large cross arm connecting the two poles.

Conductors (wires) aligned along a horizontal plane.

Picture below and to the right depict how the design typically looks. As noted, these higher voltage powerlines (above 11,000 volts) transmit electricity over longer distances, in many cases through rural environments. Furthermore, the individual spans between each pole structure are greater than that of distribution poles, requiring the poles to be larger and stronger.

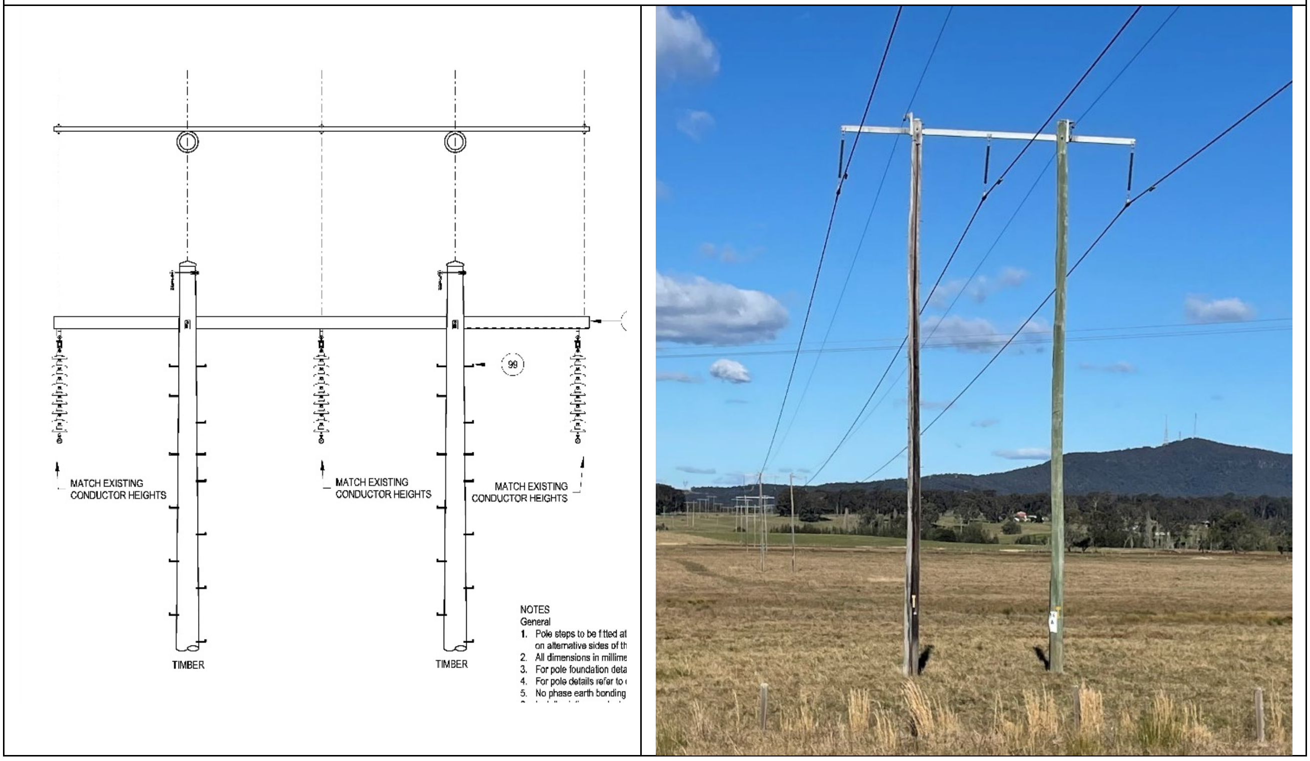


Figure 4: Detailed elevation and plan view of a 66,000 volt sub-transmission design in theory and practice

Technological and engineering improvements have influenced powerline design approaches. Two pole suspension designs have largely been replaced by single pole horizontal insulator design. Typically, this type of design has replaced wooden poles with either steel or concrete poles. Wooden poles are still used in this more modern design, however, steel and concrete offer many life-cycle benefits, such as reduced maintenance and longer life spans.

Horizontal insulator or post insulator design can be either single or double circuit and the design can accommodate lower voltages strung underneath the main circuits. For example, an 11,000 volt circuit could be slung underneath a 66,000 volt or 132,000 volt powerline. This design is more compact than a two pole suspension arrangement and reduces the opportunity for birds roosting and perching by reducing flat spots, like the cross arms of the abovementioned designs.

Pole heights for this design are typically 21 metres above the ground, however it can accommodate much larger poles where the topography or other constraints require heavier engineering solutions. Spans between poles of this design are typically in the order of 200 metres, however, it can accommodate spans up to nearly 300 metres. Whilst high in height, this design is more compact when compared to other designs and generally requires less structures across the landscape.

Horizontal or pole insulators powerline in dual circuit configuration. The arrangement can be single circuit requiring only three insulators all on one side, or an alternative offset arrangement (i.e. two insulators top and bottom on one side, with the middle insulator on the opposing side of the pole).

Conductors (wires) are aligned along a vertical plane compared to the previous powerline designs where conductors were arranged along a horizontal plane.

Picture below and to the right depicts a dual circuit 132,000 volt powerline with an 11,000 volt underbuild. This pole contains three circuits (effectively three powerlines in the one compact design). This solution would not have been possible with the former two pole suspension design, and would have required three separate powerlines as opposed to the three powerlines on the one pole as shown in the example below.

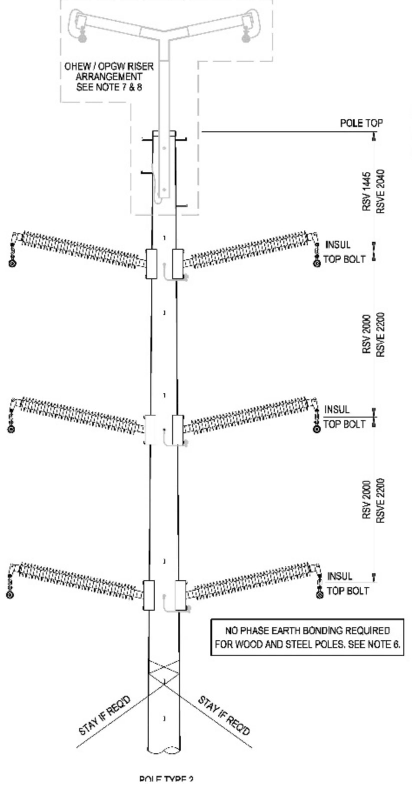


Figure 5: Detailed elevation view of a 132,000 volt sub-transmission design in theory and practice

Powerline designs detailed above provide an overview of some different types of powerlines. Other designs exist that have not been detailed above. For example, different types of steel lattice towers and transmission powerline designs for voltages greater than 132,000 volt, such as 330,000 volt and 500,000 volt.

Statutory framework

Assessing the impacts upon the environment is largely directed by environmental and/or planning legislation. For this proposed development, three jurisdictions (Commonwealth, NSW and ACT) and the following pieces of legislation need to be considered:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
- NSW *Environmental Planning and Assessment Act 1979*
- NSW *Biodiversity Conservation Act 2016*
- ACT *Planning and Development Act 2007* and
- ACT *Nature Conservation Act 2014*.

All three jurisdictions provide a process for listing and conserving threatened species, communities and their habitats, and describe the process for considering impacts from developments. Both the NSW and ACT jurisdictions integrate the consideration of impacts to threatened species through their development assessment process.

Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides the main legal framework for protecting and managing nationally significant flora and fauna, as well as internationally important wetlands, heritage places and nuclear actions, amongst other things. The act provides a listing mechanism for threatened species, communities and their habitats, and a referral and approval process for actions that will, or are likely to, have a significant impact upon matters of national environmental significance .

Assessing the significance of impacts is guided by considering the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (**the Guideline**), or where applicable, relevant species-specific significant impact guidelines. According to the Guideline, a ‘significant impact’ is an impact which is important, notable, or of consequence, having regard to its context or intensity. Significant impact criteria are provided in the Guideline, which will change depending upon listing status, i.e. either critically endangered, endangered or vulnerable. A person proposing to undertake an action with the potential to harm a matter listed under the EBPC Act has a mandatory obligation to consider the Guideline and determine the potential significance of that action on that listed matter.

Actions that have been assessed as likely to have a significant impact upon a listed EPBC Act species, community, or habitat must be referred to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW).

NSW Biodiversity Conservation Act 2016 (BC Act)

The NSW *Biodiversity Conservation Act 2016* (BC Act) provides the legal framework for the protection and management of NSW State-listed threatened species, communities, and their habitats. The purpose of the act is to maintain a healthy, productive, and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development.

Contained within the BC Act and associated regulations are:

- numerous potential pathways for approval;
- an offsetting process to mitigate impacts;
- a listing mechanism for flora and fauna, as well as assessment and protection provisions;
- a biodiversity offset scheme;
- provisions for private land conservation agreements; and
- biodiversity assessment and approvals process.

For this development, impacts to listed threatened species, ecological communities or their habitats would need to be assessed to determine if a significant impact would be likely. Relevant to this process is section 7.3 of the BC Act, which provides a test of significance. Where a proposal assessed under section 7.3 is likely to have a significant impact upon threatened species, communities or their habitats, the proposal would be required to be assessed and approved through the biodiversity offset scheme or a species impact statement.

The consideration of impact to threatened species, communities or their habitats is a mandatory obligation under Part 5, Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which is required prior to works occurring.

ACT Nature Conservation Act 2014 (NC Act)

The ACT *Nature Conservation Act 2014* (NC Act) aims to protect, conserve, and enhance the biodiversity of the ACT. This is achieved by protecting, conserving, enhancing, restoring and improving nature conservation, involving and promoting community participation in conservation, and promoting the principles of ecologically sustainable development.

The NC Act achieves some of its aims by providing a legal framework for the protection and management of threatened species, communities and their habitats. This is achieved through the appointment of a Conservator of Flora and Fauna (Conservator) with statutory functions, and a process for listing species and communities.

For proposed developments, the NC Act is integrated with the ACT *Planning and Development Act 2007* (P&D Act), whereby the Conservator plays a key role in reviewing certain development applications. For example, under the Impact Track planning approval pathway, the development must be referred to the Conservator for review and advice. Any advice provided by the Conservator must be considered by the planning authority, and any decision that is made must be consistent with that advice.

If the Conservator is satisfied on reasonable grounds that a proposed development is likely to have an adverse environmental impact, then the Conservator must give written advice in accordance with section 318 of the NC Act to the planning authority. However, the advice must include:

a) An outline of the environmental impact of the proposed development
b) Advice about ways to avoid or minimise the environmental impact of the proposed development
c) An assessment of whether the proposed development is likely to have a significant adverse environmental impact on a protected matter
d) If the proposed development is likely to have a significant adverse environmental impact on a protected matter – advice about suitable offsets for the proposed development.

In preparing the advice, as outlined above, the Conservator has a mandatory obligation to consider the Guideline (EPBC Act), in addition to the offsets policy.

The provision of advice by the Conservator must provide an outline of the environmental impacts and include an assessment on whether the proposed development is likely to have a significant adverse environmental impact on a protected matter. That is, the Conservator must demonstrate how such a significant adverse impact will result, and provide an assessment to detail out such a conclusion. In preparing the advice and the assessment of significance, the Conservator is bound to consider the Guideline (EPBC Act), which provides the basis for demonstrating the assessment of significance.

Important grassland ecology

The EIS scoping document requires the proponent to consider the potential indirect impacts of the development on increasing predation efficiency on nearby grasslands. The genesis of such a request to consider the above potentially stems from the ACT Government and Commonwealth Government recovery action plans relating to the Dragon (*Tympanocryptis pinguicolla*) and other threatened species present in the grassland areas, including the striped legless lizard (*Delma impar*).

The ACT Grassland Earless Dragon *Tympanocryptis pinguicolla* Action Plan (**ACT action plan**) draws heavily on the work carried out by Robertson, P. and Evans, M. (2009/2012), National Recovery Plan for the Grassland Earless Dragon *Tympanocryptis pinguicolla* (**Commonwealth recovery plan**).

The Dragon, according to the ACT action plan, is a sit-and-wait predator, and eats a variety of small invertebrates, especially ants, beetles, spiders and moths. The species takes shelter in burrows and tussocks when disturbed. Ideal habitat management for the species includes grassland that has a well-defined tussock structure of heights between 5 and 15 centimetres. Such a structure should avoid creating grass sward that is uniformly very short or uniformly very tall and dense. A patchy sward containing a mix of heights is likely to provide the species with a greater range of sites for shelter.

According to the Commonwealth recovery plan, ‘the effect of introduced predators is not understood, but it may be significantly detrimental, especially in grasslands adjacent to urban areas. Similarly, the impact of native predatory birds is not understood in areas where cover has been removed through overgrazing, slashing or burning, or where artificial perches (posts, fences, buildings) are present’ (Robertson et al 2009:19).

The ACT action plan speculates on this subject in a similar manner, suggesting that ‘increased predation by native animals’ due to ‘an increase in artificial perches (posts, fences, buildings) for birds such as magpies, ravens and raptors; exposure due to loss of groundcover; or enhanced shelter for snakes (e.g., through dumped materials or added logs/woody debris near *T. pinguicolla* habitat). Eastern Brown Snakes have been found to be efficient predators of *T. pinguicolla* (Doucette, unpublished data) (ACT action plan:218).’

Contained within the Commonwealth recovery plan are a number of actions focussed on targeted research to inform the formulation of appropriate management questions. One of those actions, C9.2.8, identifies the need to ‘investigate the effects of predation on grassland earless Dragon population, noting that these effects are currently unknown and that artificial perches (posts) for predatory birds in grasslands have been identified as a potential threat.’

Furthermore, the Commonwealth recovery plan notes, in the recommended management of grassland earless Dragon habitat, number 13, that fences and other structures (e.g. posts, antennas, marker stakes) should be minimised to avoid providing perching sites for predatory birds (Robertson 2009/2012:58). However, the recommendation, somewhat contradictory, notes the need for fencing to maintain habitat and refers to lower height structures.

For the ACT action plan, despite the inference of artificial perches being a threat contributor, no management actions have been proposed in the recovery plan to address this matter. Indeed, the section identifies snakes as being of particular concern for their predation potential. Moreover, the artificial perches that are identified are ones typically close to the ground. For example, posts, fences and buildings, which are potentially relevant to the prey attack of birds, like magpies and raven, which are primarily ground-based foraging species.

As observed by Reecher and David (2010), of 15 foraging events by magpies, 67 percent occurred on the ground, with an average foraging height of 4 metres. As O’Leary and Jones 2001 observed, foraging activities for magpies predominantly occurred between dawn and 9:00am, and again late in the afternoon (from 3:00pm to dusk). Such foraging times would place the magpie largely out of the active time period for a lizard. O’Leary and Jones further note that magpies are generalist insectivores that consume a wide variety of foods, with the authors drawing upon the findings of Vestjens and Carrick (1974) that identified that beetles, weevils, spiders, earthworms and ants were the most abundant items in the diet of magpies from Canberra. That is not to say a lizard would not find its way into a magpie stomach; more that it would be an unusual occurrence given a magpie’s dietary preference for insects.

There are two important factors to consider in the respective recovery plans for the Dragon. One is that the exact risk of artificial perching has not been quantified; rather, it has been identified as a potential threat. Secondly, the matter of perches is focused on ‘posts’, with strong reference to fences. The ACT action plan refers to posts, fences and buildings (perches of a lower height). An important consideration in thinking about the potential risk a power pole may pose, particularly one that is 21 metres in height, with horizontal insulators (limited flat platforms).

Certainly, the references to posts in the context provided in both recovery plans points to issues around predatory advantage from lower heights. Furthermore, not all power poles are equal, with significant engineering and structural differences across the spectrum of different voltage types and construction methodologies. For example, an urban low voltage 11,000 volt distribution power pole approximately 12 metres in height is a completely different proposition to a 21 metre high 132,000 volt power pole (as outlined in the powerline design section above). Additional matters to consider include the current induction from higher voltage powerlines, their operating temperature, and design.

As per the EPBC Act listing for the Dragon, a number of key threats to the survival of the species were identified, including habitat degradation, fragmentation and loss. The listing also identifies ‘other threats’ as being creation of harbourage sites or structures increasing predation pressure from brown snakes, feral cats, magpies or birds of prey. The potential threat of bird predation is seen as a lower potential threat than that of habitat loss, which is identified as a key threat. Given the uncertainty around the level of threat posed by bird predation in the Commonwealth recovery plan, and lack of commitment to allocate resources to investigating the potential, it would seem that this risk is not seen as a priority for the Commonwealth Government. This idea is further supported by the paucity of dedicated resources to study[1] and understand the potential threat posed by birds utilising artificial structures, further supporting the inference that this action is of lower priority.

Optimal height for bird predation in different substrates

Bird predation approaches differ according to the bird, the landscape and environment, density and availability of prey, climatic conditions, and dietary preferences. A bird must consider a variety of factors when searching for prey, with different methods requiring different rates of energy consumption.

Andersson (1978) developed a detailed model examining the differences in energy intake from predator prey choices between continuous travel (soaring, hovering) and alternating pause travel (perching, sitting). The model considered mode of search, search height, pause duration (giving up time) and move length (movement distance from prey observation). According to Andersson (1978), ‘a predator trying to hunt optimally faces several decision problems. Should it search travelling, perching or alternative? If there is a choice, from which height should it search? Continuous travel might be superior when the rate of energy expenditure increases continuously from zero velocity, like a fish, which can choose the speed which maximises the net rate of surplus energy intake. In most flying organisms there is a large, discontinuous rise in energy expenditure as the animal shifts from rest to flight’ (Andersson 1978:59).

When discussing attributes of the model, Andersson (1978) notes that ‘there exists an optimal search height, which maximises the predator's net energy yield’ (Andersson 1978:59). That is, as height increases, the detection area grows in proportion as it contains more prey. However, at the same time, the detection intensity decreases. This reduces the probability of detecting any given prey, an effect which overrides the increase in detection area if height is sufficiently large. Above a certain search height, the probability (or rate) of prey detection therefore decreases. Conversely, if height is reduced, detection levels increase.

Furthermore, Andersson (1978) notes, ‘the factor with strongest influence on optimal search height appears to be prey detectability. If hovering or traveling is decreased, the predator can partly restore the detection intensity by reducing the search height.’ The optimal search height, therefore, decreases with reduced prey detectability.

In thinking about the environmental context in which the proposed new powerline will be built, it is considered open plain grassland with limited mid or upper storey, which is the preferred habitat type of the Dragon. In considering the environmental conditions, physical size of the Dragon and its prey method (i.e. sit and wait), the detectability of the species would be at the lower end of detection intensity. Therefore, optimal search height for Dragon predators would need to be closer to the lower end of the height scale to detect movement either visually or audibly.

The relationship between predation height and foraging method was assessed in detail by Remesova et al 2019. Remesova et al (2019) investigated the co-existence of species, and how species share their ecological space. They found that birds foraged along the whole vertical extent of vegetation, but individual species concentrated their foraging within particular strata. To quantify foraging behaviour,

[1] Research on implementation of action plans has not indicated progress against the study of avian influence and perching from structures as a risk to the recovery of threatened reptiles.

21 sites in woodlands and open forests of eastern Australia were examined over a 3,000km long latitudinal transect, from the tropics to southern temperate regions.

A total of 5,894 prey attacks from 2,624 individual birds were recorded. The attacks were categorised by foraging method (e.g. flycatch, pouncing, snatching, gleaning etc.) and foraging substrates (e.g. air, ground, bark, leaf etc.). In considering the potential for prey attack from perching at height, *pouncing* is the most relevant foraging method involving 'direct flight from a perch to the site where the prey is taken (usually ground) whereby the bird lands and takes the prey; it may continue flying afterwards (eg butcherbirds, Cracticidae and Australiasian robins, Petrocidae' (Remesova et al 2019:24).

Approximately 78% of all foraging methods were gleaning (taking prey from the same substrate the bird is in), probing (extracting food from a thick substrate – soil, litter or flowers) and snatching (moving on/through the substrate and making short flights to take prey from nearby surfaces – prey is taken while the bird is in the air). That leaves approximately 20% of all other prey methods limited to five foraging types, including pouncing. The results of the records were presented in the following figure.

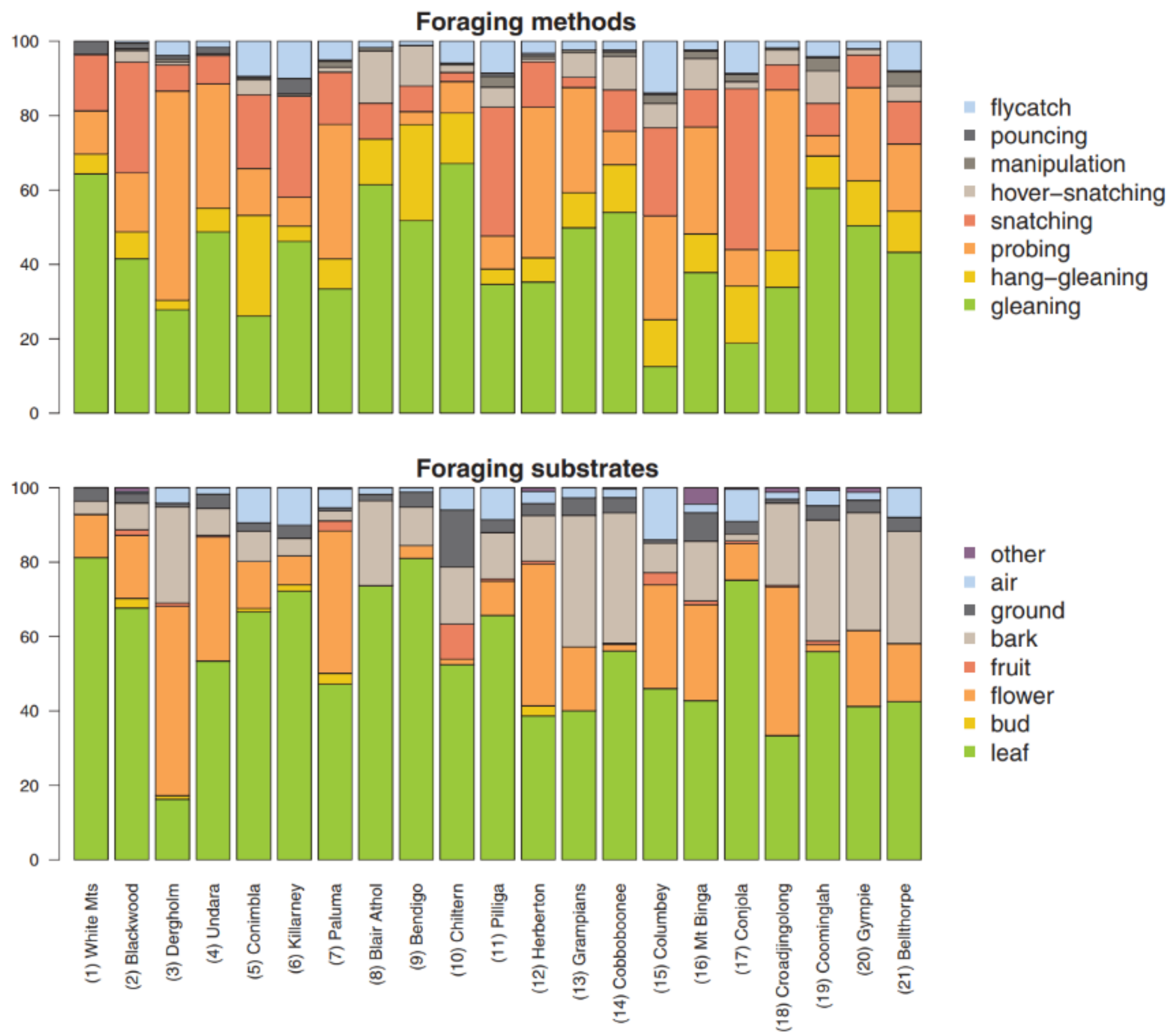


Figure 6: proportions of foraging methods and substrates used by all species at our 21 sites showing site to site variability in the foraging strategies used. Sites are ordered by mean canopy height (from lowest to highest) (Remesova et al 2019:25)

As noted in the abovementioned figures, the ground, as a foraging substrate, provided a regular means for birds seeking prey. However, pouncing, the act of taking a direct flight from a perch to a site where prey is taken, is at the lower end of choice for foraging methods. This trend is even more pronounced as the vegetation becomes taller. There tends to be a much clearer relationship with lower vegetation and pouncing as a foraging method whereby the effectiveness of pouncing diminishes with height. This would appear to support the approach taken in the relevant action plans discussed above, whereby the focus is on 'posts' and 'fences' as potential perch sites, rather than taller structures. Figure 4 within Remesova et al (2019) identifies that the concentration of predation at the ground substrate is dominated by birds using vegetation at the lower end of the median foraging height scale (around 10 metres and less) (Remosevo et al 2019:28).

Ricardo et al (2011) drew similar conclusions in considering the influence of perch height and vegetation structure on the foraging behaviour of Little Owls *(Athene noctua)* in woodlands, compared to pseudo-steppe (grassland areas). Hunting success was found to be similar despite the difference in vegetation types and heights of perches. Ricardo et al (2019) noted, ‘in spite of the maximum available perch height (consisting of the highest branches of Holm Oaks at approximately 5 metres), Little Owls selected lower perches (average 2.76 metres) (Ricardo et al 2019:23).

This suggests the existence of an optimal foraging height above which hunting is less rewarding. As experimentally shown by Andersson et al (2009), in open habitats where grass is much taller than prey, prey is only visible from almost directly above’ (Ricardo et al 2011). Similarly, Andersson et al 2009 noted ‘prey that are much smaller than grass sward height are only visible from almost directly above. Such situations may instead favour hunting by ear (Rice 1982, 1983; Bye et al. 1992), which in turn can favour lower search height and continuous travel, rather than pause-travel search’ (Andersson 1981a; Rice 1983; Andersson et al 2009:377).

Based upon the work detailed above, the scientific evidence suggests that birds like butcherbirds, magpies or ravens would not be expected to pounce from substantial heights. Rather, they would be expected to seek out the ground and/or lower level perches to increase their detection of prey. A lower predatory perch would offer significantly greater predator advantages and efficiencies compared with poles that are 21 metres in height. Raptors, however, soar at heights and would approach predation in a different manner.

Raptors

According to the Avian Power Line Interaction Committee (APLIC) 2006, powerline structures provide perching, roosting and nesting substrates for some avian species. This is particularly true for raptors that inhabit open areas where natural substrates are limited. Whilst the report is applicable to the northern American experience, Essential Energy has experienced similar issues along coastal areas with the Eastern Osprey (*Pandion cristatus*).

Given Australia’s urbanisation focussed on coastal locations, and the reduction of suitably old, large trees to provide habitat, Eastern Ospreys regularly use Essential Energy infrastructure for roosting and nesting. However, Eastern Ospreys have a particular preference for certain electricity structures, whilst they actively avoid other designs. In Essential Energy’s experience, raptors, such as the Eastern Osprey, seek out structures that contain a base from which to build a nest. As a consequence, their occupation of assets has typically been on steel lattice towers or distribution powerlines, structures that contain a flat platform. Refer to **Plate 1**.

Plate 1: Osprey nest built within a steel lattice tower for a large waterway crossing

Plate 1 above demonstrates the establishment of an Eastern Osprey nest on a 66,000 volt powerline crossing the Tweed River. Steel towers in this configuration with offset cross arms (large separation distance between conductors) provide roosting opportunities for ospreys, whilst minimising the potential for electrocution. An additional example of an Eastern Osprey nesting is provided in **Plate 2**, which is on a single pole post insulator design with an underslung 11,000 volt distribution circuit providing a platform (cross arm) to nest upon.

Plate 2: Osprey nest on the cross arm (flat surface) of an underslung lower voltage circuit

In **Plate 2** and Eastern Osprey nest on a 66,000 volt powerline (horizontal insulator or post insulator design) with an 11,000 volt underbuild. Note the cross arm on the 11,000 volt circuit is preferred to the 66,000 volt horizontal insulators near the top, and provides a platform for the bird to build a nest.

In Essential Energy's experience, horizontal or post insulators, like those shown in the top circuit in **Plate 2**, do not experience issues with birds roosting like steel towers and distribution power poles. A horizontal insulator design does not provide an adequate platform from which birds can build a nest or roost. In any event, the issue of raptor co-habitation with powerlines is predominantly a coastal issue and not one typically experienced in inland landscapes (none to date from the author's experience).

Essential Energy's experience is also similar to that experienced in other locations. APLIC (2006) note that powerline structures provide suitable habitat for perch hunting raptors, and note a strong association between raptor activity and utilities following the construction of a 230,000 volt transmission line (tower construction) in Colorado (APLIC 2006:108).

Similarly to Essential Energy, APLIC (2006) observed the following: 'ospreys, on natural substrates, typically nest on flat tops of dead trees. Likewise, on power structures, ospreys prefer the upper portions of transmission towers or the tops of distribution poles' (APLIC 2006:110). Observations made by APLIC (2006) identify that powerline design and construction is an important factor in considering perching and predation. The powerline, proposed as part of this development, is a single pole dual circuit 132,000 volt powerline with horizontal insulators. No flat top area conducive to nest building is a function of that design. The development is neither a distribution line, with cross arms, nor a transmission tower, which can facilitate large nests. In addition, empirical evidence suggests that power poles, as roosting structures, are predominantly attractive to coastal-based raptors, like the Eastern Osprey, rather than inland birds and raptors.

Dwyer and Doloughan (2014) conducted a test on avian perch deterrent systems in sage-brush habitat. A redundant distribution powerline was used as a test bed for evaluating the effectiveness of deterrent products, and a previous study by Slater and Smith (2010) was referenced that reported reduced perch frequency on a transmission line where all horizontal surfaces were fitted with spiked perched deterrents. Part of their study examined the ability of birds to predate from the poles. To determine the use of poles as hunting platforms, in the absence of leg bands, other markers and outside of the camera frame, a recorded occurrence of a bird departing a pole without prey and returning within 5 minutes with prey was considered a prey capture. The study recorded 44 prey captures from poles, which consisted of small mammals and passerines, noting that the exact species could not be identified from their records.

Important considerations about this study were that the poles were distribution poles (smaller in height) with a horizontal cross arm providing perching opportunities. In addition, the targeted prey by the birds were much larger fauna consisting of small birds and small mammals. Certainly, larger species than the Dragon (and other reptiles of concern), which makes detection more likely from heights.

Existing artificial and natural structures providing perching opportunities

The subject powerline alignment extends for approximately six kilometres with a section of approximately 900 metres located between the ACT Jerrabomberra East Grasslands Nature Reserve (JEGNR) and the NSW Queanbeyan Nature Reserve (QNR). The alignment comprises a currently disused (although still deemed active) railway corridor, including structures related to the operation of a railway line. In addition to those structures, is a planted row of Cypress pine trees that adjoin the QNR boundary to the west. Cypress pine tree plantations are a regular feature in the area, and Cypress pine trees are commonly planted along property boundaries (refer to **Figure 7**).

Contained within the railway corridor are redundant communication poles related to the historical operation of the railway. These communication poles extend approximately 9 metres in height, comprising steel poles with two cross arms, which would have once supported light telecommunication wires. Most of the wires or cabling associated with the poles have either been removed or have fallen into disrepair over time, with the poles largely standing without interconnecting wires.

A site assessment was conducted on 2 August 2022 to review artificial and natural structures within and adjoining the railway corridor. During the site visit, the location of the former railway communication poles along the section of the corridor, predominantly between JEGNR and QNR, were captured with GPS and are presented in **Figure 8**. A total of two structures representing former communication poles with cross arms were identified in the section adjoining grassland areas (more redundant communication poles were identified, but not recorded, further to the north).

Towards the southern end of the approximately 900 metres that adjoins the two reserves, extensive metal fencing approximately two metres in height, believed to be kangaroo exclusion fencing, was observed throughout the grassland area on the ACT side of the border. The fencing is quite extensive extending through a large section of the JEGNR. Due to the magnitude of the fencing, it was not captured during the site investigation, however, the extent of some of the fencing was determined from the ACT Government Eastern Kangaroo Conservation Management (KCM), and is depicted on **Figure 8**.

The fencing was observed to extend further than what is indicated in the KCM, and reproduced in **Figure 8**, and included a section that extended parallel and closer to Woods Lane, which is far beyond the area noted in **Figure 8**. The other fence may be related to the Alexander Maconochie Centre (ACT correctional facility) or may be an extension of the Kangaroo exclusion fence. The extent of the mapped fencing is 1,780 metres in length and is located directly within the grassland area. No evidence of an EPBC Act referral and environmental significance opinion could be found[2], therefore indicating that an assessment deemed the risk of installing fencing within the grassland itself to not be a significant impact and thus not warranting referral (despite being specifically referenced in the recovery plans as a potential threat).

During the site visit, the row of Cypress pines adjoining the QNR to the north of Lanyon Drive for approximately 850 metres was observed as providing habitat supporting a diversity and abundance of avian species. A number of birds were observed along the alignment, including Galahs, Magpies, Ravens, Black-shouldered Kites and a Sacred King Fisher. A Raven was observed chasing away a Black-shouldered Kite from a tree as per below.

Plate 3: Raven chasing away a Black-shouldered Kite from its perch

[2] The author was unsuccessful in finding any EPBC referral and/or environmental significance opinion (ESO) relating to the kangaroo exclusion fence. An ESO may not have been required because of section 252(2)(a)(iii) and 252(2)(c) *Nature Conservation Act 2014* being activities related to a controlled native species management plan and a conservation officer exercising a function under the act respectively.

Similar to the observations made by Remesova et al (2019), Magpies and Ravens were observed as sitting on perches between 0 and 8 metres in height, even when other taller perches were available on the same tree. A Magpie was observed sitting at approximately 6 metres in height before swooping down to join another Magpie on the ground. This behaviour was repeatedly observed during the site assessment.

Ravens were observed utilising a fallen dead tree of a maximum height of four metres and a nearby Raven was perched on the kangaroo exclusion fence that has been established around parts of the reserve. An individual magpie was spotted perching on the JEGNR identification sign. In contrast, the Galahs perched higher up in the trees (near the top of trees).

In combining the habitat and perching potential of the trees, existing redundant infrastructure and the extensive kangaroo exclusion fence, the area contains an array of potential bird roosting and perching structures. The location of those natural and artificial perching structures in landscapes closer to the known recorded range of threatened grassland reptiles, plus their design and heights, makes those structures much more conducive to (and therefore likely to be used for) predation compared to a 21 metre high powerline. Particularly in low density environments, where the prey of concern is much smaller than the surrounding environment.

On 2 August 2022 a site inspection was also carried out on an existing Essential Energy 132,000 volt powerline (constructed to dual circuit, but only circuit attached) near Cooma. The powerline was observed over a 15 kilometre length, and no birds were identified as sitting on the conductors, insulators or any part of the powerline. Near the intersection of Polo Flat Road and the Snowy Mountains Highway, a smallish hawk or kite (brown colour) was seen hovering near the highway at about 30 metres in height. The selection of hovering was an interesting choice considering the number and range of available powerlines, ranging from distribution through to sub-transmission of different designs, situated within a two kilometre radius of where the bird was observed hovering.

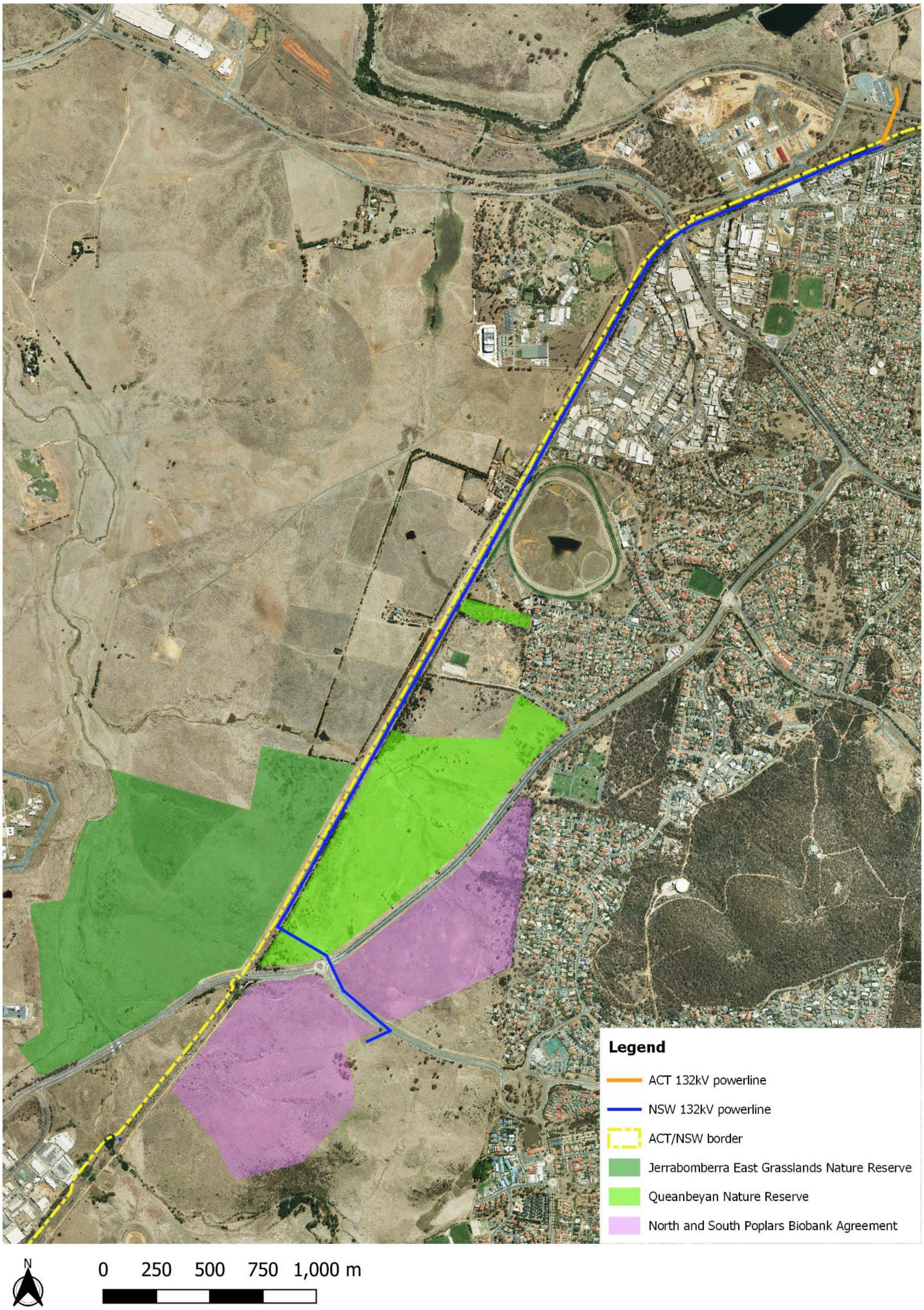


Figure 7: Location of grassland conservation areas

Figure 8: Location of some existing structures along the corridor

Picture 1 – Railway advisory sign	
Picture 2 – Sign identifying the land as being part of Jerrabomberra East Grasslands Nature Reserve. A magpie was spotted sitting on the sign	

Picture 3 – Old railway track cut and positioned in the ground for a marker post	
Picture 4 – Ravens seeking refuge on a dead fallen tree. In the picture foreground is the kangaroo exclusion fence that has been erected throughout the reserve	

Picture 5 – Redundant railway communication pole	
Picture 6 – Redundant railway communication pole near Lanyon Drive	

Picture 7 – A raven seeking refuge on a portion of the kangaroo exclusion fence that extends extensively throughout the reserve	
Picture 8 – Magpie sitting on the cross arm of a distribution pole towards the northern end of the rail corridor near HMAS Harmon (away from grassland areas)	

In discussing the issue of potential predation from perching on powerlines, APLIC (2006) noted that 'the goal of such efforts [perching prevention] is to reduce predation, although the actual impact of raptors hunting from poles on populations of these species (small mammals, ground dwelling birds) has not been adequately studied, qualified or verified. Utilities that attempt to discourage raptors from using portions of a powerline, as well as agencies requiring such actions, should be aware that predation can occur regardless of the presence of a power line' (APLIC 2006:17). Particularly where conditions favour continuous travel, like soaring.

Energy consumption between pause-travel tactics (perching) and continuous travel (hovering/soaring) may not appear as obvious on first glance. Naturally pause-travel would involve less energy burden upon a bird thereby conserving energy compared to continuous travel, however, soaring flights should be less costly. According to Andersson (1978), 'situations may exist where continuous travel is optimal with a given [energy consumption], whereas hover-travel becomes superior if [energy consumption] at hovering is reduced, for example, due to wind of a suitable speed, which reduces the energy cost of hovering' (Andersson 1978:73).

Prevailing wind is an important consideration for birds of prey, particularly raptors, whereby the abundance of energy from winds within a certain range can provide the necessary lift for birds to scan a large area with minimal energy expended. In such a circumstance, as noted by Andersson (1978), this would offer substantially more energy efficiency benefits over pause-travel perching.

Wind speed and soaring

The soaring characteristics of birds have been closely studied to inspire aircraft design. According to Penn et al (2022), 'several species of birds, including ospreys, kestrels, and pied kingfishers, can hover at low altitudes when flying into the wind, essentially keeping their heads stationary relative to the Earth's surface as they watch for small prey moving below' (Penn et al 2022:1). Soaring and wind hovering, however, require a specific set of circumstances and conditions. For a falcon, hawk or, likely, small eagle (comparative in size to the aforementioned), wind speed needs to range from between 6.1 metres per second to approximately 16 metres per second (approximately 21 kilometres per hour to 57 kilometres per hour).

Meteorological data was obtained from the Canberra Airport weather monitoring station to understand the wind characteristics of the local area. The Canberra Airport weather monitoring station is located within the airport precinct, and takes measurements at 10 metres in height. The data was analysed over a 12 year period from 2010 to 2022 to understand the prevailing wind speed at different times of the day. To determine the wind speed at elevated heights, to reflect the likely height that an eagle would soar, a wind speed gradient[3] was applied to determine the estimated wind speed at 100 metres[4] in height.

As noted by Dimond (2010), the most active period for the Dragon is between February and May, reflecting the time when adults and juveniles are most active. Some activity from the Dragon would likely occur between September and November, as the weather warms, with a potential reduction during the hotter parts of the year, being December to January. In considering the active time period, the range of year the Dragon is most at risk of predation, the modelling of wind data was undertaken for the months between February and May over a 12 year period[5].

Wind speed modelling based on a logarithmic wind profile is an estimate only. However, the equation used in the models below takes into consideration surface roughness and obstacles, which have an influence on wind speed. Given the optimal range for soaring being between 21km/h and 57km/h and the ability of birds to increase or decrease elevation (thereby finding optimal soaring wind speed) the model provides a reasonable approach to make some observations.

[3] Wind gradient applied was based on the Swiss Wind Power Data Website: https://wind-data.ch/tools (accessed 27/07/2022)

[4] According to Debus 1983, in regard to the Little Eagle, 'a hunting eagle would soar or glide often at about 40m (twice the height tree tops) but up to 100m or more. The ACT Government notes the species as being able to soar up to 500m, in searching for prey (ACT Government 2008). For the purposes of wind modelling, 100m was taken as the reference height.

[5] Although only months corresponding with the most active time period for the Dragon are shown, the wind speed data is fairly consistent across 12 months.

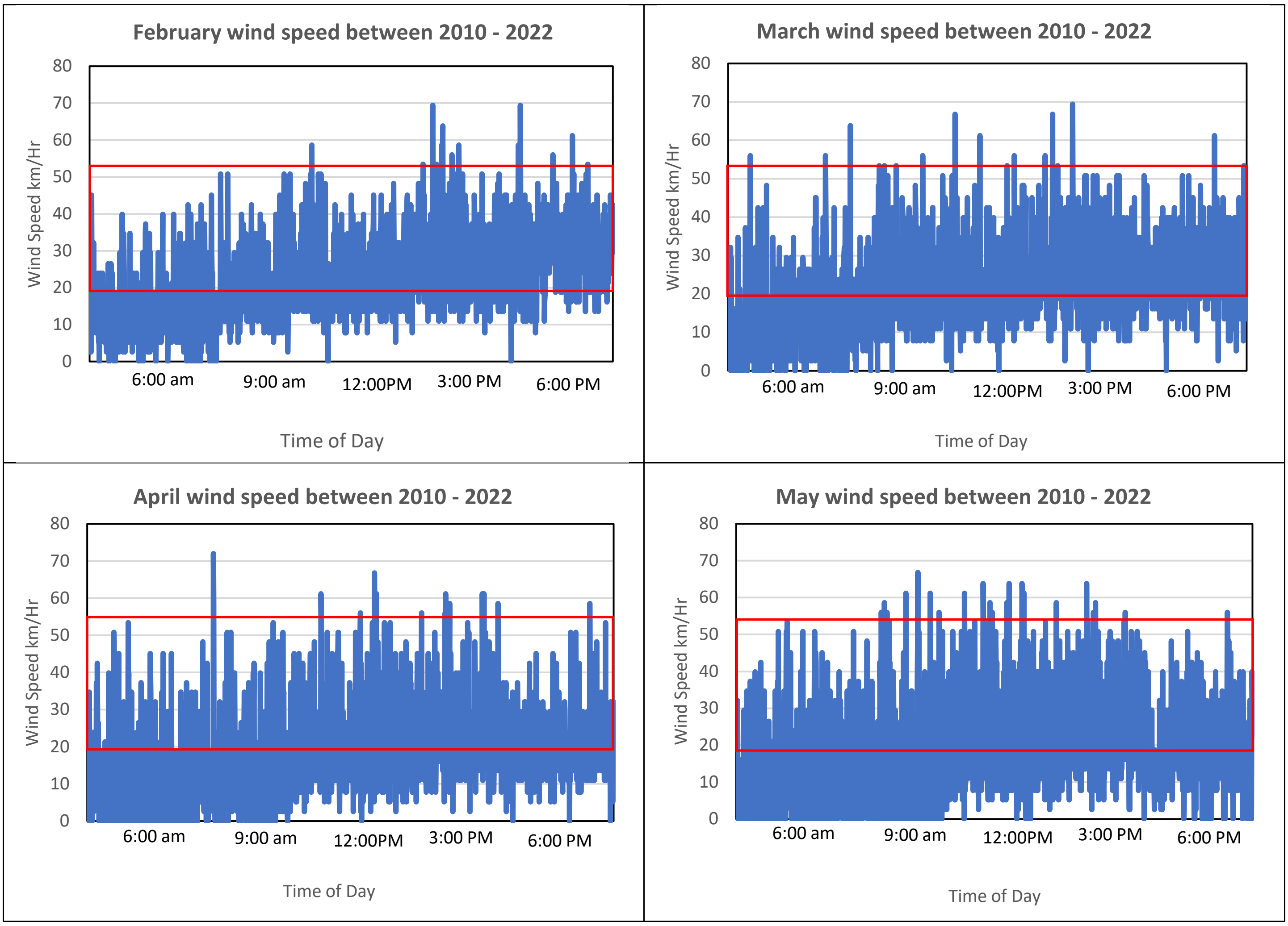


Figure 9: Approximate wind speed over time between February and May over a 12 year period

As can be seen in the above graphs, wind speed for the months where the Dragon is most active is in the optimal range for the Little Eagle to soar. As noted by Andersson (1978) above, continuous travel (soaring) can offer a superior rate of energy consumption compared to pause-travel or perch prey attack, whereby a lot of energy is expended when launching from zero velocity. Continuous travel offers the additional benefit of being able to visually assess a larger area than offered by perch visual inspection where prey detection is extremely limited, being essentially immediately beneath the perch. This is particularly so in low density environments where the prey is difficult to detect.

Optimal climatic conditions that favour a low energy consuming form of prey detection, such as soaring, would mean that the Little Eagle, if given the option, would likely choose soaring over perching or pause-travel. In such a circumstance, the addition of a powerline, especially one that is designed without good roosting opportunities, is not likely to result in a potential advantage in prey detection. As discussed above with reference to Andersson (1978), continuous travel would potentially place the Little Eagle above the height of the pole and, therefore, reduce probability of prey detection in low density environments. However, continuous travel offers the advantage of scanning a vast array of the landscape by moving across a large area within a short timeframe. Areas of interest could be examined closely with reducing altitude, with the bird moving on in the event of an unsuccessful prey attempt.

Given the lack of suitable perching opportunities from the design of the powerline, the limited area of prey detection from a stationary structure, and favourable prevailing wind conditions for soaring, the proposed development is not likely to increase the predator efficiency for raptor type birds. Particularly in a low density environment where the prey is smaller than the surrounding vegetation, detecting prey would be limited to immediately below the perch.

Notwithstanding the likely option of raptors to favour soaring over perching hunting methods, there is an abundance of both natural and artificial perches available within the immediate vicinity of the powerline. The locations of such structures are optimally placed within or immediately adjoining the grassland areas, when compared to the proposed powerline, which will extend along a highly disturbed railway corridor.

Powerline operational deterrents

The proposed development involves the construction of a new dual circuit 132,000 volt powerline, which will supply a proposed new substation within the Poplars development precinct. Several proponents, including a datacentre, property developers and Council, are seeking the electricity network upgrade to ensure supply to the development areas around South Jerrabomberra. The predicted load on the powerline and substation, which forms part of the design criteria, is 60 megavolt amperes (MVA). More than half of that load will be allocated to a datacentre.

Stable consistent electricity supply is an essential requirement to the operation of a datacentre. For the proposed new powerline and substation, the operational consequence is that the load will be continuous rather than one that fluctuates within a 24 hour period. The powerline is being designed for an operating temperature rating of 85 degrees Celsius, however, such an operating temperature would seldom occur, and relates to high loads and hot weather conditions.

Powerline operating temperature is a function of electricity current passing through the conductors and any resistance that is experience during that process. As noted by Dimond (2010), monitoring protocols for the grassland earless Dragon were conducted from early February to mid-March when the species is most active. According to the average monthly temperatures for Canberra, the average maximum temperature range for February through to March is between approximately 25 degrees Celsius and 30 degrees Celsius. Ambient temperatures in that range, combined with moderate load on the powerline, would mean an operating conductor (wire) temperature of between approximately 44 degrees Celsius and 48 degrees Celsius. Operating temperatures in this range would be expected to be uncomfortable for perching and would potentially deter birds from perching on the conductors (wires).

Powerlines, when conducting electricity, create an electric field, whereby the intensity of the field varies depending upon a range of factors such as powerline design, conductor type, conductor length, and load on the powerline (the amount of current being drawn from the network). Electric field intensity can impact species differently depending upon, for example, the thickness of skin, size, resistance of outer layers, proximity to the powerline, and other factors. A bird, for example, will be rendered uncomfortable by the intensity of an electric field long before a human would.

According to Eleperuma (2006), in modelling of electric fields on composite insulators, Parrots, primarily Galahs, had a tendency to continuously chew on composite insulators. Chewing behaviour patterns on the insulators provides an insight into bird tolerance of electric fields. In modelling electric fields on transmission tower insulators, the field was strongest at the end point where the conductor is attached to the insulator. Chewing by Parrots was concentrated on the section of the insulator from approximately 0.35 metre from the end of the insulator. Correlating that distance to the electric field intensity provided an indicated parrot electric field tolerance of 0.085 kilovolts per millimetre. Refer to **Figure 10**.

In correlating the chewing behaviour against the electric field model, electric fields above 0.085 kilovolts per millimetre are likely to be uncomfortable for birds and act as a deterrent from perching. Regarding the proposed development, modelling of electric fields was carried out by Brennan Consultants Pty Ltd (2022) (**Figure 11)** based upon nitrogen conductor (21 millimetres diameter) with a conductor separation distance of 2200 millimetres. As noted in **Figure 11**, the voltage gradient or electric field on the conductor of the proposed powerline would likely be in the order of 1.6 kilovolts per millimetre. An almost doubling of the electric field observed by Eleperuma (2006) as causing discomfort to Parrots.

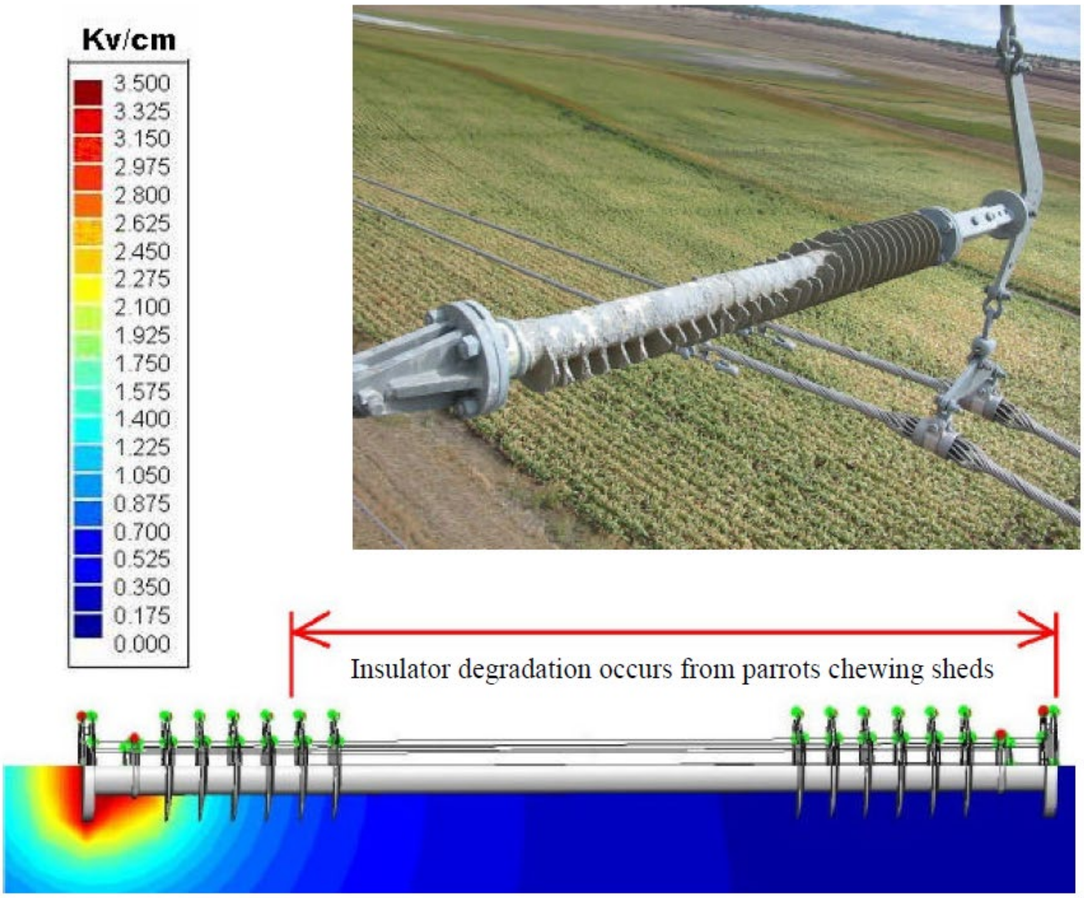


Figure 10: Electric field from a post insulator showing shed degradation from parrots (Eleperuma 2006:44)

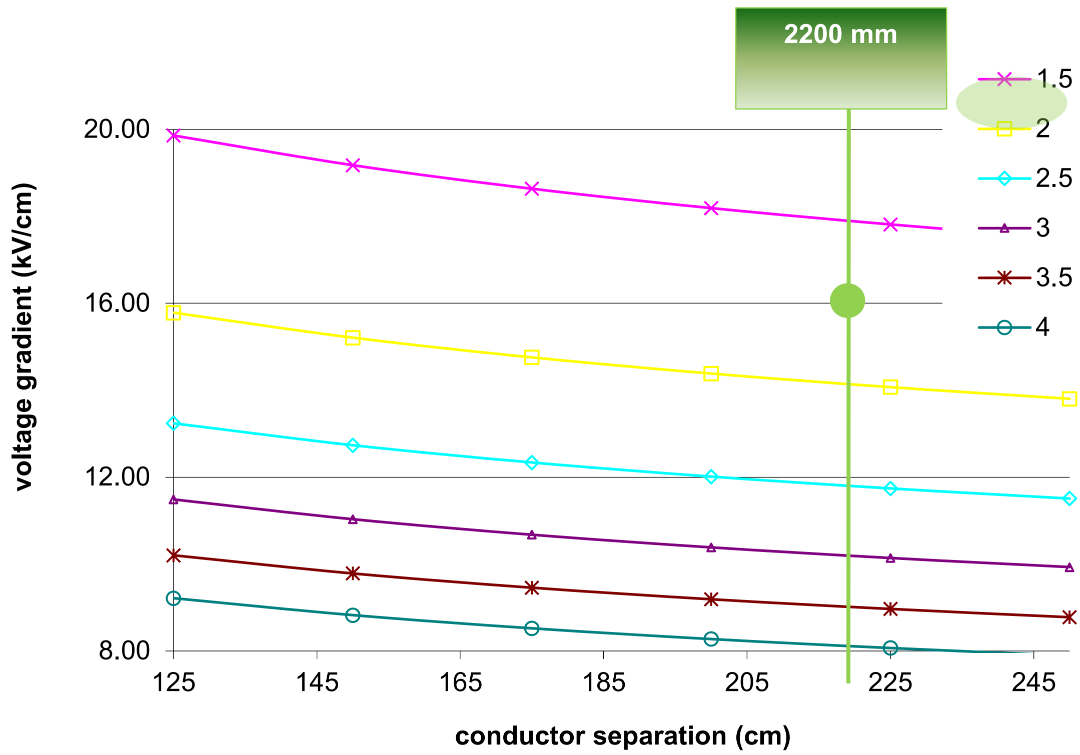


Figure 11: Voltage gradient relative to conductor separation

During the site visit carried out on the 2 August 2022 on a 132,000 volt sub-transmission powerline, similar to the development being proposed, no birds were observed as perching on the powerline for one kilometre in either direction (nor along a 6 kilometre range of various powerlines), despite observing bird activity in the immediate vicinity. Refer to **Plate 4**.

Research works carried out by Eleperuma (2006) provides an indication, only, of potential electric field tolerance of avian species. More work would be required to confirm the validity of the observation, however, birds perching on high voltage powerlines is not a common occurrence. A number of factors could contribute to higher voltage powerlines not being considered optimal perching opportunities, such as height, temperature and electric induction.

Plate 4: Photo of the Cooma to Bega 132,000 volt powerline taken approximately five kilometres from Cooma to the east

Increase in bird mortality from collision with powerlines

A large body of international literature is available on bird interaction with powerlines. According to Bernardino et al (2018), there are a number of factors that contribute to bird collisions. First, specific characteristics of certain bird species play a role. This includes species morphology and physiology where the birds with short wings and heavy bodies were more prone to collisions, as were birds with poor eyesight. Other factors such as bird flight behaviour were less conclusive, i.e., flying in flocks versus sole fliers indicated that those individuals flying at the back of the flock may have less chance to see the upcoming line, although contrasting, it also suggested that those flying in flocks may have a greater chance of seeing the powerline. Gender specific factors may also play a role.'

Other non-bird factors, including topography and adjoining habitat features, particularly coastline habitat, may lead to more incidents of bird strike because of migrating bird patterns, however the data was less than conclusive in this regard. Weather and light conditions were also factors, with adverse weather conditions (fog, rainfall, snow and cloudy conditions), as well as wind speed and direction playing a role. For powerline-specific factors, the number of vertical wire levels was shown to play a role. There is some evidence to suggest that a reduction of vertical lines, mainly related to transmission lines (which have multiple vertical levels of lines), can result in a reduction in bird collisions.

Wire diameter and earth wire were also widely accepted to be a determinant factor of a collision risk. Generally, the thicker the wire, the more likely the bird would avoid collision. The presence of an overhead earth wire (which is often thinner than the conductors) also played a role, although it is acknowledged that this may be due to the bird reacting late to the conductor and rising up to avoid collision with the conductor and then colliding with the thinner earth wire above.

The article also reviewed various strategies to mitigate collisions, including underground cabling (obvious benefits but the article acknowledges not always economically feasible), route planning, powerline configuration (i.e. reduction in number of vertical levels of powerline, removal of earth wire, keeping line as low as possible, span lengths as short as possible and conductors used as thick as possible), modification of habitat and land use practices adjacent to powerlines to change local flight paths and prevent bird collisions, and line marking.

In considering line marking effectiveness, although some studies referenced in this article suggested a resulting reduction of bird collisions, other variables, such as habitat, type of markers used, and carcass persistence and detectability were not well studied. The article also acknowledges the technical constraints of line marking, interfering with the operation of the powerline, as well as the deterioration of markers over time leading to ongoing maintenance work to replace the marker.

An older (2012) American manual also supports the many factors described in the Bernardino et al (2018) article which may contribute to bird collisions with powerlines, including species-specific factors (i.e. short-winged, heavy-bodied birds), weather, light conditions etc. For powerline factors, consistent themes also emerge, such as the number of vertical lines, height and thickness of conductor (21 millimetres thick conductor is proposed to be used) being determinant factors.

The largest at risk group of birds for powerline interactions relate more to short-winged, large-bodied birds. According to D'Amico et al (2018), the most relevant morphologic feature increasing collision risk has been suggested to be the combination of a heavy body and relatively small wings, for instance in bustards and grouses (Bevanger 1994, 1998; Janss 2000). Birds with narrow visual fields, such as storks and cranes, are also heavily affected by collisions (Martin and Shaw 2010; Martin 2011). Long legs or wings, such as for example in storks or eagles, can easily trigger the electrocuting trap (Bevanger 1998; Janss 2000; D'Amico et al 2018:651).

Raptors, including the Little Eagle, are generally more agile and have superior eyesight. Nonetheless, the design of the proposed powerline at Jerrabomberra incorporates many of the observed mitigating factors, such as a conductor separation distance of approximately 2m along the vertical plane, and a thicker and heavier conductor. Despite D'Amico et al (2018) noting that 'these vertical infrastructures [power poles] provide a wide field of view, enhancing predation efficiency', the study referenced by D'Amico et al (2019) to support that claim did not investigate predation efficiency, but rather the efficiency of perch deterrents. Indeed, according to Prather and Messmer (2010), 'we did not record any raptor or corvid electrocutions or direct predation on Gunnison sage-grouse'.

Despite the findings by Prather and Messmer (2010), there are occasions where birds can collide with powerlines, including raptors. The event is rare but can happen from time to time and as such, the development may result in the odd occasion of fatality. The risk of such an outcome is mitigated through the design, through the use of large and heavier conductor, and the arrangement of the powerlines within the one column separated by over 2 metres of distance between conductors. Whilst a bird fatality is a potential outcome, over the life of the development it is not likely to result in an overall increase in raptor mortality. The findings above support the view that more agile birds, like raptors, have a low risk of powerline collision, especially when compared to short-winged heavy birds, or long-winged and/or long-legged birds. Birds observed during site investigations include the type of birds (Galahs, Ravens, Magpies, Black-shouldered Kite) that are not likely to collide with powerlines.

Assessments of significance

When considering the potential impact of a development upon threatened species, communities or their habitats at the Commonwealth level, and within the ACT, the Guideline must be followed to determine the level or significance of impact. Accordingly, the Guideline contains impact criteria to be assessed against in determining whether an adverse or significant impact is likely.

The question posed by the ACT EIS scoping requirements was on potential impact of the proposed development on increasing predation efficiency and predator abundance. The most likely candidates to be impacted would be species that utilise the grassland as core habitat being the Dragon, nationally listed as endangered and the Striped Legless Lizard, nationally listed as vulnerable. For the purposes of the impact assessment, the more stringent criteria (for endangered species) were used in **Table 1**.

Table 1: Assessment of significance in accordance with Significant Impact Guidelines 1.1 – Matter of National Environmental Significance under the EPBC Act (The Guideline) – Grassland Earless Dragon

	An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or probability that it will:
Criteria	**Lead to a long-term decrease in the size of the population**
Response	No. The proposed development will be constructed within a largely disturbed former railway corridor that sits just outside two large reserve areas. The action will not impact upon the life cycle of the Dragon, reduce habitat extent, or increase opportunities for predation or disturbance.
Criteria	**Reduce the occupancy of the species**
Response	No. The proposed action will not result in a reduction of the occupancy of the species as the powerline will extend over a large section adjoining key Dragon habitat, not within it. Once constructed, any disturbance areas can naturally rehabilitate with limited ongoing ground disturbances or maintenance activities over the life of the development.
Criteria	**Fragment an existing population into two or more populations**
Response	No. The location of the powerline is within a largely disturbed rail corridor that dissects the two reserves. Whilst some natural regeneration of habitat values has occurred, the two reserves remain separated. The habitat of the Dragon is grassland, which can co-exist with a powerline development. Being lower storey vegetation, the powerline can span (approximately 220 metres) over large sections between poles and will require very limited ongoing vegetation maintenance when compared to a forested area. The development of the powerline will not result in the fragmentation of two populations, nor hamper the ability to connect the reserves in the future if the railway line is deemed ‘non-active’ and removed.
Criteria	**Adversely effect the habitat critical to the survival of the species**
Response	No. The proposed action is contained within a highly disturbed and modified environment consisting of a railway corridor. There will be no impacts on habitat that has been dedicated to the preservation and conservation of the Dragon.
Criteria	**Disrupt the breeding cycle of a population**
Response	No. The proposed activity will not impact upon the breeding cycle of any population, and construction works for those small section of the corridor (approximately 850 metres) in proximity to potential Dragon habitat can be constructed during the cooler months when the Dragon is less active.
Criteria	**Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline**
Response	No. The proposed action will occur within a disturbed rail corridor. Impacts would occur during construction, however, post construction natural rehabilitation of the area around

	the poles can occur. The works will be undertaken adjacent to two large reserves dedicated for the preservation of grassland fauna. As per the table below there is 292.1 hectares of land under private and public conservation within the immediate vicinity. The powerline will extend across a portion of the Queanbeyan Nature Reserve, however, structures (poles) will be kept outside of the reserve boundaries.

Conservation lands name	Area (ha)
Jerrabomberra East Grasslands Nature Reserve (ACT)	110ha (estimated)
Queanbeyan Nature Reserve	83ha (confirmed via GIS)
Poplars North Biobank Agreement	43.4ha (confirmed via GIS)
Poplars South Biobank Agreement	55.7ha (confirmed via GIS)
Total	**292.1**

Criteria	**Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat**
Response	No. To respond effectively to this question requires the consideration of 'what is an invasive species?' According to the Guideline, an 'invasive species' is an introduced species, including an introduced (translocated) native species, which out-competes native species for space and resources, or which is a predator of native species. Introducing an invasive species into an area may result in that species becoming established. An invasive species may harm listed threatened species or ecological communities by direct competition, modification of habitat, or predation In order to respond in the affirmative to the above question, three condition precedents must be satisfied. First, it is not necessary that the species being introduced is a non-native species. As noted, an invasive species is not one that exclusively comprises introduced species, but one that extends to native species. However, in such circumstance it relates to a native (or introduced) species that may be introduced into a location or ecosystem that it had not previously been a part of. Secondly, the introduction of that species (be it native or non-native) must have a corresponding consequence on existing native species. Whether that be from a species out competing established species, or one that results in the established species becoming prey to the newly introduced species, which were not preyed upon previously. The third condition relates to the species becoming established. That is, the introduction of the species is more than a temporary or short-lived experience, and is one in which the longer-term consequence of its establishment places pressure on existing species' ability to survive. The proposed development will not result in the introduction of species, native or otherwise, into an area where they are not currently established. Predators of listed threatened species are naturally currently established whereby they form a part of the current landscape and broader ecological values. For example, Ravens and Magpies (species identified in the recovery plan as a potential concern) are regularly seen throughout the Canberra area, and more locally at the proposed powerline site inhabiting the many tree resources available adjacent to the proposed development. Therefore, the action will not create a situation (natural or otherwise) that would encourage predator efficiency or increase their numbers. Furthermore, in considering the work by Remesova et al (2019), Andersson (1978) and site observations of local bird characteristics, 'pouncing' prey occurs predominantly from lower perches, there are diminishing rates of return for prey success the higher a species is (particularly in low density environments where the prey is hard to detect) and there are ample suitable perching opportunities that make predation more attractive than a powerline. For example, artificial posts linked to the extensive

	kangaroo exclusion fencing contained within the grassland itself, historical structures, and a row of Cypress pine trees adjoining the Queanbeyan Nature Reserve (and proposed powerline corridor) that extends for over 850m from the north of Lanyon Drive. During the site visit on 2 August 2022, avian wildlife were observed exactly as described by Remesova et al (2019), seeking out lower perches when higher perches were available to detect potential prey. The kangaroo exclusion fence sits approximately two metres above the grassland and extends over an area of at least 1,780 metres (more fencing beyond the mapped exclusion fencing is present). In low density, small prey environments, a two metre high perch would be a more favourable perching proposition to a 21 metre high pole that sits outside of the grassland areas. Birds of concern (Ravens and Magpies) have shown a preference for smaller height perches even when higher perches are available. Combining the availability of lower perches either by the extensive kangaroo fence or natural tree branches within the Cypress pine plantations, the proposed development will not impact upon prey efficiency or abundance. Extending along the rail corridor are also a number of redundant railway communication poles. Similar in design to distribution power poles, these historical structures comprise a single pole with two horizontal cross arms. There is little evidence, (i.e. nesting, roosting) of birds utilising these structures. The powerline design is such to deter and discourage active roosting on the powerline by providing no to minimal horizontal top surfaces, thereby not facilitating habitat conditions. As noted by APLIC (2006) above, predation can occur irrespective of the powerline development. Indeed, other predation methods such as soaring, under certain circumstances, provide greater energy efficiency compared to perch and launch attacks. Furthermore, the height of the poles offers diminishing returns for predation efficiency, particularly in a grassland landscape where the prey (reptiles) is smaller than the surrounding grass tussocks. Low density prey in difficult-to-see environments restricts visual cues, resulting in predator birds needing to seek lower perches to see or hear movement.
Criteria	**Introduce disease that may cause the species to decline, or**
Response	The proposed action will occur over an approximate distance of six kilometres within the same locality. Given the location and extent, there is limited potential for biosecurity risks to be spread given the confined working site. Biosecurity control measures would be introduced, such as ensuring vehicles travelling from other regions to be used will be thoroughly cleaned and free of debris
Criteria	**Interfere with the recovery of the species**
Response	The proposed action will not interfere with the recovery of the species, as it will not fragment, reduce the extent of habitat, enable an introduced species to become established, impact upon the life cycle, nor create a situation that places the Dragon at risk of harm. Recovery efforts currently underway will not be impacted by the proposed action, such as habitat recovery measures and the captive breeding and release of Dragons.

The above assessment of significance confirms that the potential risk of increasing predation efficiency and predator abundance is not likely and that any risk is considered low. Avian species of interest, for their predation potential, are readily established within the local area and form an important part of the local ecological systems using many of the available perching opportunities that currently exist in either natural or artificial form. Moreover, the extensive kangaroo exclusion fencing would provide superior perching opportunities to predate from than a proposed powerline that, as a minimum, is 21 metres high. The absence of an EPBC Act referral in relation to the erection of the fence indicates that the kangaroo exclusion fence was not considered to be a significant impact, which would likely increase predation potential risk (as outlined in the Dragon recovery plan) significantly above a 21 metre high powerline.

Conclusion

Increases in predation efficiency and predator abundance are influenced by many factors. Artificial structures have previously been identified as a potential opportunity for predators to take advantage of in their hunt for prey, particularly threatened species. However, the success of such perch hunting approaches is limited, and is more successful when the prey is a small mammal that is readily recognisable from a distance over prey that is smaller than the surrounding environment. Success of prey methods, such as pouncing, is largely driven by perch height, which in low density environments requires a lower-level perch to detect prey either visual or listening. Consequently, any prey search attempts using the perch hunting method are also limited in the scope and breadth of habitat that can be searched, confining such prey attempts to immediately below, or within the direct vicinity of, the perch. For ground-based predators, for example a Magpie, greater success would be experienced by on-ground predation methods, which is supported by published field observations.

Conversely, predation approaches by raptors, which prey at heights, are likely to favour soaring over pause-travel due to the energy efficiency that soaring offers over zero velocity launches. Combining the limited field of view from perches, plus the required energy expended to pounce from a perch, a soaring approach whereby vast amounts of habitat can be scanned for movement would likely be the preferred predation method of raptors.

A range of literature has been reviewed in the development of this paper examining various attributes of avian predation. There are a number of factors that must be considered when assessing the potential impacts of any development, and the influence that they may have on natural predation processes. To determine the seriousness of an impact, careful consideration needs to be given to the spatial scale of a threat, whether that be at the local, regional or state level, the magnitude of possible impacts, the perceived value of the environment, temporal scale of possible impacts, and the reversibility of an impact. Numerous papers have been referenced in compiling this paper that discuss at length the optimal height for predation in different environments by taking into consideration the density of prey, surrounding landscape, prey size and energy consumption from prey activities.

Landscape features of the locality include planted Cypress pine trees commonly planted along property boundaries, including between the railway corridor the QNR. Field observations identified that the Cypress trees were supporting an abundance of avian life comprising an array of species such as Ravens, Magpies, Galahs, Kites and Kingfishers. Such species are local to the Canberra district in large numbers. Consequently, the proposal will not lead to an increase in avian abundance as the avian wildlife already exists within the locality and forms in important component of the local ecology.

Avian interactions with powerlines can result in fatalities. The likely risk a powerline may pose to avian wildlife is contingent on a number of factors. For example, the powerline design, position within the landscape (especially hill tops and ridgelines), phase separations, thickness of the conductor, and the type of bird that has the potential to interact with a powerline. Birds that have short bodies and large wings or long legs are most at risk of a collision with a powerline. Avian species within the local area of the proposed development are ones that generally have a low risk of collisions with powerlines and, therefore, the proposed development is not likely to place local birds at an increased risk of mortality.

Through this methodological, rigorous approach, the scientifically credible scenario is that the proposed powerline will not lead to an increase in predation efficiency or predator abundance. There is no evidence to suggest that the proposed powerline, in considering its design and operation, will provide an increase in perching opportunities, and subsequently lead to an increase in predation efficiency on threatened reptiles. Particularly in low density landscapes where the prey (small lizards) are much smaller than grass. In such circumstances, lower prey heights, and predators situated directly above the prey, is required for detectability. Indeed, where height is increased, the evidence suggests there is a diminishing rate of return for predation success. Furthermore, any advantages that height may provide for detecting prey, which the literature suggests needs to be the size of a small mammal or bird for the predator to detect, is counteracted by the increase in distance, leading to a lower success rate for long strikes.

For the reasons outlined in this paper, the proposed dual circuit 132,000 volt powerline is not likely to:

- Increase predation efficiency or predator abundance on adjacent grasslands, nor
- Increase mortality of birds due to collisions with the proposed powerline, especially the Little Eagle, which is an agile and nimble bird.

Acknowledgment

- Afreen Hussain, Essential Energy, Graduate Civil Engineer, paper review
- Alex Baitch, BES (Aust) Pty Ltd, assistance with powerline operating temperature calculations and literature review
- Cameron Perry, Essential Energy, Environmental Engineer, wind gradient data extrapolation and graphs (adapted from Bureau of Meteorology Canberra Airport weather monitoring station)
- Chris Dunn, Essential Energy, Environmental Engineer, paper review
- Gary Brennan, Brennan Consultants Pty Ltd, provisions of powerline voltage gradients and literature review
- Melissa Bice, Essential Energy, Senior Lawyer, paper review
- Mike Lloyd, Essential Energy, Environmental Operations Manager, paper review
- Nathan Hegerty, Essential Energy, Senior Environmental Engineer, paper review and bird collision contribution

References

- Andersson, M, 1978, *On Optimal Predator Search* Theoretical Population Biology, Department of Zoology, University of Gothenburg, Sweden Vol 19, No. 1 February 1981
- Andersson, M, Wallander, J, Isaksson, D, 2009, *Predator perches: a visual search perspective*, Functional Ecology 23, 373-379, Department of Zoology, University of Gothenburg, Sweden
- Australian Capital Territory Government, *Grassland Earless Dragon Tympancryptis pinguicolla Action Plan*
- Australian Capital Territory Government, 2022, Environment, Planning and Sustainable Development Directorate – Environment, https://www.environment.act.gov.au/nature-conservation/conservation-and-ecological-communities/threatened-species-factsheets/little_eagle website accessed August 2022
- Avian Power Line Interaction Committee (APLIC) 2006, *Suggested Practices for Avian Predation on Power Lines: The State of Art in 2006*. Edison Electric Institute, APLIC, and the California Energy Commission. Washington D.C and Sacramento, CA.
- Bayle, P 1999, *Preventing Birds of Prey Problems at Transmission Lines in Western Europe*, The Raptor Research Foundation Inc. 33(1):43-48 Marseille, France
- D'Amico, M, Catry, I, Martins, R, Ascensao, F, Barrientos, R and Moreira, F, 2018, *Bird on the wire: Landscape planning considering costs and benefits for populations coexisting with power lines*, The Royal Swedish Academy of Sciences 47:650-656
- Debus, S, 1983, *Behaviour and Vocalisations of Nesting Little Eagles*, Australian Bird Watcher, Vol. 10(3)

- Dimond, W, 2010, *Population decline in the endangered grassland earless dragon in Australia: Identification, cause and management*, Institute of Applied Ecology, University of Canberra, Australia
- Dwyer, J and Doloughan, 2014, *Testing systems of avian perch deterrents on electric power distribution poles in sage-brush habitat*. Human-Wildlife Interactions 8(1): 39-55, Spring
- Eleperuma, K, 2006, *Modelling of Electric Fields on Composite Insulators – Volume II*, School of Information Technology and Electrical Engineering, The University of Queensland
- O'Leary, R and Jones, D, 2002, *Foraging by Suburban Australian Magpies During Dry Conditions* Corella 26(2): 53-54, Suburban Wildlife Research Group, Australian School of Environmental Studies, Griffith University Queensland, Australia
- Prather, P and Messmer, T, 2010, *Raptor and Corvid Response to Power Distribution Line Perch Deterrents in Utah*, Journal of Wildlife Management 74(4): 796-800
- Penn, M, Yi, G, Watkins, S, Martinez Groves_raines, M, Windor, S and Mohamed, A, 2022, *A method for continuous study of soaring and windhovering birds*, Scientific Reports 12:7038
- Raptor Protection of Slovakia, 2019, *Protecting birds from power lines focusing on countries of Danube/Carpathian region*
- Remesova, E, Matysiokova, B, Rubacova, L and Remes, V, 2020, *Foraging behaviour of songbirds in woodlands and forests in eastern Australia: resource partitioning and guild structure*, EMU – Austral Ornithology, Vol. 120, No.1, 22-32, Department of Zoology and Laboratory of Ornithology, Faculty of Science, Palacky University, Olomouc, Czech Republic, Department of Zoology, Faculty of Natural Science, Comenius University, Bratislava 4, Slovakia
- Ricardo, T, Dias, M, Chumbinho, P, Claudia, A and Carolina, B, 2011, *Influence of perch height and vegetation structure on the foraging behaviour of Little Owls Athene noctua: how to achieve the same success in two distinct habitats*, Ardea 99(1): 17-26, Netherlands Ornithologists Union
- Robertson, P. and Evans, M. (2009/2012). National Recovery Plan for the Grassland Earless Dragon *Tympanocryptis pinguicolla*. As varied October 2012. ACT Department of Territory and Municipal Services, Canberra
- Steven J. Slater and Jeff P. Smith, 2010 "Effectiveness of Raptor Perch Deterrents on an Electrical Transmission Line in Southwestern Wyoming," Journal of Wildlife Management 74(5), 1080-1088,

Appendix C – Aboriginal Due Diligence Assessment

Aboriginal and Historical Cultural Heritage Due Diligence Assessment 132vK Powerline Installation

Report Prepared for Essential Energy

3 February 2022

www.pasttraces.com.au

email: office@pasttraces.com.au

Document Control

Revision	Date	Author	Reviewed
V1	12/01/2022	G.Scully	Lyn O'Brien, Essential Energy.
V2	03/02/2022	Lyn O'Brien	Essential Energy

Disclaimer

Past Traces Pty Ltd has undertaken this assessment in accordance with the relevant Federal, State and Local Government legislation. Past Traces accepts no liability for any damages or loss incurred as a result of use for any purpose other than that for which it was commissioned.

Restricted Information

Information contained within this report is culturally sensitive and should not be made publicly available. The information that is restricted includes (but is not limited to):

- Maps, Mapping Grid Reference Co-ordinates or images for Aboriginal heritage sites, places and objects.
- Location or detailed information regarding places of Aboriginal cultural significance, as expressed or directed by Representative Aboriginal Organisations, Aboriginal elders, or members of the wider Aboriginal community.
- Other culturally appropriate restricted information as advised by Aboriginal representatives and traditional knowledge holders.

Information in the report covered by the above categories should be redacted before being made available to the general public. This information should only be made available to those persons with a just and reasonable need for access.

www.pasttraces.com.au

email: office@pasttraces.com.au

CONTENTS

www.pasttraces.com.au

email: office@pasttraces.com.au

EXECUTIVE SUMMARY

This report provides Aboriginal and Historical heritage due diligence advice for the proposed installation of a 132kV power line, along the Goulburn Bombala Railway corridor. The project runs south along the Bombala railway corridor from the approximate junction between the Canberra and Bombala rail lines for an approximate length of 4.7km before heading south-east across Lot 1 DP878275 prior to crossing Lanyon Drive into Tompsitt Drive. At approximately 800m the trajectory diverts south-west across Lot 1 DP1263364 and terminates at the substation location.

The railway corridor has been highly impacted by the construction of the railway, associated infrastructure and ongoing use of the railway. Sections of the properties Lot 1 DP 1263364 and Lot 1 DP828275 have been moderately impacted by historical use as a rural property. The study area is shown on Figure 1 in a regional context with details of the proposed powerline in Figure 2.

This Due Diligence heritage assessment has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (DECCW 2010a).

The proposal would involve the following impacts:

- The installation of power poles and overhead cabling
- Movement of plant and disturbance of topsoils
- Vegetation removal and trimming.

No heritage sites or areas of Potential Archaeological Deposit (PAD) were identified within the project area based on a review of previous reports.

Field survey was undertaken across the project area in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b). The field survey covered areas of the railway corridor, road verge and rural property. Ground visibility was low to moderate at the time of field survey, with some areas of exposed soils throughout, with one Aboriginal heritage site identified by field survey.

As a result of the field survey and background research completed for the project, the following recommendations have been developed:

- One heritage site is present within the area of works (SJ1). Design works, should aim to avoid impacting upon this location, where possible.
- If impacts to site SJ1 cannot be avoided, the completion of an Aboriginal Cultural Heritage Assessment Report (ACHAR) to support an application for an Aboriginal Heritage Impact Permit (AHIP) from NSW Heritage is required. An ACHAR requires full consultation with the Aboriginal community. No impacts to the recorded site can occur prior to the granting of an AHIP.

- All Aboriginal objects are protected under the *NSW National Parks and Wildlife Act 1974*. It is an offence to disturb an Aboriginal site without a permit issued by NSW Heritage. Should any Aboriginal objects be encountered during works then works must cease and the find should not be moved until assessed by a qualified archaeologist.
- In the unlikely event that human remains are discovered during the construction, all work must cease. NSW Heritage, the local police and the appropriate Local Aboriginal Land Council (LALC) should be notified. Further assessment would be required to determine if the remains are Aboriginal or non-Aboriginal.
- Further archaeological assessment would be required if the proposal activity extends beyond the area of the current investigation.

1 INTRODUCTION

This report provides Aboriginal and Historical heritage due diligence advice for the proposed installation of a 132kV power line, along the Goulburn Bombala Railway corridor. The project runs south along the Bombala railway corridor from the approximate junction between the Canberra and Bombala rail lines for an approximate length of 4.7km before heading south-east across Lot 1 DP878275 prior to crossing Lanyon Drive into Tompsitt Drive. At approximately 800m the trajectory diverts south-west across Lot 1 DP1263364 and terminates at the substation location.

The railway corridor has been highly impacted by the construction of the railway, associated infrastructure and ongoing use of the railway. Sections of the properties Lot 1 DP 1263364 and Lot 1 DP828275 have been moderately impacted by historical use as a rural property. The study area is shown on Figure 1 in a regional context with details of the proposed powerline in Figure 2.

The proposal would involve the following impacts:

- The installation of power poles and overhead cabling
- Movement of plant and disturbance of topsoils
- Removal and trimming of vegetation.

Impacts from the works will be limited in nature, confined to the immediate vicinity of powerpoles and soil disturbance. The majority of the project area containing the overhead cabling alignment will not be impacted except in a minor degree by vehicle movement and vegetation trimming. Heritage sites may be located on the surface, or subsurface in areas of high potential for the preservation of archaeological remains. These heritage sites may relate to historical events or past usage by Aboriginal groups.

To assess the potential impacts of the proposed works on heritage this Due Diligence Heritage Assessment has been undertaken.

This report, field survey and associated research has been conducted in accordance to the requirements of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (OEH 2010.

1.1 PROJECT OBJECTIVES

The due diligence assessment is being undertaken to complete the following objectives:

1. Review of the NSW Heritage, Aboriginal Heritage Information Management System (AHIMS), to identify any recorded heritage sites within the project area.
2. Review of historic registers to identify any historic heritage.
3. Review of previous reports in area to develop predictive model of site location

4. Assess landforms present in project area against predictive model to determine potential for heritage sites and determine level of disturbance
5. Complete site visit to visually inspect impact areas or areas assessed as holding potential based on predictive model and record any identified heritage sites. The site visit will also document levels of disturbance within project area.
6. Complete due diligence report with management recommendations to avoid or minimise impacts within the project area.

1.2 ABORIGINAL CONSULTATION

Consultation with the Aboriginal community is not a requirement of the Due Diligence Code of assessment, which is undertaken at the preliminary planning stage of the project. However, the Ngambri Local Aboriginal Land Council was engaged and a member of the LALC attended the field survey.

If the assessment finds that impacts to Aboriginal heritage will occur as a result of the development then consultation will be undertaken with the LALC and the wider Aboriginal community, in accordance with the consultation guidelines required by NSW Heritage during the development of the ACHAR.

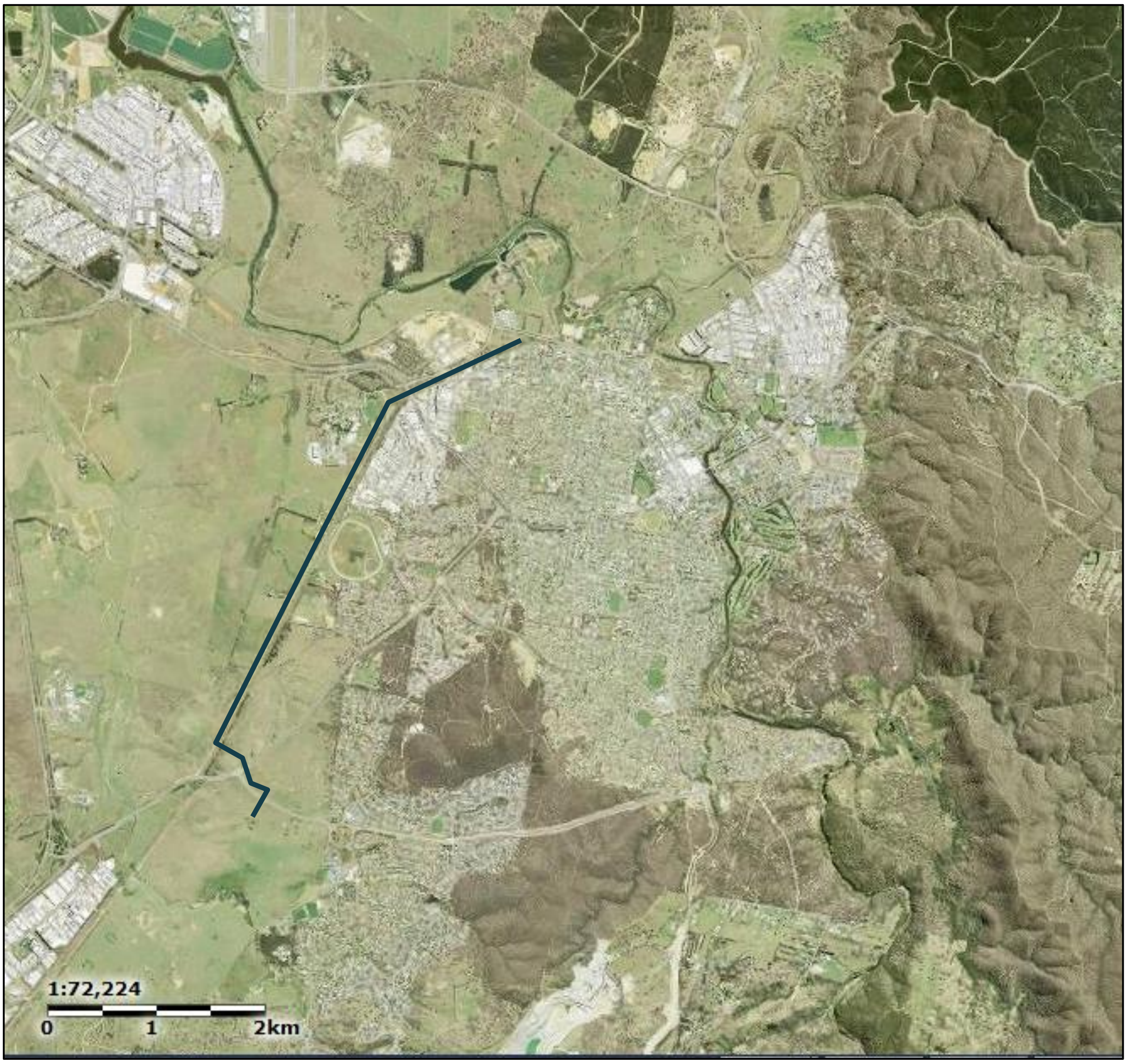


Figure 1. Location of project area - Regional (Base Map SixMaps NSW)

www.pasttraces.com.au

email: office@pasttraces.com.au

Figure 2a. Detail of proposed works - Northern Section

www.pasttraces.com.au

email: office@pasttraces.com.au

Figure 2b: Southern Section

www.pasttraces.com.au

email: office@pasttraces.com.au

2 DESKTOP ASSESSMENT RESULTS

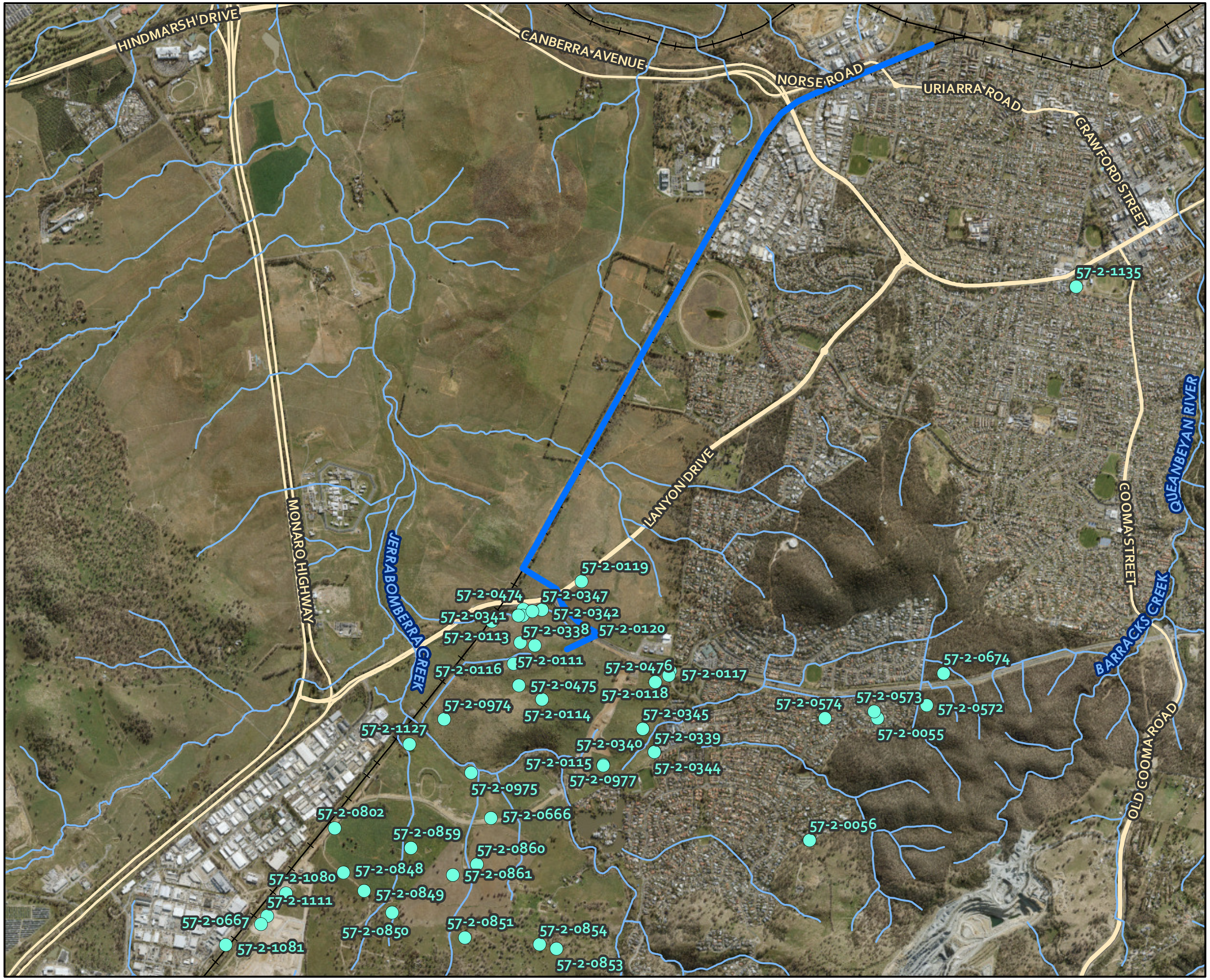
2.1 AHIMS SEARCH

A search of the NSW Heritage AHIMS database was undertaken on the 30 September 2021 covering the 1km surrounding area centred on the project area. The extensive search revealed no previously recorded heritage sites within the project area with 50 sites within the wider search area. The recorded sites consist of an isolated artefacts, small artefact scatters and areas of Potential Archaeological Deposit (PAD).

Within the wider Queanbeyan area several studies have been undertaken (Kuskie 1989, Williams 2006, NOHC 2010a&b, 2014, 2018, CHMA 2014) which have resulted in the identification of a number of Aboriginal sites, mainly consisting of artefact scatters or isolated finds. These studies have resulted in a site location model being developed for the region. This model predicts the majority of sites will consist of small artefact sites located on level ground or terrace features in proximity to water sources, with larger sites with subsurface deposits being present in proximity to water features such as a creek confluence or major water sources. This is directly applicable to the project area. This predictive model is discussed in more detail in Section 2.2.

The recorded sites listed on AHIMs for the area are shown on Figure 3 in relation to the project area.

Figure 3: AHIMS



Legend

AHIMS

NSW 13kV

Watercourse

Railway

Major Road

N

1:40,000

0 0.25 0.5 1 1.5 2

Kilometers

Coordinate System: GDA 1994 MGA Zone 55

Imagery: © ACTmapi

PastTraces Heritage Consultants

2.2 HISTORICAL HERITAGE SEARCH

Within NSW Local government is responsible for listing and regulating local heritage items. This responsibility is mainly fulfilled by listing heritage items in the Local Environmental Plans (LEPs) under the *Environmental Planning & Assessment Act 1979*. Council approval maybe required to impact any listed item.

Heritage items can also be of 'state significance' in which case they are listed on the NSW Heritage Register by the NSW Heritage Council under the *Heritage Act 1977*. These items are usually substantial and consist of buildings, bridges or other structures that represent events in the local area.

A search of the NSW Heritage Register, the Queanbeyan LEP 2012 and the Palerang LEP 2014 was undertaken for the project (accessed 11/10/2021) revealing that the project area is not within any local or State registered heritage sites. The closest site is that of the State registered Queanbeyan Railway precinct, but the project will have no impact on the site. This precinct includes the following heritage listed items, the Queanbeyan Railway Group, comprised of the Queanbeyan Railway Station, the Railway Worker's Cottage, the Station Master's Cottage and Bull's Cottage. These heritage items do not intersect directly with the project area but are located close by to the east of the area.

The Queanbeyan Railway Station Group covers the intact structures of the railway. The Queanbeyan Railway Station was opened in 1887 and accompanying residences of the Station Master's and Railway Worker's cottages also built in the late 1880s. The station is an excellent example of Victorian train station complexes that remain in good condition. The building of the railway had a significant economic impact on the Queanbeyan township, as local manufacturing businesses were closed after failing to compete with the Sydney producers the railway exposed them to. The location of the station and its associated structures established Oaks Estate as a working-class suburb, causing the subsequent subdivision and settlement of the estate.

The substantial brick station and station master's cottage are indicative of Queanbeyan's status as an important regional centre of NSW, as the period in which they were constructed was a period of financial difficulty. the Queanbeyan station building is the largest and most ornate on the Bombala rail line. Between 1887 and 1892 Queanbeyan station was one of only 10 stations to be constructed with brick buildings with the 121 other stations being relegated to using the cheaper construction materials of timber and iron (Queanbeyan Railway Station Group – NSW State Register Entry 01226 – accessed 11/01/2022). As such the buildings were part of an exclusive group of major buildings opened in the late Victorian era. The group also belongs to the last years of the high Victorian period of railway construction between 1886 and 1892 in NSW and is an example of the Victorian Free Classical Style architecture.

Plate 1:Locomotive 3214 hauling northbound Sunday passenger train from Canberra arriving at Queanbeyan [station], and 4 car Canberra-Sydney diesel set, 10 April 1995 (National Library of Australia).

Built to a standard design, the Station Master's Cottage is a good example of its type, and the Assistant Station Master's Cottage is an intact timber cottage dating from the early twentieth century.

The station also contains a fine example of railway technology, a turntable still in working order, a kind of technology no longer in production.

Overall, the group is a valuable for its social and historical associations for the Queanbeyan community.

Also to the southern end of the project area, on the Goulburn-Bombala rail line, was the Letchworth Station, opened 22 October 1926. This station was decommissioned on 1 May 1956. The station was named for Letchworth Garden City of London, named by land developer H.F. Halloran, as the station was part of an incomplete residential sub-division of Halloran, also called Letchworth. The station would have also served another sub-division of Halloran, Environa NSW.

A review of historical parish maps was also undertaken with no known structures or items identified within the project area.

2.3 ABORIGINAL GROUPS WITHIN THE PROJECT AREAS

The major language group identified in the Carwoola/Queanbeyan region by Norman Tindale (1974) in his seminal work on Aboriginal tribal boundaries are the Ngarigo people. The boundaries of the Ngarigo covered most of the Monaro Tablelands and extended into the Australian Alps covering the area of Mt Kosciusko and Jindabyne. To the south of Bombala the Bidewal people occupied the area to the coast. This distribution with minor amendments is still accepted and the review of tribal boundaries undertaken in the 1990s (Horton 1996) confirmed these earlier linguistic divisions. The area of Queanbeyan is considered to be the boundary of the Ngunnawal people and the area to the east of Queanbeyan was probably visited by people from both groups.

The traditional clothing of the Aboriginal people in the region was described as consisting of long possum cloaks, worn with the fur turned in for warmth and the tanned skins on the outside for waterproofing, and string belts made from possum or kangaroo hair (Govett 1977:8, Bennett 1967:175, Boswell 1890:9). Boswell described in detail the process of making possum cloaks (Boswell 1890:9). Boswell records that glass was now being used by the Aboriginal community in the making of the possum cloaks and was replacing traditional materials.

The ceremonial dress used was also described by Bennett with head dresses of kangaroo incisors and possum tails, head bands and necklaces. The use of white and red ochre to decorate the upper body and face for ceremonies was noted (Bennett 1967:323-326).

The men travelled with spears, (Govett 1977:36,) some of which were used for hunting while others were for fighting. Woomerahs (spear throwers) were approximately 1m long with a flat handle and a hook at the end (Govett 1977: 11, 36). Hatchets or axes had a ground stone head fastened to a wooden shaft by fibre binding. Govett notes that like the use of glass, iron axes were replacing stone ground axeheads and were greatly valued by the Aboriginal community (Govett 1977:11).

The women travelled with items that showed their main focus on gathering. Women constructed nets from plant fibres which were used to carry items slung over the body – this could also include babies and infants. Govett recalls this practise of 'slinging' babies behind a mothers shoulders (1977:8). Digging sticks consisting of hard wood approximately 1.5m long, burnt at one end to create a hardened point were carried by the women. The process of foraging was continued whilst on the move with food stored in the expanding nets until a camping site was reached (Govett 1977:23).

This traditional clothing was replaced by the blankets distributed by the Government and a mixture of European clothing. Governor Macquarie began a policy of distributing blankets to Aboriginal people in 1814 and groups became increasingly dependent as their traditional resources were destroyed by the impact of pastoralism and their groups suffered cultural impacts from disease, alcohol and displacement.

2.4 PREVIOUS HERITAGE STUDIES

A number of heritage studies have been undertaken in the immediate area along Captains Flat Road for residential subdivisions. These have been mainly small scale and development focused. Studies covering a larger area and generating models of occupation have been undertaken for the Queanbeyan and Jerrabomberra Regions (Kuskie 1989, Williams 2006, NOHC 2010a&b, 2014, 2018, CHMA 2014). A review of this large body of work has been undertaken to provide context and site location modelling for the project area. The most relevant reports for the current project are summarised below.

2.4.1 Queanbeyan Region

Boot and Heffernan (1989) completed one of the earliest archaeological studies undertaken in the region around Jumping Creek in Queanbeyan over a large area of 100 acres. They identified 20 sites of which 4 consisted of large artefact scatters with over 50 artefacts. They recorded a diverse assemblage with a high proportion of backed blade and micro lithic technology. They recorded a high proportion of unmodified debitage and concluded that lithic manufacture was occurring at the larger sites on local stone sources. The largest sites were located on the confluence of Jumping Creek on creek flats and lower slopes. Smaller sites were located on mid and lower slopes of ridge lines with isolated finds on ridge crests.

As a comparison to the work of Boot and Heffernan, and following on from their recorded sites, Peter Kuskie also recorded sites in Jumping Creek in 1989. His findings were consistent with the assemblages and locations recorded by Boot and Heffernan. Sites contained high proportions of backed blade and micro lithic technologies. Slope gradient was found to be a prime factor in site location with the majority of sites located with a 3-4^0 gradient. Steep slopes appear to have been avoided and no sites are recorded in steep gradients.

Moffit (1997) undertook an assessment for the proposed Harcourt Ridge Winery Development located on Blocks 597,598 and 599 Majura, located to the east of Oak Hill Road. These blocks have since been renamed to Blocks 680 and 699 Majura. This survey was the first across this area and identified 4 Aboriginal scarred trees (T1-T4), two artefact scatters (S1, S2) and 1 isolated find (L1). All of these sites are located to the south of the project area.

NOHC 2000 completed a second survey for the Harcourt Winery Estate. The survey identified three additional artefact sites HRE1, HRE2 and HRE3. The potential for subsurface deposits was recorded at HRE2. These sites were located on the upper and basal slopes of a spurline and knoll. All of these sites are also located to the south of the project area.

NOHC (2013) completed the Oaks Estate Aboriginal Heritage Masterplan. Three artefact sites and three areas of PAD were identified on the northern banks of the Molonglo River. One of the aims of the study was to assess the boundaries of the Oak Estate Precinct, in regards to Aboriginal pathways and the wider cultural landscape to determine if the boundary needed to be extended. The study found that no items of high significance were identified, and the boundary was adequate to conserve heritage values.

CHMA in 2018 completed an assessment for the Molonglo Healthy Rivers Waterways Project along a section of the Molonglo to the northeast of the current study area, running from Block 680 Majura and Block 66 Kowen. The survey identified two new heritage sites (one isolated find and one small artefact scatter) and additional areas of PAD and potential scarred trees. The importance of the area of the Junction of the Molonglo and Queanbeyan Rivers was noted with a large area of PAD, recorded sites and potential area of burial.

2.4.2 Beard (Queanbeyan Industrial Area)

In 1992 Argue and Saunders completed an assessment on Block 2010 Jerrabomberra located to the south-west to the current study area. This assessment located one small artefact scatter on the elevated ridge line to the south of the railway line.

In 1994, NOHC undertook a preliminary investigation of the Canberra Abattoir site to the west of the study area, resulting in the identification of seven artefact scatters (CA1- 7) and two isolated finds (CIF1-2). These sites are located to the west of the current project area, on the western side of Mountain Road. The heritage overlay indicates that CA5 is located in the current block, but the mapping in NOHC clearly defines the boundary of CA5 as west of Mountain Road.

Further investigation was recommended and additional survey and subsurface investigation was undertaken by BIOSIS through 2008 and 2009 in the area of sites to the west of Mountain Road. An extensive test pitting program consisting of one hundred and ten testpits were excavated over five sections of the project area. The highest area of concentration, equalling 98% of all recovered artefacts was from one site, CA5 where 67 testpits resulted in 2592 artefacts. All of these works are located to the west of Mountain Road, with no recordings extending into the current project area or block.

Prior to the salvage works by Biosis in 2009, NOHC in 2002 completed a survey for the proposed Queanbeyan Heavy Vehicle Bypass. No heritage sites were identified by the study, but NOHC noted the presence of site CA5 in the adjacent paddocks.

Saunders (2004) completed another assessment over the Jerrabomberra Blocks recording changed artefacts numbers in sites located by NOHC 1994, increasing in some areas, but decreasing in others. This is a feature of ground surface visibility which can change the number of surface artefacts identified due to changes in ground cover and disturbance.

2.4.3 Jerrabomberra Region

Southern Cross Heritage (Barber) undertook an archaeological assessment of Hume and adjacent areas to inform future planning for Hume Industrial area in 2000. The field survey identified nineteen (19) Aboriginal heritage sites consisting of nine small artefact scatters, eight isolated finds and two culturally modified trees. Sites were located mainly on level ground in proximity to creek lines. Barber predicted that the most common site type would consist of stone artefacts and be in proximity to creek line landforms.

NOHC (2003) undertook the initial survey for the Tralee Development. NOHC surveyed 229ha identifying 1 small artefact scatter and 1 area of PAD along the southern bank of Jerrabomberra Creek. In 2010 NOHC resurveyed the area identifying a further 6 sites consisting of three artefact scatter and three areas of PAD.

Dearling (2007) undertook an Archaeological and Heritage Assessment for GHD Canberra Pty Ltd, for the proposed upgrade of Lanyon Drive, including a duplication between Monaro Highway, ACT and Tompsitt Drive, NSW, new bridges over the Goulburn-Bombala Railway and Jerrabomberra Creek, and the improvement of the junction of Lanyon Drive and Sheppardson Street, Hume (across from the current project area). No Aboriginal sites were located by survey, with findings of disturbance and low potential for unrecorded sites.

NOHC (2014) undertook the assessment for the Northern entry road South Tralee. This reviewed previous work and completed a field survey over the entry road. Two previously recorded sites were relocated but no additional sites or areas of potential were recorded. These sites conform to the predictive modelling for the region.

NOHC (2016) completed further field surveys for the South Tralee Residential Development identifying an additional six Aboriginal heritage sites. These sites consisted of 1 artefact scatter, four isolated finds and two areas of PAD which when tested held sub-surface deposits. These areas of PAD were located in basal slope contexts in proximity to creek lines, again conforming to site locational modelling.

NOHC reviewed all previous work undertaken for the South Tralee Development in 2018 and completed a field survey of the 183ha development. An additional four isolated finds were located all in valley floor contexts on creek lines. This confirmation of the model through all of the studies for the South Tralee development lends credibility to this site location model and is considered applicable to the current project area which is located to the north.

In 2021 NOHC was engaged by AARNet Pty Ltd to complete a Cultural Heritage Assessment & Statement of Heritage Effects for the proposed Fyshwick to Hume Optic Fibre Cable. The alignment covers a length of approximately 5km running alongside HMAS Harman, Woods Lane, and Lanyon Drive. Five previously recorded Aboriginal sites were identified in the study area, with no additional sites being identified by the survey.

2.4.4 Predictive Model

NOHC 2010 provides the following summary for the region:

- the majority of sites are located near creek lines and low gradient basal slopes
- Sites will consist of low numbers or single artefacts
- scarred trees may occur wherever old growth trees of sufficient age have survived (locally at least 140-150 years); and
- stone procurement sites may occur where rock suitable for stone tool manufacture is present on the surface.

The following predictive model has been developed for the project area (Table 2). The project impact area is limited in size and confined to mid to upper slopes amidst undulating terrain.

This site prediction model is based on:

- Site distribution in relation to landscape features within the project area
- Consideration of site type and densities likely to be present within the project area
- Potential Aboriginal use of natural resources present or once present within the project area
- Opportunities for movement through the landscape
- Soil properties.

Table 1 Site Prediction Model

Probability	Site Type	Definition	Landform
Moderate to low	Isolated finds and surface scatters of stone artefacts	Stone artefacts ranging from single artefact to high numbers	Creek lines and spur crests. No such features are present within the study area.
Low to nil	Potential Archaeological Deposits (PADS)	Area considered on landform to hold higher potential for unidentified subsurface deposits	Varies, but most frequent on elevated terraces along creek lines and spurlines. No such features present and high levels of disturbance.
Nil	Culturally Modified Trees (CMTs)	Trees which have been modified by scarring, marking or branch twining	May be present on old remaining trees. No mature trees present.
Nil	Rock Engravings	Images engraved on flat rock surfaces	Escarpments, rock platforms or rock shelters - not present
Nil	Stone arrangements	Arrangements of stones by human intention, including circles lines or patterns.	Crest lines or large ceremonial areas on creekflats, - not present
Nil	Stone quarries/Ochre sources	Quarry sites where resources have been mined.	Any landform that has not been disturbed – not present

Probability	Site Type	Definition	Landform
Nil	Axe grinding grooves	Grooves in stone caused by the grinding of stone axes	Usually in creek lines, as water is used as abrasive with sand - not present
Nil	Burials	Burials of Aboriginal persons	Usually requiring deep sandy soils on eastern facing slopes – not present
Nil	Aboriginal places	A place that hold spiritual, traditional or historical significance to Aboriginal people	Any landform, identified through consultation with RAPs and historical sources

2.5 LANDFORM AND DISTURBANCE LEVEL ASSESSMENT

The landforms within the project area consist of gently undulating hillslopes and long waning middle slopes. Water sources are only present in the form of two small drainage lines which feed southwards into Jerrabomberra Creek. The 1st order drainage lines would have been intermittent and would have provided a water source only after rains. The Molonglo and Queanbeyan rivers are present to the north of the northern extent of the project.

The project area has been impacted by European settlement from the mid nineteenth century, particularly by the construction of the Bombala railway line and subsequent infrastructure placement along the rail corridor. The project area to the south of the rail corridor has been under continual grazing and pastoral regimes over a lengthy period of time. These past use impacts are typical for the Canberra and Queanbeyan regions and consist of the following:

- Vegetation and tree clearance
- Stock impacts
- Vehicle tracks – some consisting of minor roads, other of impact trails
- Extensive impacts in areas of housing including landscaping
- Construction of sheds, outbuildings, yards and fencing
- Ploughing of topsoils for pasture improvement or light cropping.

All of these landscape and soil impacts reduce the potential for archaeological or heritage sites to remain intact within the landscape. Confined areas of disturbance are present at gates and along fence lines. Exposed ground may be present in areas of stock impact, vehicle tracks, fence lines, under trees and large areas of erosion. As a result of the landform assessment the study area contains low potential to contain any unrecorded heritage sites or areas of PAD and has suffered a high to moderate degree of previous impact.

3 FIELD SURVEY RESULTS

A site visit and field survey of the project area was undertaken across three days, the 28/29th October and 24th of November 2021, to verify the findings of the desktop review of landforms and disturbance. The survey covered both sides of the railway easement to a width of approximately 40m and an easement of 20m along the proposed powerline route in the open paddocks.

The aim of the investigation was to identify heritage objects or places of Potential Archaeological Deposit (PAD). Based upon the background research, known Aboriginal site patterning, and current aerial photography, the areas of the access road, building envelopes and surrounding landforms were inspected.

All surveyed areas and items of interest were recorded on a topographic map of the study area (using a GPS and GDA 94 coordinates), along with levels of visibility, erosion, soil conditions, and evidence of land disturbance.

Ground surface visibility (GSV) is the percentage of ground surface that is visible during the field inspection. GSV increases in areas of exposures such as stock impact trails, roads, gates and along areas of erosion such as creek banks and dam walls. As a result, surveys undertaken in areas with high exposure rates result in a more effective survey coverage.

Due to the differing survey conditions in the two areas, the Queanbeyan railway corridor (including the east and west sides of the railway) and the Lanyon Drive/Tompsitt Drive intersection, these two sections are discussed separately in the following sections.

3.1.1 Queanbeyan Railway Corridor (West and East)

Grass coverage along both sides of the railway corridor and beneath the railway underpass was high at the time of survey with several areas heavily overgrown with vegetation. There are some areas of natural vegetation as the western area falls into the Queanbeyan Nature Reserve, although most areas of vegetation are dense areas of exotic grasses and weeds. The entire corridor is heavily disturbed by the construction of the railway, ancillary road and service tracks, with most surfaces having been mechanically smoothed and graded to form a level surface. Additionally, ditching, trenching and other digging for various infrastructure including underground pipes, gas lines, electricity cables and fibre optic lines has been conducted across the study area, and has been exacerbated by erosion. This level of disturbance also contributed to consistent exposures across the study area.

Due to the prevailing vegetation, large areas of exposed ground were present under trees, along fence lines, along the current access roads and at gates. The railway corridor in particular has several maintenance roads and walking tracks through the reserve, and areas of industrial disturbance. An aerial review reveals the areas as generally dry, but due to recent rains the several tributaries of Jerrabomberra Creek held water and the surrounding reedy vegetation was thick and overgrow across the railway corridor. The GSV as a result is rated low at 30% with large areas of exposure. The area

www.pasttraces.com.au

email: office@pasttraces.com.au

of railway corridor covered by the survey was approximately 5km on either side of the corridor, the width of which varied across the project area particularly passing through suburban areas of Queanbeyan to the north of the area.

The conditions at the time of the field survey are shown in plates 1 to 6.

Plate 1: West railway corridor, facing north at beginning of sloping creek valley.

Plate 2: East railway corridor, looking south along old road (Territory Parade) to south of old Letchworth Railway Station.

Plate 3: Edge of suburban Queanbeyan at Henderson St looking north.

Plate 4: Remains of old concrete ford across Jerrabomberra Creek, Territory Parade looking south.

Plate 5: West railway corridor. Example of industrial disturbance posts, poles, corrugated iron, truck chassis, mesh, fencing etc. All structural features in thicket on creek flat.

Plate 6: East railway corridor, facing south. Narrow and heavily disturbed/excavated and thickly vegetated strip.

3.1.2 Lanyon Drive/Tompsitt Drive Intersection

The Lanyon/Tompsitt Drive study area included sections of Lot 1 DP 1263364 (to the south of Tompsitt Drive) and Lot 1 DP828275 (a section of the property between Lanyon Drive and Woods Lane), and the northern road verge of Tompsitt Drive. The conditions of this study area varied between the properties and road verge, with the road verge more heavily disturbed by road constructure and drainage infrastructure, and grass length recently maintained. The section of Lot 1 DP 1263364 that was surveyed covered an alignment north to south, heading up the northern side slope of a small hill and along a fence line.

At the time of the survey the area was densely vegetated following recent rain, with a GSV of <10% due to long grass, thistle and blackberry bushes. Some areas of exposure were present at gates and rocky outcrops. The small alignment of the project area in Lot 1 DP828275 headed east to west between Woods Lane and the fence line parallel to Lanyon Drive. Due to lack of stock and recent rains, the project area here also had a low general rating of GSV, around 20% with an average grass height of 50cm. Some areas of exposure were also present across this area, due to stock impacts, vehicle tracks and rock outcrops.

The conditions at the time of the field survey are shown in plates 7 to 10.

Plate 7: Tompsitt Dr south road verge, exposure from construction of road.

Plate 8: Tompsitt Drive drainage infrastructure of land running beneath road, facing west.

Plate 9: Lot 1 DP828275 west of Lanyon Drive, facing north over creek flat.

Plate 10: Lot 1 DP 1263364, north facing overlooking Tompsitt Drive.

www.pasttraces.com.au

email: office@pasttraces.com.au

3.1.3 Results

A single Aboriginal site was identified by the field survey within the railway corridor. No Aboriginal heritage sites or areas of PAD were identified by the survey of the Lanyon/Tompsitt Drive study area.

Details of the identified site are shown below.

3.1.4 MGA55 SJ1 – 699581.6084760

This site consists of an isolated find, a white quartzite blade flake. Located along the western corridor of the railway, the isolated artefact was found on an area of exposure (bare soils) on the boundary between DP1244968 and the south-west corner of DP1111063, the Queanbeyan Racecourse. The area is highly disturbed with a surface that has been scraped back, featuring banked and mixed soils at the top of the railway cutting. This site is not in-situ and is in a disturbed context. An image of the isolated find is shown in plate 11 with the site location shown in Plate 12 and Figure 4.

	
Plate 11: SJ1 isolated find, quartzite blade flake.	Plate 12: Site location looking north east

3.1.5 Summary

The desktop review over the project area identified no previously recorded sites within the project area. The field survey was undertaken at a time of high grass coverage across the paddock areas with only limited GSV and exposures, and along the rail corridor, which features high levels of disturbance and large areas of exposure. The field survey identified a single heritage site (SJ1) and no areas of PAD.

www.pasttraces.com.au

email: office@pasttraces.com.au

The site types recorded in the wider region are in conformance with the landform and predictive modelling and are regularly recorded throughout the region. Most sites are in association with elevated landforms (terraces, spur line toes) in association with creek lines or overlooking spurlines. Within the project area only small ephemeral drainage lines are present with low lying creek flats. No elevated landforms that would have provided areas for camping or resting are present within the project area. As a result the landforms are considered to hold low potential for unrecorded sites.

Figure 4. Recorded site location (Base Map SixMaps NSW)

4 IMPACT ASSESSMENT

The impacts from the installation of the 132vK powerline would be confined within a corridor of approximately 5.7km in length and 20m width involving, installation of powerline poles and movement of plant. These areas have been assessed and a field survey undertaken over the entire width of the railway corridor. One previously unrecorded heritage site was identified.

The project area has a high degree of disturbance within the rail corridor. In the paddocks to the south of the rail corridor, the soils appear to be thin and overlaying base clays and shale. Due to the lack of topsoils, this area is considered to hold low potential for unrecorded sites or subsurface deposits. The gently undulating gradients along most of the route are considered to hold low potential for unrecorded heritage sites or subsurface deposits

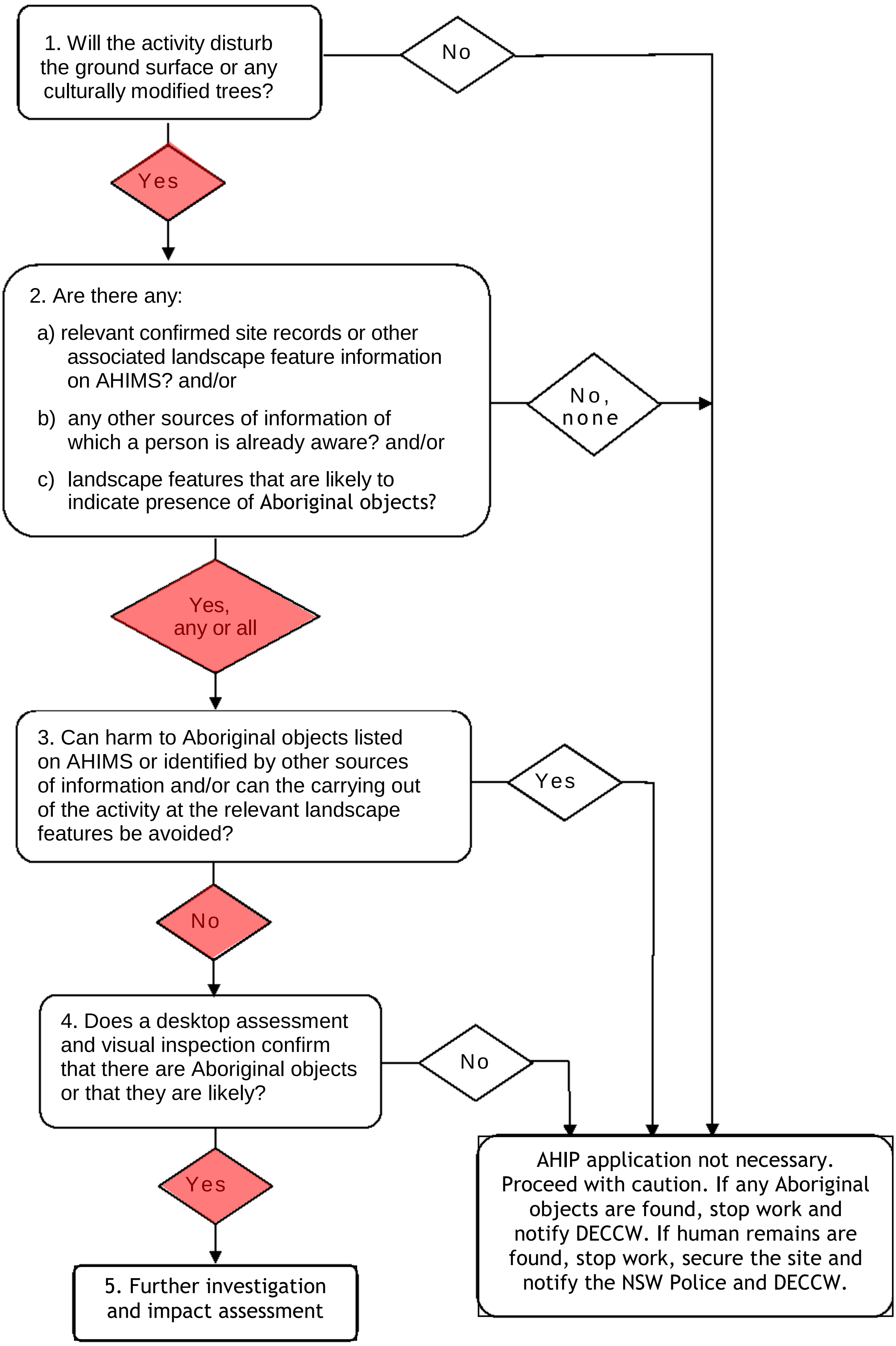
Based on the assessment the impacts from the project are as follows:

- One known Aboriginal object or place, SJ1, within the rail corridor may be impacted by the proposed works.
- No known Historical objects or places are present in the project area. Historical listings are present to the north east of the project area but will not be affected by the works.
- No areas of high potential to contain unrecorded Aboriginal or historical objects or places are present in the project area.

The Aboriginal Due Diligence Code provides a flowchart of six questions to identify the presence of and potential harm to Aboriginal heritage. These questions and their applicability to the project are shown in Figure 5. The responses to these questions determine if further heritage investigations are required.

Based on the results of the desktop assessment and field survey further works will be required.

Figure 5: Due Diligence Flow Diagram (OEH 2010:10 - Due Diligence Code of Practice)



4.1 RECOMMENDATIONS

Based on this due diligence assessment the following actions are recommended for the project.

Recommendation 1: Avoidance of Harm.

- Design works, should aim to avoid impacting upon this location, where possible.

Recommendation 2: Further Heritage investigation required.

- If impacts to site SJ1 cannot be avoided, the completion of an Aboriginal Cultural Heritage Assessment Report (ACHAR) to support an application for an Aboriginal Heritage Impact Permit (AHIP) from NSW Heritage is required. No impacts to the areas of PAD or recorded sites can occur prior to the granting of an AHIP.
- Consultation with the Aboriginal Community in accordance with the Aboriginal Cultural Heritage Consultation Requirements for Proponents (OEH 2010) is required to allow for completion of an ACHAR. This involves public notice in the local paper, letters to government agencies requesting known stakeholders and contacting known stakeholders in the region. When registered, these stakeholders will be provided with details of the project and allowed a period to provide additional information and their views on the AHIP proposal.

Recommendation 3: Discovery of Unidentified Aboriginal cultural material during works.

Under the *NPW Act 1977* all Aboriginal places and objects are protected from harm, even if they have not been previously identified during the assessment process. If Aboriginal material is discovered during works then the steps as outlined below should be followed:

- All work must cease in the vicinity of the find and project manager notified immediately.
- A buffer zone of 10m should be fenced in all direction of the find and construction personnel made aware of the 'no go' zone.
- NSW Heritage must be notified of the find and advice sought on the proper steps to be undertaken.
- After confirmation with NSW Heritage a heritage consultation should be engaged to undertake assessment of the find and provide appropriate management recommendations to the proponent.

Recommendation 4: Alteration of impact footprint

Further archaeological assessment would be required if the proposal activity extends beyond the area of the current investigation.

Implementation of the above management recommendations will result in low potential for the project to impact on heritage values or result in damage to heritage sites.

5 REFERENCES

Archaeological Heritage Surveys. (2004). *Proposed Subdivision of Pt Lot 2 DP821751 Capital Hill Estate Aboriginal Archaeological Assessment.* Report to Land Planning Solutions.

Argue, D and Saunders, P. (1992). *A Cultural Resource Survey of Jerrabomberra Block 2101* . Report to ACT Public Works.

Barber, M. (2000). *Cultural Resource Survey of Hume and Adjacent Areas.* Report to Dept of Urban Services.

Bennett, G. (1834). *Wandering in NSW, Batavia, Pedir Coast, Singapore and China: Being the journal of a Naturalist in those countries during 1832, 1833 and 1834, Vol 1.* . London: Richard Bentley .

Biosis. (2008). *Archaeological Re-assessment Block 182 Jerrabomberra ACT: Fyshwick East Development on the site of the former Canberra Abattoir.* Report to Parsons Brinckenhoff.

Biosis. (2009). *Block 2223 Jerrabomberra: Archaeological Excavations Fyshwick East Development on the former Canberra Abattoir site.* Report for Parsons Brinchenkhoff.

Boot, P & Heffernan, K. (1989). *Jumping Creek - Local Environment Study: Preliminary Archaeological Survey.* Report to Kinhill Engineers Pty Ltd.

Boswell, A. (1890). *Recollections of some Australian Blacks: Bathurst District 1835-40, Port Macquarie 1844, Hunters River 1850.* National Library of Australia.

Cultural Heritage Management Australia. (2018). *Molonglo River Healthy Waterways Project Cultural Heritage Assessment and Statement of Heritage Effects.* Report to Construction Control Pty Ltd .

DECCW. (2010). *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales.* Sydney: DECCW.

Govett, W. (1977). *Sketches of New South Wales: Written and illustrated for the Saturday Magazine in 1836-37.* Melbourne: Gaston Renard.

Horton, D. (1996). *The Encyclopidea of Aboriginal Australia: Aboriginal and Torres Strait Islander History, Society and Culture.* Canberra: Aboriginal Press Studies.

Kuskie, P.J. (1989). *Changing Land Use Patterns from Prehistoric to Modern Times at Jumping Creek Valley Queanbeyan NSW.* BA Hons Thesis, ANU, Canberra.

Moffit, K. (1997). *A Cultural Resource Survey of Blocks 297,598 and 599 Majura ACT* . Report to the Department of Urban Services .

Navin Officer Heritage Consultants . (2014). *Northern Entry Road South Tralee NSW Queanbeyan NSW Aboriginal Cultural Heritage Assessment.* Report tof Canberra Estates Consortium.

Navin Officer Heritage Consultants. (1994). *Preliminary Archaeological Assessment: Canberra Abattoir Site ACT.* Report to CMPS & F.

Navin Officer Heritage Consultants. (2000). *Harcourt Ridge Estate Vineyards Development Majura ACT - Archaeological survey of supplementary areas.* Report to Bell Management Group.

Navin Officer Heritage Consultants. (2002). *Queanbeyan Heavy Vehicle Bypass: Archaeological Assessment.* Report to NECS.

Navin Officer Heritage Consultants. (2003). *Tralee Local Environment Study Cultural Heritage Component.* Report to URSCorp.

Navin Officer Heritage Consultants. (2003b). *Tralee Local Environment Study Cultural Heritage Component.* Report to URSCorp.

Navin Officer Heritage Consultants. (2010). *North and South Tralee Residential Development CulturaL Heritage Review.* Report to Canberra Estates Consortium .

Navin Officer Heritage Consultants. (2010). *South Jerrabomberra: Forrest, Morrison, Robin & Environa Properties NSW: Preliminary Archaeological Assessment.* Report to Canberra Estates Consortium.

Navin Officer Heritage Consultants. (2013). *Oaks Estate Master Plan Aboriginal Cultural Heritage Assessment.* Report to Environment and Sustainable Development Directorate.

Navin Officer Heritage Consultants. (2015). *South Tralee Residential Area Sewer and Water Infrastructure Due Diligence Archaeological Assessment.* Report to Canberra Estates Consortium.

Navin Officer Heritage Consultants. (2018). *South Tralee Residential Development Stage 1 Aboriginal Cultural Heritage Assessment.* Report for Elton Consulting.

Tazewell, S. (1981). Early Goulburn History. *Goulburn Historical Society Bulletin September* .

Tindale, N. (1974). *Aboriginal Tribes of Australia.* Canberra: ANU Press.

Williams, D. (2006). *Stage 2 Archaeological Investigation at Headquarters Joint Operations Command between Queanbeyan and Bungendore NSW: Sub surface testing probing.* Report to URS Pty Ltd and Commonwealth Department of Defence.

Appendix D – Basic AHIMS Search Result

AHIMS Web Services (AWS)
Search Result

Your Ref/PO Number : Sth Jerra

Client Service ID : 766939

Essential Energy DST Port Macquarie

Date: 24 March 2023

PO Box 5730
Port Macquarie New South Wales 2444

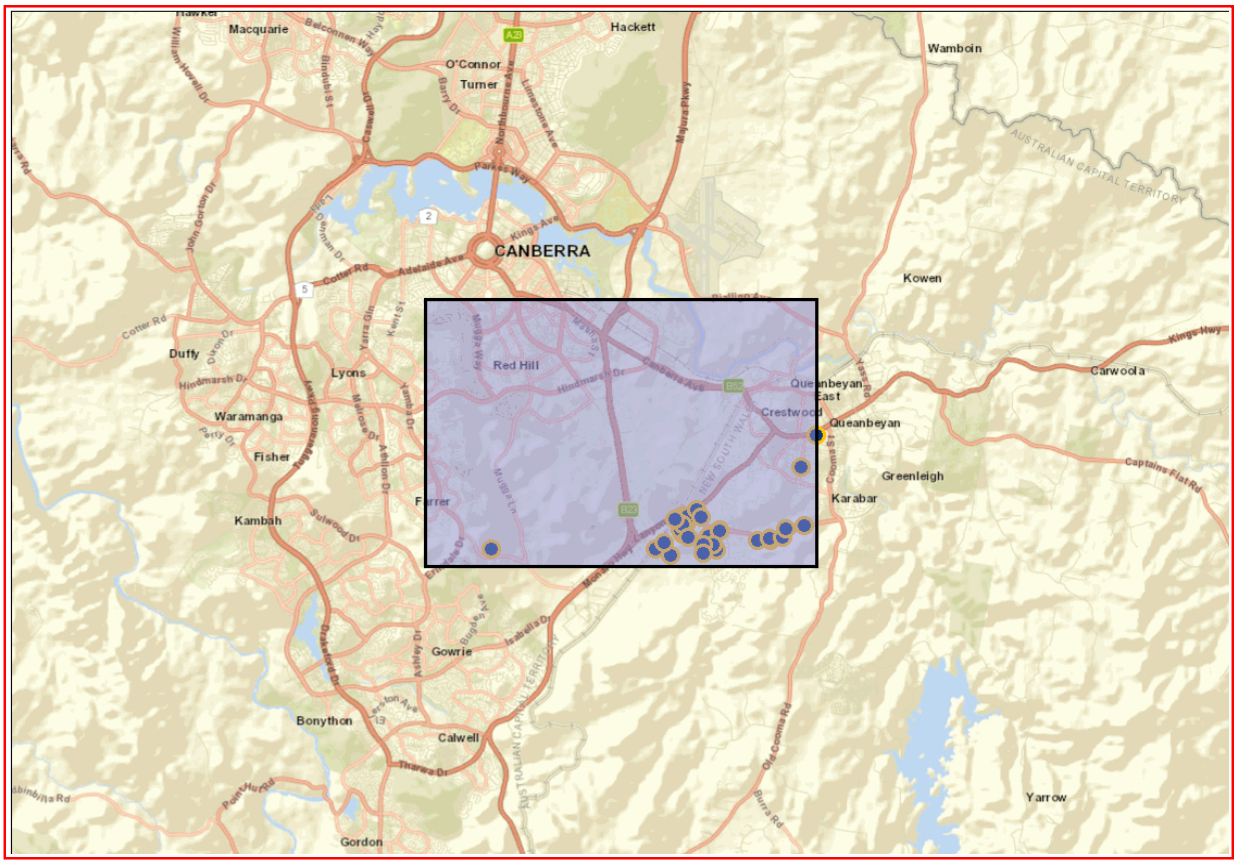
Attention: Brett Hayward

Email: brett.hayward@essentialenergy.com.au

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -35.3912, 149.1051 - Lat, Long To : -35.3212, 149.2289, conducted by Brett Hayward on 24 March 2023.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of Heritage NSW AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

41	Aboriginal sites are recorded in or near the above location.
0	Aboriginal places have been declared in or near the above location. *

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (https://www.legislation.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Heritage NSW upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Heritage NSW and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date. Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

AHIMS Web Services (AWS)

Extensive search - Site list report

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
57-2-1135	QS-1	GDA	55	702517	6085089	Open site	Valid	Artefact : -		
	Contact	Recorders	Cultural Heritage Management Australia - (Australian Archaeological Survey Consu					Permits		
57-2-0975	PAD1-South	GDA	55	698265	6081669	Open site	Not a Site	Potential Archaeological Deposit (PAD) : -		103419
	Contact	Recorders	Mrs.Nicola Hayes,Apex Archaeology,Apex Archaeology,Ms.Jenni Bate,Ms.Jenni Bate					Permits	4791	
57-2-0341	PIF5	AGD	55	698485	6082590	Open site	Valid	Artefact : 1		98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0338	PPS11	AGD	55	698515	6082590	Open site	Valid	Artefact : 3		98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0474	PIF 1	AGD	55	698520	6082635	Open site	Valid	Artefact : 1		98808,98919
	Contact T Russell	Recorders	Mr.K Heffernan					Permits		
57-2-0111	PPS 1;	AGD	55	698600	6082380	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Mr.K Heffernan					Permits		
57-2-0342	PIF6	AGD	55	698650	6082630	Open site	Valid	Artefact : 1		98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0055	Jerrabomberra/1	AGD	55	701010	6081870	Open site	Valid	Artefact : -	Open Camp Site	794
	Contact	Recorders	Darrel Lewis					Permits		
57-2-0004	Long Gully Road Woden	AGD	55	693000	6081800	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	J Webb					Permits		
57-2-0475	PIF 2	AGD	55	698490	6082100	Open site	Valid	Artefact : 1		98808,98919
	Contact T Russell	Recorders	Mr.K Heffernan					Permits		
57-2-0976	PAD:2	GDA	55	698697	6082806	Open site	Valid	Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Mrs.Nicola Hayes					Permits		
57-2-0339	PPS12	AGD	55	699440	6081630	Open site	Valid	Artefact : 2		98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0673	ELP 5 (duplicate of 57-2-0672)	GDA	55	702099	6082480	Open site	Destroyed	Artefact : 5		
	Contact	Recorders	Mr.Charles Dearling					Permits		
57-2-0345	PIF 4	AGD	55	699360	6081795	Open site	Valid	Artefact : 1		98808,98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0476	PIF 3	GDA	55	699560	6082308	Open site	Valid	Artefact : 1		98808,98919,103928,103929
	Contact T Russell	Recorders	Mr.K Heffernan,Mrs.Nicola Hayes					Permits		
57-2-1094	Karabar High School	GDA	55	702053	6084169	Open site	Valid	Artefact : 1		104120,104121,104122
	Contact	Recorders	Ms.Tory Stening,Unearthed Archaeology & Heritage					Permits	4410,4411,4447,4529	

Report generated by AHIMS Web Service on 24/03/2023 for Brett Hayward for the following area at Lat, Long From : -35.3912, 149.1051 - Lat, Long To : -35.3212, 149.2289. Number of Aboriginal sites and Aboriginal objects found is 41

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
57-2-0574	ELP 1	GDA	55	700754	6082053	Open site	Valid	Artefact : 2		
	Contact	Recorders	Mr.Charles Dearling					Permits	3048	
57-2-0116	PPS 6;	AGD	55	698450	6082250	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Mr.K Heffernan					Permits		
57-2-0343	PPS 11	AGD	55	698515	6082590	Open site	Valid	Artefact : 3		98808,98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-1226	Poplars Artefact Scatter	GDA	55	699241	6082047	Open site	Valid	Artefact : -		
	Contact	Recorders	ERM Australia Pty Ltd- Sydney CBD,Ms.Lorien Perchard					Permits		
57-2-0344	PPS 12	AGD	55	699440	6081630	Open site	Valid	Artefact : 2		98808,98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0573	ELP 2	GDA	55	701097	6082100	Open site	Valid	Artefact : 2		
	Contact	Recorders	Mr.Charles Dearling					Permits	3048	
57-2-0346	PIF 5	AGD	55	698485	6082590	Open site	Valid	Artefact : 1		98808,98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0347	PIF 6	AGD	55	698650	6082630	Open site	Valid	Artefact : 1		98808,98919
	Contact	Recorders	Ms.Trish Saunders					Permits		
57-2-0119	PPS 9;	AGD	55	698930	6082830	Open site	Valid	Artefact : -	Open Camp Site	98808
	Contact	Recorders	Mr.K Heffernan					Permits		
57-2-0117	PPS 7;	GDA	55	699664	6082384	Open site	Valid	Artefact : -	Open Camp Site	103928,103929
	Contact	Recorders	Mr.K Heffernan,Mrs.Nicola Hayes					Permits		
57-2-1127	South Jerrabomberra 01	GDA	55	697832	6081871	Open site	Valid	Artefact : -		
	Contact	Recorders	Navin Officer Heritage Consultants Pty Ltd,Mrs.Nicola Hayes					Permits		
57-2-0112	PPS 2;	AGD	55	698500	6082400	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Mr.K Heffernan					Permits		
57-2-0114	PPS 4;	AGD	55	698650	6082000	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Mr.K Heffernan					Permits		
57-2-1239	PIJ1	GDA	55	699342	6082229	Open site	Valid	Artefact : -		
	Contact	Recorders	Past Traces Pty Ltd,Mr.Nathaniel Cracknell					Permits		
57-2-0118	PPS 8;	GDA	55	699656	6082353	Open site	Valid	Artefact : -	Open Camp Site	103928,103929
	Contact	Recorders	Mr.K Heffernan,Mrs.Nicola Hayes					Permits		
57-2-0974	PAD1 - North	GDA	55	698075	6082045	Open site	Valid	Potential Archaeological Deposit (PAD) : -		103419
	Contact	Recorders	Mrs.Nicola Hayes					Permits		
57-2-0113	PPS 3;	AGD	55	698300	6082550	Open site	Valid	Artefact : -	Open Camp Site	98808
	Contact	Recorders	Mr.K Heffernan					Permits		

Report generated by AHIMS Web Service on 24/03/2023 for Brett Hayward for the following area at Lat, Long From : -35.3912, 149.1051 - Lat, Long To : -35.3212, 149.2289. Number of Aboriginal sites and Aboriginal objects found is 41

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Sth Jerra

Client Service ID : 766940

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
57-2-0340	PIF4	AGD	55	699360	6081795	Open site	Valid	Artefact : 1		98919
	Contact	**Recorders**	Ms.Trish Saunders					**Permits**		
57-2-0978	PAD:4	GDA	55	699154	6082794	Open site	Valid	Potential Archaeological Deposit (PAD) : -		
	Contact	**Recorders**	Mrs.Nicola Hayes					**Permits**		
57-2-0120	PPS 10;	AGD	55	699050	6082600	Open site	Valid	Artefact : -	Open Camp Site	98808
	Contact	**Recorders**	Mr.K Heffernan					**Permits**		
57-2-1240	PIJ2	GDA	55	699196	6081979	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Past Traces Pty Ltd,Mr.Nathaniel Cracknell					**Permits**		
57-2-0977	PAD:3	GDA	55	699193	6081729	Open site	Valid	Potential Archaeological Deposit (PAD) : -		
	Contact	**Recorders**	Mrs.Nicola Hayes					**Permits**		
57-2-0115	PPS 5;	GDA	55	699194	6081721	Open site	Valid	Artefact : -	Open Camp Site	98808
	Contact	**Recorders**	Mr.K Heffernan,Mrs.Nicola Hayes					**Permits**		
57-2-0572	ELP 3	GDA	55	701466	6082144	Open site	Valid	Artefact : 9		
	Contact	**Recorders**	Mr.Charles Dearling					**Permits**	3048	
57-2-0674	ELP 1-2-3 (relocated)	GDA	55	701586	6082369	Open site	Valid	Artefact : 23		
	Contact	**Recorders**	Mr.Charles Dearling					**Permits**		

**** Site Status**

Valid - The site has been recorded and accepted onto the system as valid

Destroyed - The site has been completely impacted or harmed usually as consequence of permit activity but sometimes also after natural events. There is nothing left of the site on the ground but proponents should proceed with caution.

Partially Destroyed - The site has been only partially impacted or harmed usually as consequence of permit activity but sometimes also after natural events. There might be parts or sections of the original site still present on the ground

Not a site - The site has been originally entered and accepted onto AHIMS as a valid site but after further investigations it was decided it is NOT an aboriginal site. Impact of this type of site does not require permit but Heritage NSW should be notified

Report generated by AHIMS Web Service on 24/03/2023 for Brett Hayward for the following area at Lat, Long From : -35.3912, 149.1051 - Lat, Long To : -35.3212, 149.2289. Number of Aboriginal sites and Aboriginal objects found is 41

Appendix E – Historical Cultural Report Queanbeyan to Bombala Rail Line

Past Traces
Heritage Consultants

Historical Cultural Heritage Background – Queanbeyan to Bombala Rail Line

Report Prepared for Essential Energy

12 January 2022

www.pasttraces.com.au

email: office@pasttraces.com.au

Document Control

Revision	Date	Author	Reviewed
D1	24/03/2022	N. Cracknell	L.O'Brien

Disclaimer

Past Traces Pty Ltd has undertaken this assessment in accordance with the relevant Federal, State and Local Government legislation. Past Traces accepts no liability for any damages or loss incurred as a result of use for any purpose other than that for which it was commissioned.

Restricted Information

Information contained within this report is culturally sensitive and should not be made publicly available. The information that is restricted includes (but is not limited to):

- Maps, Mapping Grid Reference Co-ordinates or images for Aboriginal heritage sites, places and objects.
- Location or detailed information regarding places of Aboriginal cultural significance, as expressed or directed by Representative Aboriginal Organisations, Aboriginal elders, or members of the wider Aboriginal community.
- Other culturally appropriate restricted information as advised by Aboriginal representatives and traditional knowledge holders.

Information in the report covered by the above categories should be redacted before being made available to the general public. This information should only be made available to those persons with a just and reasonable need for access.

CONTENTS

1 INTRODUCTION

This report provides background information on the Heritage listed Queanbeyan to Bombala Rail Line to inform the context of the 132kV power line installation proposed by Essential Energy. Essential Energy are proposing installation of a 132kV power line, along the Goulburn Bombala Railway corridor for which a separate Cultural Heritage Assessment Report has been completed.

The 132Kv line project runs south along the Bombala railway corridor from the approximate junction between the Canberra and Bombala rail lines for an approximate length of 4.7km before heading south-east across Lanyon Drive across Lot 1 DP878275. After around 800m the trajectory diverts south-west across Tompsitt Drive (Lot 1 DP1263364) and ends at the substation location.

The heritage listed aspects of the Rail corridor will not be impacted in any manner by the proposed works, however Essential Energy have commissioned a review of the heritage listing and compilation of background material to inform the Due Diligence Heritage Assessment completed for the project and provide a resource document.

1.1 PROJECT OBJECTIVES

The heritage review was undertaken to complete the following objectives:

1. Review of the NSW Heritage, Commonwealth and National Heritage Register Listings.
2. Review of the S170 NSW State Rail Heritage Listings.
3. Review of previous historical assessments of the rail line.

1.2 RAIL LINE CONSTRUCTION

The Queanbeyan to Bombala railway line formed part of a larger branch railway line connecting Bombala and at its height, 23 other stations to Joppa Junction. This junction then connected the line to the larger Main South line between Sydney Central to Albury and through to Victoria. This railway branch was finally completed on the 21 November 1921, with the official opening of the line on 9 December 1921. Figures 1 and 2 display the registered heritage sites for both the ACT and NSW with the Queanbeyan to Bombala rail line noted.

The building of the Bombala railway branch was begun during the c1880s with the objective of linking southern NSW townships to the Main South Line. Residents of Bombala and surrounding areas established a Railway League with the goal of lobbying the colonial government for the railway to extend to Bombala and eventually to the Victorian border (Bombala Railway Precinct Heritage). In January 1901, the Public Works Committee held a public inquiry in Bombala discussing a proposal to construct a railway from Cooma to Delegate via Bombala with the possibility of linking with Victorian lines ('History of the Line' 1921, p. 1). However, it was decided that Bombala would be the terminus for this branch railway and in 1908 the extension was finally approved by Parliament.

The Bombala railway line was built in several sections beginning at the Joppa Junction on the Main South Line being linked to Tarago. The opening of this section was reported on the 3 January 1884. An extract from the Evening paper for that day is shown in Figure 1.

Tarago Railway Opening.

(BY TELEGRAPH. FROM OUR REPORTER.)

GOULBURN, Thursday.

The special train, which left Sydney at / this morning, was crowded. Goulburn was reached shortly after midday. Among the passengers were the Hon. W. A. Brodribb, M.L.C., Messrs. Holtermann, Tooth, Garrard, and H. Clarke, M.'sL.A., Mr. W. V. Read (Railway Traffic Manager), the representatives of the Metropolitan Press, and a number of Sydney gentlemen. Tarago will be reached just after 1 p.m., when the formally opening of the line will take place. A banquet is to be held later in the day. The weather is fine and bright, but not too hot. Although no Ministers are present the affair is likely to be a great success. The whole district has united to attaining this object. The Braidwood people, and Mr. Payne especially, having been most energetic. A large number of persons got on to the train at Goulburn.

Figure 1'Tarago Railway Opening' 1884, Evening News, 3 January, p. 2. Accessed via NLA Trove 07/01/2022.

In March 1885 the line from Tarago to Bungendore was opened. During this period the contract for the railway's construction between Bungendore and Michelago was granted to Alex Johnston on 27 May 1884 and construction commenced on the Bungendore to Queanbeyan Line.

In 1887 the lines from Bungendore to Queanbeyan and then to Tuggeranong and Michelago were opened in September and December respectively. The locations of the sections of track are shown in Figure 2.

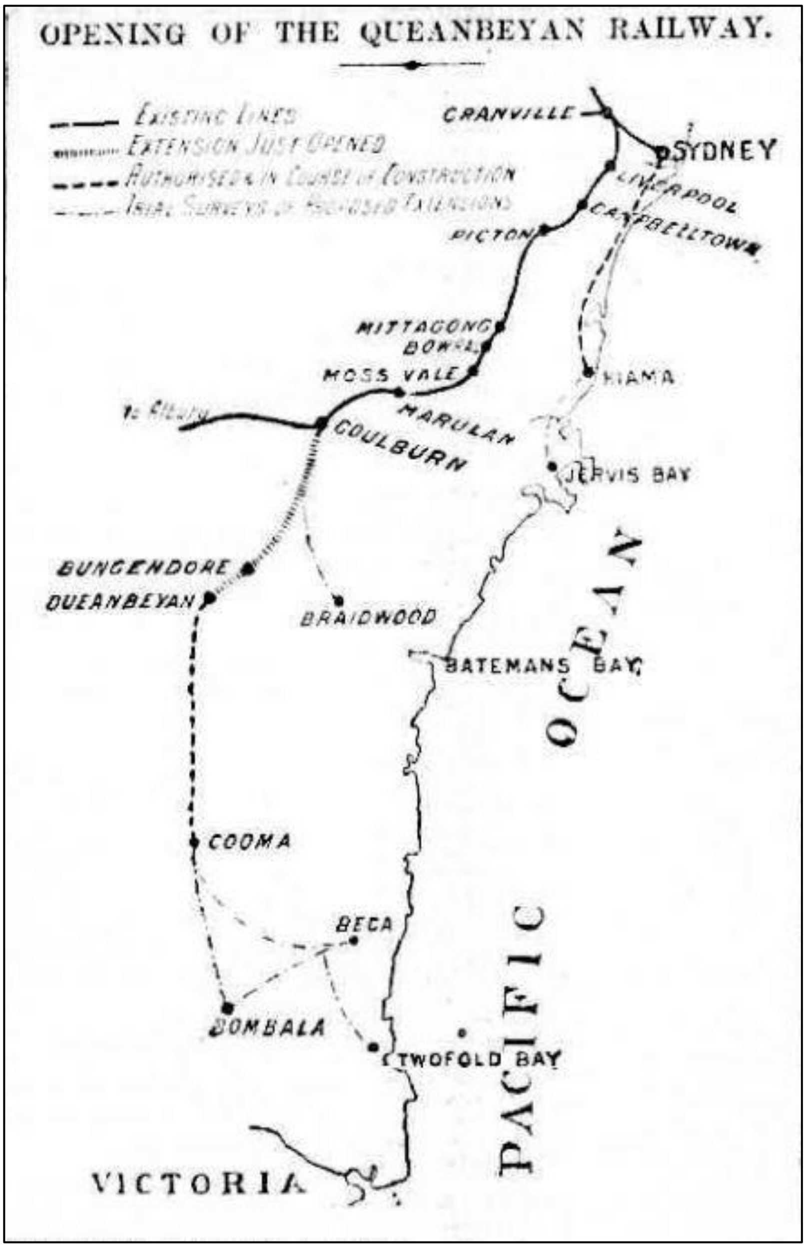
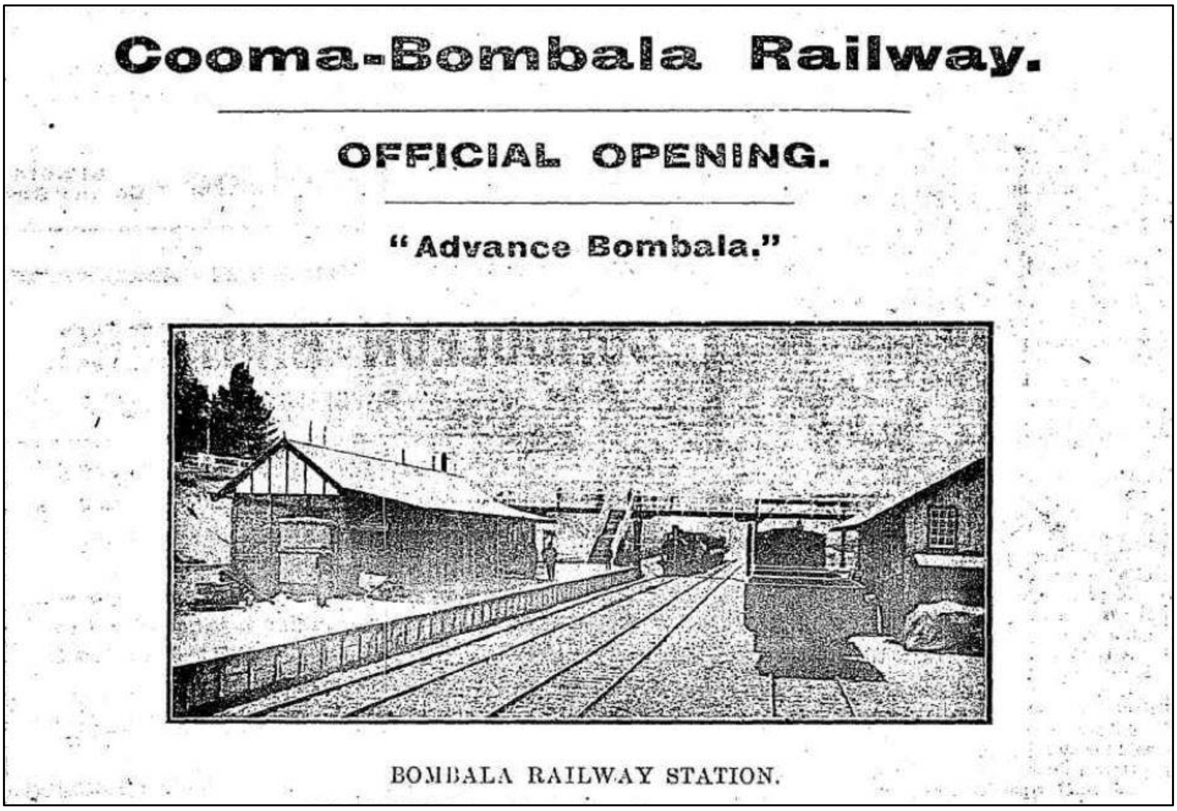


Figure 2 Map of the completed and proposed stations of the Bombala railway ('Opening of the Queanbeyan Railway' 1887, The Daily Telegraph, 9 September, p. 6. Accessed via NLA Trove 10/01/2022.)

The section of Line from Michelago to Cooma was completed in May 1889, then extended to Nimmitabel in April 1912 and finally extending to Bombala with the station officially opened for goods train traffic on 1 November 1921 with the whole railway branch being officially opened on 9 December 1921 (Bombala Railway Precinct Heritage NSW State Heritage Inventory Listing). The opening of the section of line as reported in the Bombala Times is shown in Figure 3.



Cooma-Bombala Railway.

OFFICIAL OPENING.

"Advance Bombala."

BOMBALA RAILWAY STATION.

Figure 3 Headline of the Bombala Times newspaper.
('Cooma-Bombala Railway Official Opening' 1921, The Bombala Times, 9 December, p. 1. Accessed via NLA Trove 10/01/2022.)

The line was used for both passenger services and freight, with passengers able to travel from Sydney Central to Bombala. However, regular steam operations ceased in 1962 and the 1970s saw a decline in rail services along the Bombala line with smaller junctions, platforms and stations beginning to close through the late 1960s and throughout the 1970s. August 1974 saw the last passenger train arrive in Bombala with the final goods service in March 1986 and officially closing in May 1989 (Bombala Railway Precinct Heritage NSW State Heritage Inventory Listing). This major restructuring of the State Rail Authority and the results of the 1988 Booz Allen Hamilton report on NSW rail services saw the closure of the remaining lines south of Queanbeyan with job retrenchments of around 8,000 positions and closure of 3 passenger services and 3 freight lines as part of the restructuring of rural rail services in NSW ('SRA takes axe to 8,000 jobs' 1989, p. 1.)

While most of the stations and platforms are no longer in use and passenger services do not extend any further south than Queanbeyan, several historical societies have maintained portions of the line for historic and tourism purposes. The Australian Railway Historical Society formed in 1966 in the ACT and operates heritage rail trips along portions of the disused railway south of Queanbeyan and particularly around the Michelago Tourist Railway. Similarly, the Monaro Rail Trail Inc formed in 2015 focusses on recreational activities along the disused rail corridor. As of January 2022, there are 6 NSW heritage listed sites along the Bombala railway line between Queanbeyan station and Bombala:

- Queanbeyan Railway Precinct
- Bombala Railway Precinct
- Cooma Railway Station
- Bredbo Rail Bridge Group
- Michelago Rail Bridge over the Ingalara Creek
- Michelago Railway Station Group

Further discussions of these listing is provided in Section 2.

The NSW government announced a $1 million feasibility study in 2018 in order to examine the possibility of reopening the Bombala railway line and its extension to Eden. (McKnight 2020) However, despite community enthusiasm the project was estimated to have a cost of $6.3 billion with "little if any, return on investment" (McKnight 2020).

1.3 QUEANBEYAN STATION

With the expanding railway, the Queanbeyan station yard location in the Oak's paddock was chosen due to its proximity to the centre of town, its access to the main goods transport routes and the avoidance of the nearby hospital and cemetery (Queanbeyan Railway Station Group NSW State Heritage Inventory Listing No 01226).

The location, near River Street, one of the main points of crossing of the Queanbeyan River enabled access for passengers as well as freight and provided a location above the flooding points. The surveyed location for the new station is shown in Figure 4.

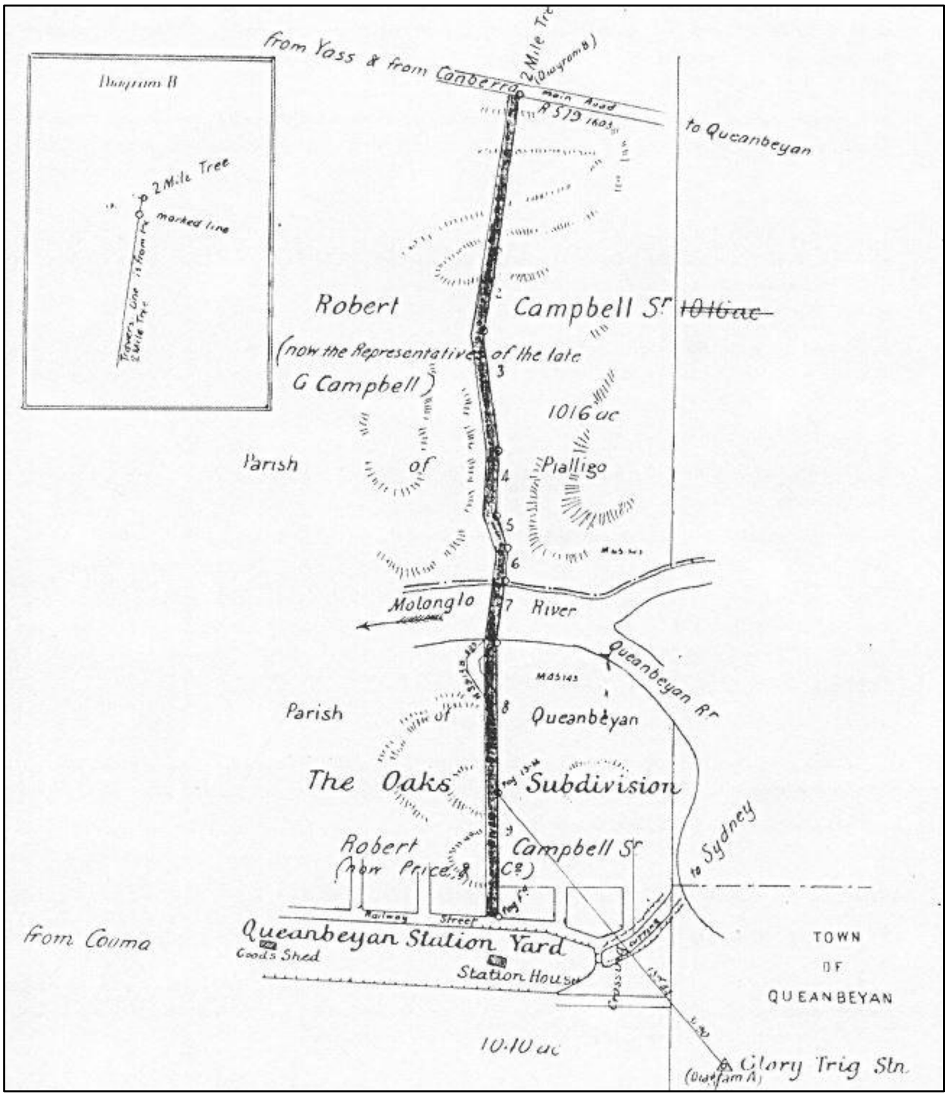


Figure 4. Surveyor's plan of 'River Street' from the Queanbeyan railway station to the main road from Queanbeyan to Yass. Originally surveyed in 1886.
NLA Map H8971.G4

Construction of the main station building, gatekeeper's cottage and station master's residence were awarded to Joseph Jordan on 12 July 1886 (Queanbeyan Railway Station Group NSW Heritage State Inventory Listing 01226). The construction of the Queanbeyan station was completed in March 1887 with the station and the single line railway from Bungendore to Queanbeyan officially opening on 8 September.

The substantial brick station and station master's cottage are indicative of Queanbeyan's status as an important regional centre of NSW, as the period in which they were constructed featured financial difficulty embodied by NSW government cost saving regulations for railway station building materials.

As such the buildings were part of an exclusive group of major buildings opened in the late Victorian era. The accompanying residences of the Station Master's and Railway Worker's cottages were also built in the late 1880s.

The Station on completion is shown in Figure 5.

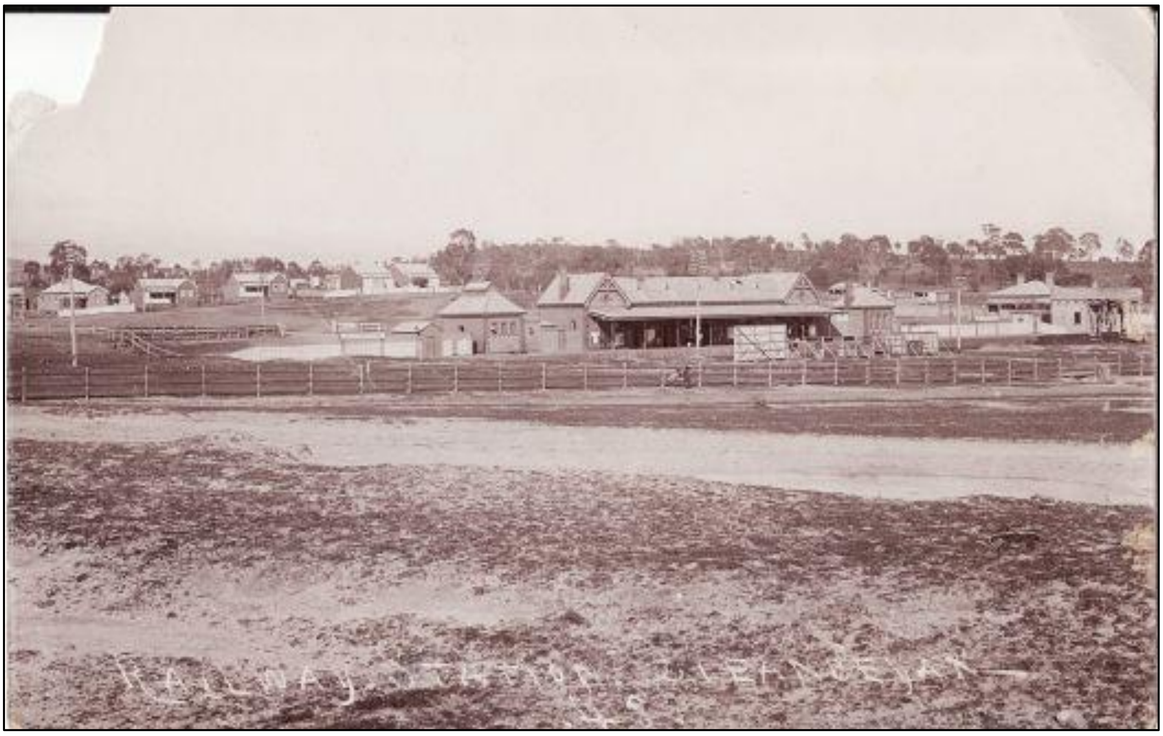


Figure 5. Photograph of the front of the Queanbeyan Railway Station.
(Queanbeyan Railway Station [n.d.], Canberra & District Historical Society Inc, online image #13850 Photograph 147, accessed 10/01/2022.)

The station complex is heritage listed. Details of the heritage listing is provided in Section xxx. The heritage listing notes the station is an excellent example of Victorian train station complexes and currently the Queanbeyan station remains in good condition.

The Queanbeyan station precinct also belongs to the last years of the high Victorian period of railway construction between 1886 and 1892 in NSW and is an example of the Victorian Free Classical Style architecture. Also featured as part of the Queanbeyan station precinct is a train-car turntable built in 1926, small gangers shed, water column, water tank, a 1920s signal box, and a F-frame signal cabin.

The line connected the many communities in the region and continued to provide this important function till the cessation of services. Figure 6 shows the arrival of a service into Queanbeyan in 1955.

Figure 6. Locomotive 3214 hauling northbound Sunday passenger train from Canberra arriving at Queanbeyan (McMillan 1955).

The NSW heritage listing for the Queanbeyan Railway Precinct notes that the Queanbeyan station building is the largest and most ornate on the Bombala rail line. Between 1887 and 1892 Queanbeyan station was one of only 10 stations to be constructed with brick buildings with the 121 other stations being relegated to using the cheaper construction materials of timber and iron (Queanbeyan Railway Station Group NSW State Heritage Inventory Listing 01226). This highlights the importance of the Queanbeyan region, even prior to the establishment of the Federal Capital Territory (now Australian Capital Territory) and the selection of Canberra as the nation's Capital. The Queanbeyan station platform is also one of only 11 remaining stations along the Sydney Trains network that was made from a precast concrete platform structure and of those remaining 11 many are in poor condition (Queanbeyan Railway Station Group NSW Heritage Inventory Listing 01226).

1.4 ABANDONED STRUCTURES

Between the Queanbeyan station and Hume in the ACT, there were several areas that were used historically but which are now abandoned or demolished along the Bombala railway line (Figure 7).

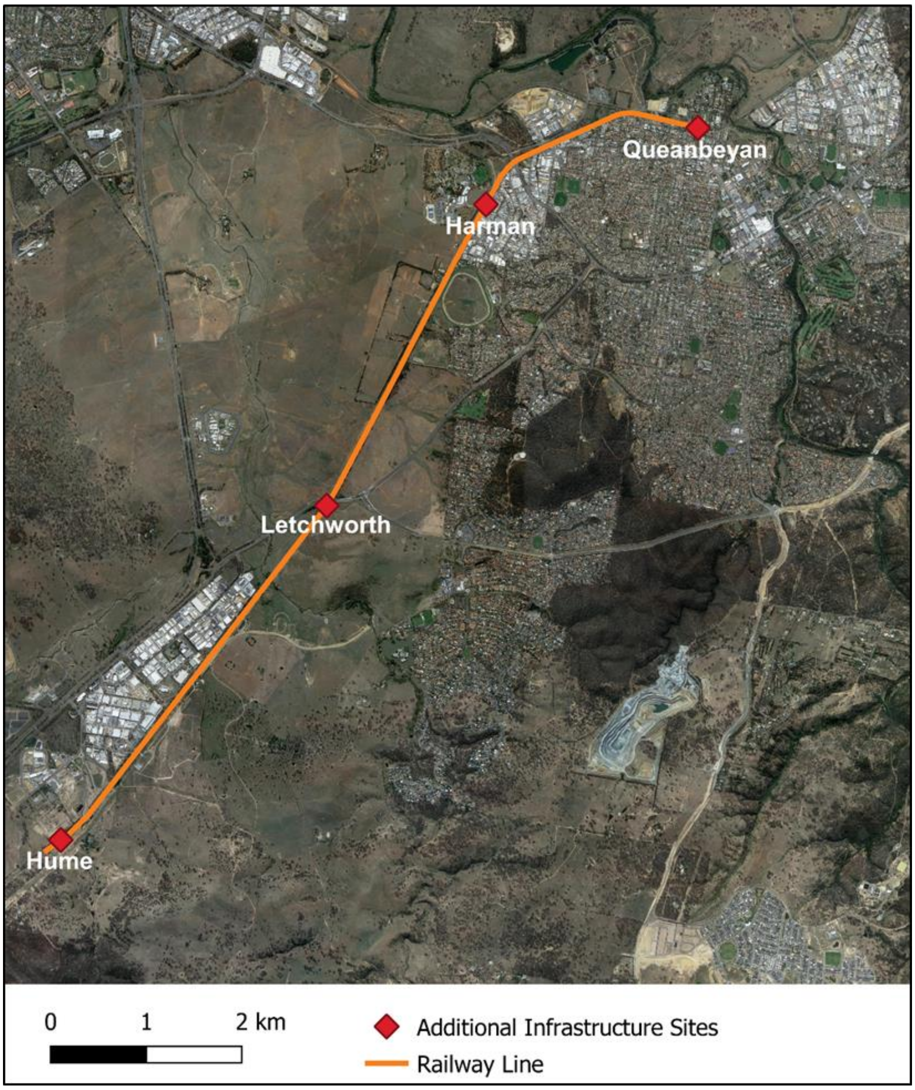
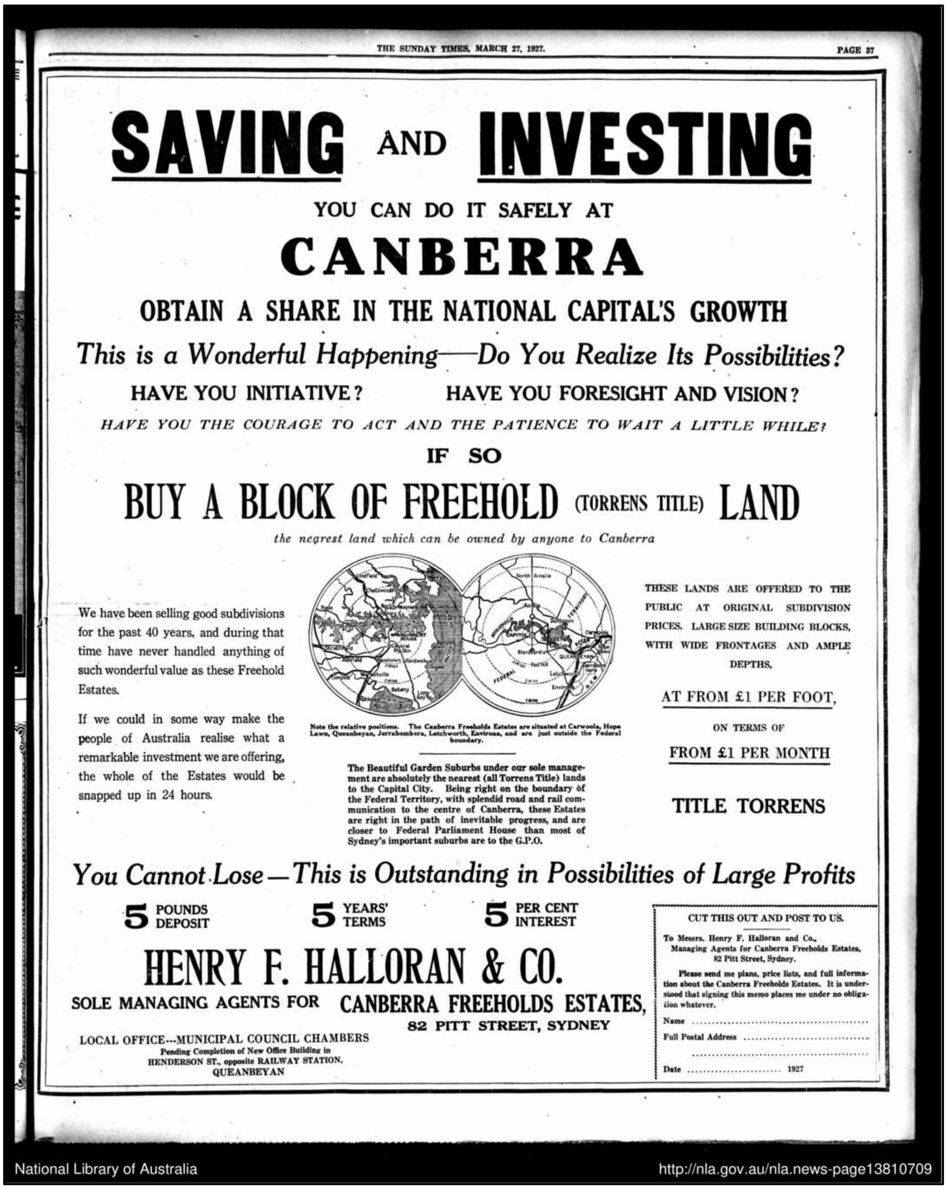


Figure 7. Railway and additional infrastructure sites of the Queanbeyan to Hume portion of the Bombala railway branch overlayed on a satellite image.

1.4.1 Letchworth

Letchworth was promoted as a freehold residential subdivision by the land developer H.F. Halloran and Co (Figure 8). Halloran ran advertisements to attract investors to his developments, which also included Jerrabomberra, Tralee and Environa. A typical example of his advertising style is provided in Figure 8.



THE SUNDAY TIMES, MARCH 27, 1927. PAGE 37

SAVING AND INVESTING

YOU CAN DO IT SAFELY AT

CANBERRA

OBTAIN A SHARE IN THE NATIONAL CAPITAL'S GROWTH

This is a Wonderful Happening—Do You Realize Its Possibilities?

HAVE YOU INITIATIVE? HAVE YOU FORESIGHT AND VISION?

HAVE YOU THE COURAGE TO ACT AND THE PATIENCE TO WAIT A LITTLE WHILE?

IF SO

BUY A BLOCK OF FREEHOLD (TORRENS TITLE) LAND

the nearest land which can be owned by anyone to Canberra

We have been selling good subdivisions for the past 40 years, and during that time have never handled anything of such wonderful value as these Freehold Estates.

If we could in some way make the people of Australia realise what a remarkable investment we are offering, the whole of the Estates would be snapped up in 24 hours.

Note the relative positions. The Canberra Freeholds Estates are situated at Carwoola, Hope Lawn, Queanbeyan, Jerrabombera, Letchworth, Environa, and are just outside the Federal boundary.

The Beautiful Garden Suburbs under our sole management are absolutely the nearest (all Torrens Title) lands to the Capital City. Being right on the boundary of the Federal Territory, with splendid road and rail communication to the centre of Canberra, these Estates are right in the path of inevitable progress, and are closer to Federal Parliament House than most of Sydney's important suburbs are to the G.P.O.

THESE LANDS ARE OFFERED TO THE PUBLIC AT ORIGINAL SUBDIVISION PRICES. LARGE SIZE BUILDING BLOCKS, WITH WIDE FRONTAGES AND AMPLE DEPTHS,

AT FROM £1 PER FOOT,

ON TERMS OF

FROM £1 PER MONTH

TITLE TORRENS

You Cannot Lose—This is Outstanding in Possibilities of Large Profits

5 POUNDS DEPOSIT 5 YEARS' TERMS 5 PER CENT INTEREST

HENRY F. HALLORAN & CO.

SOLE MANAGING AGENTS FOR CANBERRA FREEHOLDS ESTATES,
82 PITT STREET, SYDNEY

LOCAL OFFICE—MUNICIPAL COUNCIL CHAMBERS
Pending Completion of New Office Building in
HENDERSON ST., opposite RAILWAY STATION.
QUEANBEYAN

CUT THIS OUT AND POST TO US.

To Messrs. Henry F. Halloran and Co.,
Managing Agents for Canberra Freeholds Estates,
82 Pitt Street, Sydney.

Please send me plans, price lists, and full information about the Canberra Freeholds Estates. It is understood that signing this memo places me under no obligation whatever.

Name ....

Full Postal Address ....

....

Date 1927

National Library of Australia http://nla.gov.au/nla.news-page13810709

Figure 8. Newspaper advertisement promoting investment into the new estates of Carwoola, Hope Lawn, Queanbeyan, Jerrabombera, Letchworth and Environa.

('Saving and Investing: You Can Do It Safely At Canberra' 1927, Sunday Times, 27 March, p. 37. Accessed via NLA Trove 10/01/2022.)

Located south of Queanbeyan and near the modern ACT Suburb of Hume on the Goulburn-Bombala rail line, was the Letchworth Station, opened 22 October 1926. This station was decommissioned on 1 May 1956. The station was named for Letchworth Garden City of London, named by land developer H.F. Halloran, as the station was part of an incomplete residential sub-division of Halloran, also called Letchworth. The station would have also served another sub-division of Halloran, Environa NSW.

Figure 9. The location of the abandoned Letchworth station. (NSW SIXmaps accessed10/01/2022).

1.4.2 Hume Siding

The site at Hume is a gravel apron for loading and unloading freight, however the site is no longer in use (Figure 10). Since the date of the photo, the concrete platform has since been broken up and removed.

Figure 10. Photograph of the gravel apron with the railway line visible on the right. (Photograph by Monaro Rail Trail Inc accessed 10/01/2022, https://www.monarorailtrail.com.au/maps/interactive-map/)

2 HISTORICAL HERITAGE SEARCH

Within NSW Local government is responsible for managing heritage items. This responsibility is mainly fulfilled by listing heritage items in the Local Environmental Plans (LEPs) under the *Environmental Planning & Assessment Act 1979*. Council approval is required to impact any listed item.

Heritage items can also be of 'state significance' in which case they are listed on the NSW Heritage Register by the NSW Heritage Council under the *Heritage Act 1977*. These items are usually substantial and consist of buildings, bridges or other structures that represent events in the local area. These items are listed in the NSW Heritage Register.

Under the provisions of the NSW Heritage Act, State entities are required to maintain a register of heritage assets under their managements. This register covers state, regional and local level items. As the Rail corridor is under the management of a state agency – NSW Rail, any heritage items should be listed on their register and managed in accordance with state requirements.

A search of the above databases was undertaken for the project (accessed 11/10/2021) revealing the following listings as shown in Table 1.

Table 1. Heritage Listings

Register	Listing
Queanbeyan Palerang LEPs Bombala LEP	Queanbeyan Railway Group Bombala Railway Precinct
NSW Heritage	• Queanbeyan Railway Precinct • Bombala Railway Precinct • Cooma Railway Station Group • Bredbo Rail Bridge over Bredbo River • Michelago Rail Bridge over the Ingalara Creek • Michelago Railway Station Group
NSW Rail S170 Register	Queanbeyan Railway Precinct Bombala Railway Precinct

Heritage Register Extracts for each of the sites listed in the above table and described in the following sections are available from the NSW Heritage Inventory.

2.1 QUEANBEYAN RAILWAY PRECINCT.

The State registered Queanbeyan Railway precinct (Listing 01226), includes the following heritage listed items, the Queanbeyan Railway Group, comprised of the Queanbeyan Railway Station, the Railway Worker's Cottage, the Station Master's Cottage and Bull's Cottage.

The Queanbeyan Railway Station Group covers the intact structures of the railway. The station is an excellent example of Victorian train station complexes that remain in good condition. The building of the railway had a significant economic impact on the Queanbeyan township, as local manufacturing businesses were closed after failing to compete with the Sydney producers the railway exposed them to. The location of the station and its associated structures established Oaks Estate as a working-class suburb, causing the subsequent subdivision and settlement of the estate.

The substantial brick station and station master's cottage are indicative of Queanbeyan's status as an important regional centre of NSW, as the period in which they were constructed was a period of financial difficulty. the Queanbeyan station building is the largest and most ornate on the Bombala rail line. Between 1887 and 1892 Queanbeyan station was one of only 10 stations to be constructed with brick buildings with the 121 other stations being relegated to using the cheaper construction materials of timber and iron (Queanbeyan Railway Station Group – NSW State Register Entry 01226 – accessed 11/01/2022). As such the buildings were part of an exclusive group of major buildings opened in the late Victorian era. The group also belongs to the last years of the high Victorian period of railway construction between 1886 and 1892 in NSW and is an example of the Victorian Free Classical Style architecture.

Built to a standard design, the Station Master's Cottage is a good example of its type, and the Assistant Station Master's Cottage is an intact timber cottage dating from the early twentieth century.

The station also contains a fine example of railway technology, a turntable still in working order, a kind of technology no longer in production.

Overall, the group is a valuable for its social and historical associations for the Queanbeyan community.

2.2 MICHELAGO RAILWAY STATION GROUP

The Michelago Railway Station Group station buildings opened on 8 December 1887. It officially closed on 8 February 1976 (Michelago Railway Precinct NSW Heritage Listing 01192).

The Australian Railway Historical Society (ACT Division) operated the Michelago Tourist Railway from Queanbeyan to Michelago from 1993. The service was halted in 2006 due to the deteriorating condition of the line and cost of maintenance.

The station area has three main areas, general waiting room, ticket office and ladies waiting room, plus sheds, lamp room and the yard area. The station is located in the main street of the township of Michelago.

2.3 MICHELAGO RAIL BRIDGE

The Michelago Rail Bridge was constructed in 1889 by A Johnston and Co., and designed by John Whitton, the Engineer-in-Chief for Railways.

Due to decreasing funding for the railway construction, the bridge/viaduct was constructed from timber, using timber Queen post deck trusses of ironbark hardwood. Only four of these timber viaducts were built in the state (including the Bredbo Rail Bridge, listed below in Section 2.4), making the Michelago Rail Bridge an important and unique structure in place of Whitton's preferred iron lattice bridges. The bridge retains its original material. (Michelago Rail Bridge NSW Heritage State Inventory listing 01048).

The bridge is a 6-span timber truss viaduct, spanning 40 feet between each trestle located over Ingalara Creek, accessible from the Monaro Highway.

2.4 BREDBO RAIL BRIDGE

The Bredbo Rail Bridge was constructed between 1881 to 1889 by Johnston and Co., and designed by John Whitton, the Engineer-in-Chief for Railways.

This viaduct bridge was also constructed from ironbark hardwood timber due to the decrease in funding for the railway construction. The bridge retains its original material.

This bridge is a 10-span timber truss viaduct, each spanning 40 feet from the centre of each trestle, located over the Bredbo River, accessible from the Monaro Highway.

2.5 COOMA RAILWAY STATION GROUP

The Cooma Railway Station building, and platform began construction in 1888, finishing in 1889 by Walker & Swan, who were awarded the contract for the line between Michelago and Cooma in 1885. It was designed by John Whitton, the Engineer-in-Chief for Railways. The station was officially closed in 1989.

The Cooma Station opened May 31 1889, compromised of a five room station standard roadside building design, of the Railway Gothic architectural style. The station building is a fine example of a Victorian first-class roadside building. The station group has continually been added to over the last century, particularly during the 1920s and 1960s, and as such displays a significant combination of architectural styles of different eras. Two significant rare items on site include the signalling equipment, the most complete example of its kind in Australia, and the straight engine type shed, the most intact example for four existing of its type. It is also considered the only site in NSW to demonstrate the development of the railways from steam to diesel.

The station group also holds historical and social value as contributing factor to the allocation of Cooma as the headquarters of the Snowy Mountains Hydro-Electric Authority, and on which the Snowy Hydro Scheme's completion was dependent. The presence of the station and railway line in Cooma was a major influence on the town's agricultural industry and employment rates for the 100 years the trains operated between Queanbeyan and Cooma, and particularly during the construction of the Snowy Hydro. During both World Wars, the station group was an important social venue as the local departure and arrival point for troops, later contributing to the construction of barracks in the 1940s. The station group was an important factor in the development of the township of Cooma.

The station group remains in generally good condition and is in use as a tourist centre.

2.6 BOMBALA RAILWAY PRECINCT

At the terminus of the line is the heritage listed Bombala Railway Precinct. The following information has been summarised from the Bombala State Heritage listing No 3150035. The line was extended from Michelago to Nimmitabel in 1912. The Bombala precinct was constructed in 1921 and the line was closed in 1989. The statement of significance for the NSW Heritage listing state that the size of the station reflects the volume and significance of the wool trade and is one of the longest rail yards in NSW. The site holds technical significance due to the layout of the yard and can provide information on the construction policies and methods.

3 REFERENCES

Bombala Railway Precinct, NSW State Heritage Inventory Listing 3150055

Bredo Rail Bridge, NSW State Heritage Inventory Listing

'Cooma-Bombala Railway Official Opening' 1921, *The Bombala Times*, 9 December, p. 1. Accessed via NLA Trove 10/01/2022

Cooma Railway Station and Yard Group, NSW State Heritage Inventory Listing 01116

'History of the Line' 1921, *The Bombala Times*, 9 December, p. 1. Accessed via NLA Trove 10/01/2022.

McKnight, A. 2020, 'Canberra to Eden Railway Feasibility Study Finds Project is not Viable', *The Canberra Times*, 5 October, viewed 10 January 2021, https://www.canberratimes.com.au/story/6955248/end-of-the-line-canberra-to-eden-railway-feasibility-study-finds-project-is-not-viable/

McMillan, J.M. 1955, *Locomotive 3214 hauling northbound Sunday passenger train from Canberra arriving at Queanbeyan, and 4 car Canberra-Sydney diesel set*, photograph accessed 10/01/2022 via NLA, https://nla.gov.au/nla.obj-155277045/view/

Michelago Railway Group, NSW State Heritage Inventory listing 01192

Michelago Rail Bridge over Ingalara, NSW State Heritage Inventory listing 01048

'Opening of the Queanbeyan Railway' 1887, *The Daily Telegraph*, 9 September, p. 6. Accessed via NLA Trove 10/01/2022.

Philip Leeson Architects, 2013. *Heritage Assessment: Oaks Estate, ACT*. Report prepared for the Environment, Planning and Sustainable Development Directorate.

Queanbeyan Railway Station Group, NSW State Heritage Inventory Listing 01226

Queanbeyan Railway Station [n.d.], Canberra & District Historical Society Inc, online image #13850 Photograph 147, accessed 10/01/2022, https://www.canberrahistory.org.au/resource/13850/queanbeyan-railway-station.html?page=1&q=railway+bombala+queanbeyan/

'Saving and Investing: You Can Do It Safely at Canberra' 1927, *Sunday Times*, 27 March, p. 37. Accessed via NLA Trove 10/01/2022.

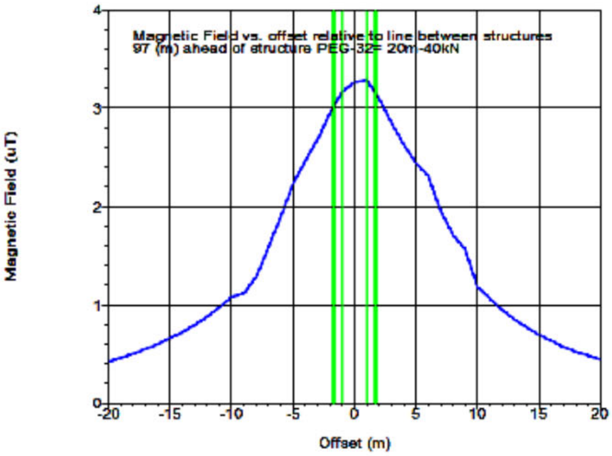
'SRA takes axe to 8,000 jobs' 1989, *The Sydney Morning Herald*, 14 July, p. 1.

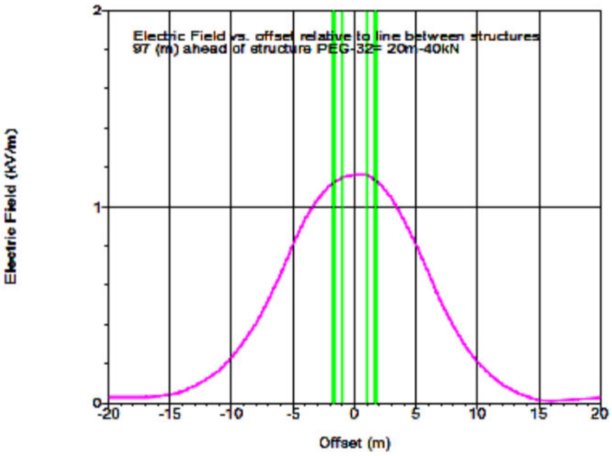
'Tarago Railway Opening' 1884, *Evening News*, 3 January, p. 2. Accessed via NLA Trove 07/01/2022.

Williams, K. 1997, *Oaks Estate: No Man's Land*. ACT, K. Williams

Appendix F – EMF modelling

Wire low point cross section results between structures PEG-32= 20m-40kN and PEG-33= 20m-40kN





3D EMF Point Results Span from PEG-32= 20m-40kN to PEG-33= 20m-40kN:

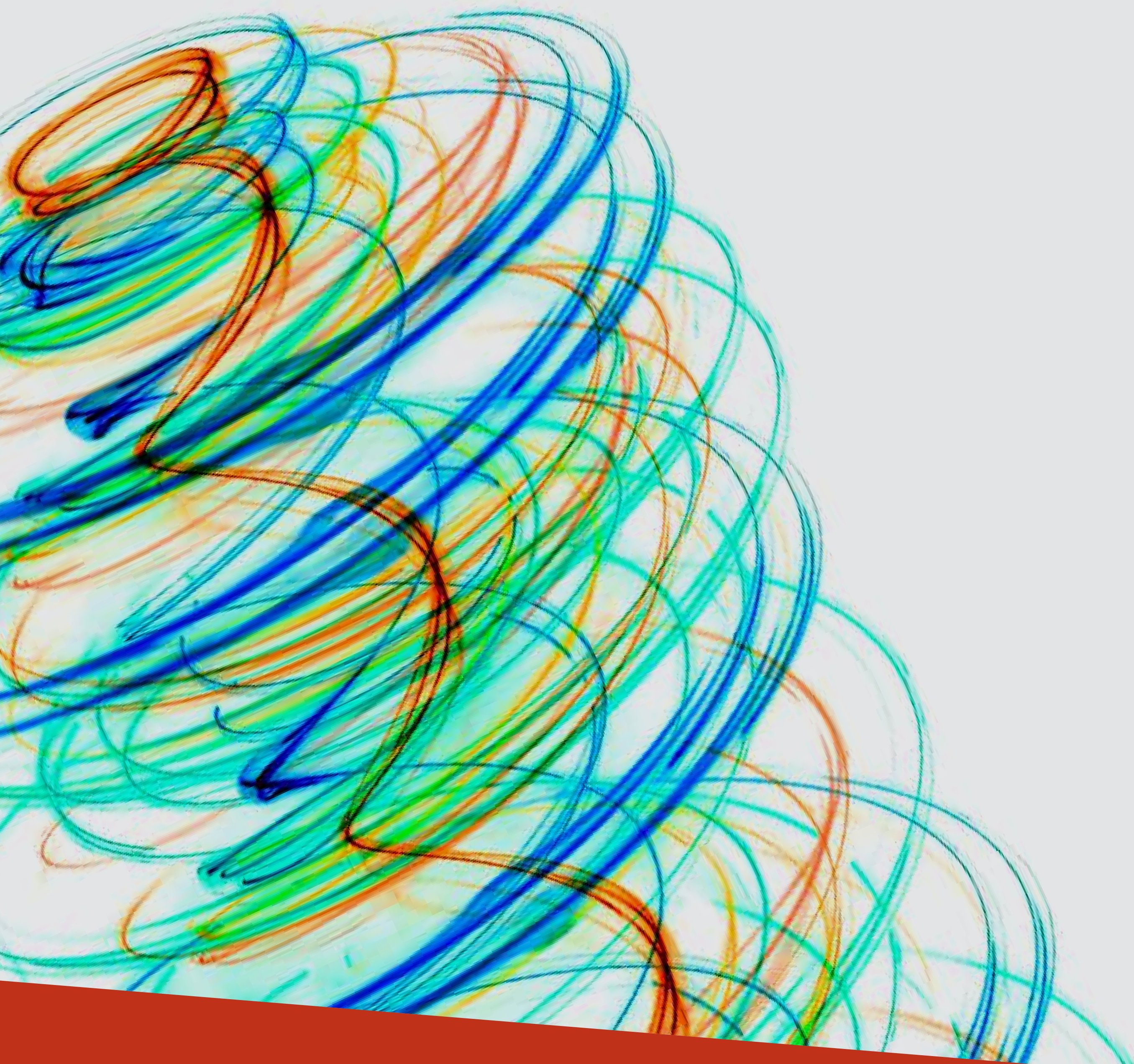
Measurement			B					H	EF					Space Potential			
X (m)	Y (m)	Z (m)	Real (uT)	Imaginary (uT)	Angle (deg)	Magnitude (uT)	Polarization Axial Ratio %	Magnitude (A/m)	Real (kV/m)	Imaginary (kV/m)	Angle (deg)	Magnitude (kV/m)	Polarization Axial Ratio %	Real (kV)	Imaginary (kV)	Angle (deg)	Magnitude (kV)
699294.3	6084261.0	602.5	0.113	0.412	74.6	0.427	7.3	0.340	0.008	0.029	74.4	0.030	4.1	-0.007	0.006	-43.0	0.009
699293.4	6084261.5	602.5	0.128	0.446	74.0	0.464	8.0	0.369	0.011	0.026	66.5	0.029	6.0	-0.008	0.007	-42.8	0.011
699292.5	6084261.9	602.5	0.145	0.484	73.3	0.505	8.9	0.402	0.016	0.023	54.8	0.028	8.6	-0.010	0.009	-42.7	0.013
699291.6	6084262.4	602.5	0.165	0.526	72.5	0.551	9.8	0.439	0.023	0.018	38.5	0.029	11.1	-0.012	0.011	-42.6	0.016
699290.8	6084262.9	602.5	0.189	0.573	71.7	0.603	10.9	0.480	0.031	0.011	19.6	0.033	11.4	-0.014	0.013	-42.5	0.019
699289.9	6084263.4	602.5	0.217	0.625	70.9	0.662	12.1	0.526	0.043	0.004	5.2	0.043	9.0	-0.018	0.016	-42.4	0.024
699289.0	6084263.9	602.5	0.250	0.683	69.9	0.727	13.6	0.579	0.059	0.013	12.7	0.061	6.1	-0.023	0.021	-42.2	0.031
699288.1	6084264.4	602.5	0.289	0.748	68.9	0.802	15.2	0.638	0.081	0.031	20.9	0.087	3.9	-0.029	0.026	-41.9	0.039
699287.3	6084264.9	602.5	0.334	0.819	67.8	0.885	17.2	0.704	0.110	0.054	26.4	0.122	2.5	-0.038	0.033	-41.4	0.051
699286.4	6084265.3	602.5	0.389	0.898	66.6	0.979	19.4	0.779	0.147	0.085	30.1	0.170	1.5	-0.049	0.043	-40.9	0.065
699285.5	6084265.8	602.5	0.452	0.985	65.3	1.084	22.1	0.862	0.197	0.125	32.5	0.233	0.9	-0.064	0.055	-40.4	0.084
699284.6	6084266.3	601.9	0.474	1.009	64.8	1.115	25.9	0.887	0.263	0.179	34.2	0.318	2.2	-0.245	0.179	-36.1	0.303
699283.8	6084266.8	602.4	0.592	1.157	62.9	1.299	29.0	1.034	0.337	0.238	35.3	0.412	1.0	-0.164	0.128	-38.1	0.208
699282.9	6084267.3	603.1	0.791	1.378	60.1	1.589	32.5	1.264	0.423	0.313	36.5	0.526	0.8	0.098	-0.061	-32.0	0.116
699282.0	6084267.8	603.6	1.027	1.609	57.4	1.909	37.2	1.519	0.526	0.406	37.7	0.664	2.8	0.369	-0.277	-36.9	0.462
699281.1	6084268.3	603.9	1.294	1.841	54.9	2.250	43.4	1.791	0.632	0.515	39.2	0.816	5.3	0.620	-0.507	-39.3	0.801
699280.3	6084268.7	603.8	1.465	1.984	53.6	2.466	51.1	1.962	0.698	0.631	42.1	0.941	7.2	0.640	-0.588	-42.6	0.869
699279.4	6084269.2	603.8	1.640	2.138	52.5	2.695	59.5	2.144	0.715	0.756	46.6	1.040	10.1	0.640	-0.700	-47.6	0.948
699278.5	6084269.7	603.9	1.829	2.317	51.7	2.952	68.6	2.349	0.669	0.886	52.9	1.110	14.7	0.623	-0.880	-54.7	1.078
699277.6	6084270.2	603.9	1.969	2.486	51.6	3.171	76.0	2.524	0.553	1.008	61.2	1.149	19.3	0.515	-1.061	-64.1	1.179
699276.8	6084270.7	603.9	1.994	2.595	52.5	3.273	76.8	2.605	0.383	1.098	70.8	1.163	20.8	0.306	-1.156	-75.2	1.196
699275.9	6084271.2	603.9	1.945	2.658	53.8	3.293	71.6	2.621	0.234	1.141	78.4	1.164	19.2	0.081	-1.208	-86.2	1.210
699275.0	6084271.6	603.8	1.737	2.563	55.9	3.096	64.1	2.464	0.181	1.105	80.7	1.120	13.7	-0.102	-1.025	84.3	1.030
699274.1	6084272.1	603.7	1.514	2.411	57.9	2.847	57.4	2.265	0.236	1.013	76.9	1.040	9.1	-0.190	-0.808	76.8	0.830
699273.3	6084272.6	603.6	1.332	2.266	59.6	2.629	51.9	2.092	0.287	0.886	72.1	0.931	6.6	-0.232	-0.678	71.1	0.717
699272.4	6084273.1	603.7	1.185	2.134	61.0	2.441	47.2	1.943	0.300	0.743	68.0	0.801	5.5	-0.267	-0.623	66.8	0.678
699271.5	6084273.6	604.0	1.089	2.051	62.0	2.323	43.1	1.848	0.287	0.605	64.6	0.669	5.6	-0.332	-0.672	63.7	0.749
699270.6	6084274.1	603.7	0.866	1.753	63.7	1.955	39.5	1.556	0.237	0.459	62.7	0.516	3.2	-0.216	-0.384	60.6	0.441
699269.8	6084274.6	603.6	0.722	1.548	65.0	1.708	36.4	1.359	0.190	0.343	61.0	0.392	2.2	-0.160	-0.256	58.0	0.302
699268.9	6084275.0	603.9	0.638	1.426	65.9	1.562	33.4	1.243	0.149	0.253	59.6	0.294	2.1	-0.161	-0.246	56.8	0.294
699268.0	6084275.5	602.5	0.441	1.093	68.0	1.178	31.4	0.938	0.105	0.177	59.3	0.206	0.6	0.022	0.067	71.9	0.071
699267.2	6084276.0	602.5	0.380	0.987	68.9	1.057	29.2	0.841	0.073	0.122	59.1	0.143	0.4	0.014	0.051	75.2	0.053
699266.3	6084276.5	602.5	0.328	0.891	69.8	0.950	27.2	0.756	0.048	0.081	59.5	0.095	0.2	0.007	0.039	80.0	0.040
699265.4	6084277.0	602.5	0.284	0.806	70.6	0.855	25.4	0.680	0.028	0.051	61.0	0.058	0.2	0.002	0.030	86.5	0.031
699264.5	6084277.5	602.5	0.247	0.731	71.3	0.771	23.7	0.614	0.013	0.029	64.8	0.032	1.6	-0.002	0.024	-85.3	0.024
699263.7	6084278.0	602.5	0.215	0.664	72.0	0.697	22.2	0.555	0.003	0.012	76.0	0.013	11.3	-0.005	0.019	-75.9	0.019
699262.8	6084278.4	602.5	0.188	0.604	72.7	0.633	20.8	0.503	0.006	0.003	28.3	0.007	49.1	-0.007	0.015	-66.1	0.016
699261.9	6084278.9	602.5	0.165	0.552	73.4	0.576	19.6	0.458	0.012	0.009	37.9	0.015	9.0	-0.008	0.012	-57.0	0.015
699261.0	6084279.4	602.5	0.145	0.505	74.0	0.525	18.4	0.418	0.015	0.015	43.8	0.021	4.2	-0.009	0.010	-49.2	0.013
699260.2	6084279.9	602.5	0.128	0.463	74.5	0.481	17.4	0.383	0.018	0.019	46.5	0.026	2.7	-0.009	0.009	-43.0	0.013
699259.3	6084280.4	602.5	0.114	0.426	75.1	0.441	16.4	0.351	0.020	0.022	48.1	0.029	2.1	-0.009	0.007	-38.3	0.012

Appendix G – ENA EMF Guideline

energy networks association

EMF MANAGEMENT HANDBOOK

January 2016



DISCLAIMER

This document refers to various standards, guidelines, calculations, legal requirements, technical details and other information.

Over time, changes in Australian Standards, industry standards and legislative requirements, as well as technological advances and other factors relevant to the information contained in this document, may affect the accuracy of the information contained in this document. Accordingly, caution should be exercised in relation to the use of the information in this document.

The Energy Networks Association Limited (ENA) accepts no responsibility for the accuracy of any information contained in this document or the consequences of any person relying on such information.

Correspondence should be addressed to the CEO, Energy Networks Association, Level 1, 110 Giles Street, Kingston ACT 2604

CONTENTS

1. INTRODUCTION

ELECTRIC AND MAGNETIC FIELDS (EMF) ARE PART OF THE NATURAL ENVIRONMENT AND ELECTRIC FIELDS ARE PRESENT IN THE ATMOSPHERE AND STATIC MAGNETIC FIELDS ARE CREATED BY THE EARTH'S CORE.

EMF is also produced wherever electricity or electrical equipment is in use. Powerlines, electrical wiring, household appliances and electrical equipment all produce power frequency EMF. This handbook deals with power-frequency EMF (also known as extremely low frequency or ELF EMFs) which have a frequency of 50 Hertz (Hz).

Research on power frequency EMF and health has been conducted since the 1970's. This includes more than 2,900 studies at a cost of more than $490 million[1].

Based on the findings of credible public health authorities, the body of scientific research on EMF does not establish that exposure to EMF at levels below the recognised[2] guidelines cause or contribute to any adverse health effects. Some scientists however believe there is a need for further scientific research, although the World Health Organization has found that the body of research on EMF already is extensive.

The Energy Networks Association (ENA) is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia. The industry's position on EMF has been adopted in the light of authoritative reviews having concluded that no adverse health effects have been established from exposure to EMF below the recognised international guidelines. ENA recognizes that even so some members of the public continue to have concerns about the issue. The ENA position on EMF includes:

» recommending to its members that they design and operate their electricity generation, transmission and distribution systems in compliance with recognised international EMF exposure guidelines and to continue following an approach consistent with the concept of prudent avoidance,

» monitoring engineering and scientific research, including reviews by scientific panels, policy and exposure guideline developments, and overseas policy development, especially with regard to the precautionary approach,

» communicating with all stakeholders including assisting its members in conducting community and employee education programs, distributing information material including newsletters, brochures, booklets and the like, liaising with the media and responding to enquiries from members of the public, and

» cooperating with bodies established by governments in Australia to investigate and report about power frequency electric and magnetic fields.

---

1 Repacholi M, "Concern that 'EMF' magnetic fields from power lines cause cancer." Sci Total Environ (2012), doi:10.1016/j.scitotenv.2012.03.030, page 3. [citing PubMed]

2 The World Health Organisation recognises the following two international EMF exposure guidelines:

Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz - 100 kHz), issued by the International Commission on Non Ionizing Radiation Protection (ICNIRP). - Health Physics 99(6):818-836; and Standard C95.6 - Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz. issued by the IEEE International Committee on Electromagnetic Safety (see Section 6 below)

2. PURPOSE AND SCOPE

THE PURPOSE OF THIS HANDBOOK IS TO PROVIDE COMMON, INDUSTRY-WIDE INFORMATION FOR GUIDANCE TO THE AUSTRALIAN ELECTRICITY DISTRIBUTION AND TRANSMISSION INDUSTRY TO ADDRESS THE EMF ISSUE.

The handbook is aimed at engineers and professionals within the industry who have an understanding of electricity transmission and distribution. Members of the public may find information in this handbook useful; however, some of the content is industry specific and technically complex. Further information can be found from the references provided in this handbook or by contacting your electricity network operator.

This Handbook is applicable to exposures from 50 Hz sources owned or operated by the Australian electricity distribution and transmission industry.

The Handbook applies to both public and occupational exposure situations associated with electricity networks and covers:

- electric and magnetic field basic information,
- the science of EMF and health,
- EMF exposure guidelines,
- methods for assessing compliance against exposure guidelines,
- measuring and calculating EMF,
- methods to reduce magnetic fields,
- prudent avoidance / precaution,
- process for evaluating precautionary measures,
- medical implants,
- signage, and
- EMF communication.

The Handbook does not cover:

- direct current (DC) fields,
- radio frequency (RF) fields,
- smart meters[3], and
- EMF management for electrical wiring in industrial, commercial and residential premises and from electrical appliances or metering[4].

The guidance in this Handbook may be modified and adopted as required by individual businesses.

3 More information about smart meters can be found at www.arpansa.gov.au,www.ena.asn.au or your metering provider. ARPANSA's advice is "*The scientific evidence suggests that the low level exposures to the radio waves produced by smart meters do not pose a risk to health. The combination of the relatively low power of the smart meter transmitters, their location on the outside of buildings and the very short time spent transmitting means that the overall exposure from smart meters is very low.*"

4 Some background information about magnetic field sources within the home is provided in section 3. This may be a useful reference for those wishing to reduce their personal exposure.

3. ELECTRIC AND MAGNETIC FIELDS

EMF IS PART OF THE NATURAL ENVIRONMENT AND ELECTRIC FIELDS ARE PRESENT IN THE ATMOSPHERE AND STATIC MAGNETIC FIELDS ARE CREATED BY THE EARTH'S CORE.

EMF is also produced wherever electricity or electrical equipment is in use. Powerlines, electrical wiring, household appliances and electrical equipment all produce power frequency EMF.

It is not uncommon for EMF to be confused with electromagnetic radiation (EMR).

EMR is a term used to describe the movement of electromagnetic energy through the propagation of a wave. This wave, which moves at the speed of light in a vacuum, is composed of electric and magnetic waves which oscillate (vibrate) in phase with, and perpendicular to, each other. This is in contrast to EMF, where the electric and magnetic components are essentially independent of one another.

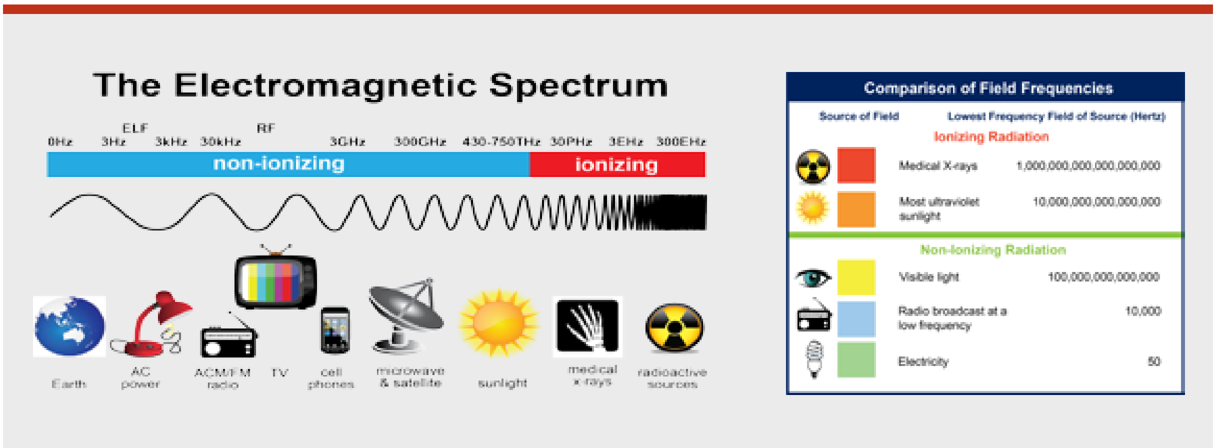
EMR is classified into several types according to the frequency of its wave; these types include (in order of increasing frequency): radio waves, microwaves, teraherz radiation, infra-red radiation, visible light, ultraviolet radiation, X-rays and gamma rays. X-rays and gamma rays are in the ionising part of the spectrum and have enough energy to damage DNA[5].

Whereas EMR causes energy to be radiated outwards from its source e.g. light from the sun or radio-frequency signals from a television transmitter, EMFs cause energy to be transferred along electric wires.

The distinction between EMF and EMR is addressed by the New Zealand Ministry of Health in its public information booklet "Electric and Magnetic Fields and Your Health"[6] as follows:

> "The electric and magnetic fields around power lines and electrical appliances are not a form of radiation. The word "radiation" is a very broad term, but generally refers to the propagation of energy away from some source. For example, light is a form of radiation, emitted by the sun and light bulbs. ELF fields do not travel away from their source, but are fixed in place around it. They do not propagate energy away from their source. They bear no relationship, in their physical nature or effects on the body, to true forms of radiation such as x-rays or microwaves."

FIGURE 3.1 THE ELECTROMAGNETIC SPECTRUM



5 The capability to damage DNA is determined by the "frequency" of the source. Frequency is measured in Hz representing the number of cycles per second. For a source to produce enough energy to damage DNA, it must be at a frequency of approximately 10,000,000,000,000,000Hz. By comparison, EMF from the use of electricity is at a frequency of only 50 Hz.

6 Electric and Magnetic Fields and Your Health: National Radiation Laboratory, New Zealand Ministry of Health, 2008

3.1 ELECTRIC FIELDS

Electrical energy involves 'voltage', which is the pressure behind the flow of electricity and produces an electric field, and 'current', which is the quantity of electricity flowing and produces a magnetic field. An electric field is proportional to the voltage, which remains constant[7] as long as the equipment is energised. The higher the voltage is, the higher the electric field. Even if the appliance is 'off' and the power point is 'on' an electric field will be present as the cord remains energised.

Electric fields are shielded by most objects, including trees, buildings and human skin. For this reason there are negligible electric fields above underground cables. Like magnetic fields, their strength reduces quickly as you move away from the source (see Section 3.2).

The units commonly used to describe electric field strength are volts per metre (V/m) or kilovolts (1,000 Volts) per metre (kV/m).

3.2 MAGNETIC FIELDS

Whenever an electric charge moves (i.e. whenever an electric current flows) a magnetic field is created that is proportional to the current - the higher the current, the higher the magnetic field.

When a piece of equipment is completely turned off, there is no flow of current and so there is no magnetic field.

Like electric fields, the strength of magnetic fields drops quickly as you move away from the source. Unlike electric fields, magnetic fields cannot easily be shielded and pass through most materials.

Magnetic fields are often described in terms of their flux density which is commonly measured in units of Tesla (T) or the older unit of Gauss (G) where:

- 1 Tesla (T) = 1,000 milliT (mT) = 1,000,000 microT (µT)
- 1 µT = 10 mG
- 1 Gauss (G) = 1,000 milliG (mG)

Figure 3-2 can be used to convert from one magnetic field unit to the other. For example, a magnetic field of 1 mT is the same as 1,000 µT, 10^6 nT, 10 G, and 10^4 mG.

In some cases magnetic field strength is expressed as A/m.

1 T = 7.95775×10^5 A/m which is $1/\mu_0$

(This conversion for A/m is only relevant for air and non-magnetic materials.)

FIGURE 3.2 MAGNETIC FIELD UNITS' CONVERSION TABLE

mT	µT	nT	G	mG
10	10^4	10^7	1000	10^5
1	1000	10^6	10	10^4
0.1	100	10^5	1	1000
0.01	10	10^4	0.1	100
0.001	1	1000	0.01	10
10^{-4}	0.1	100	0.001	1
10^{-5}	0.01	10	10^{-4}	0.1
10^{-6}	0.001	1	10^{-4}	0.01

7 Slight changes in power system voltage may occur as a result of loading conditions

How magnetic field decrease with distance

All magnetic fields decrease with distance from the source. Generally at a distance from the source (n), the fields will decrease as follows:

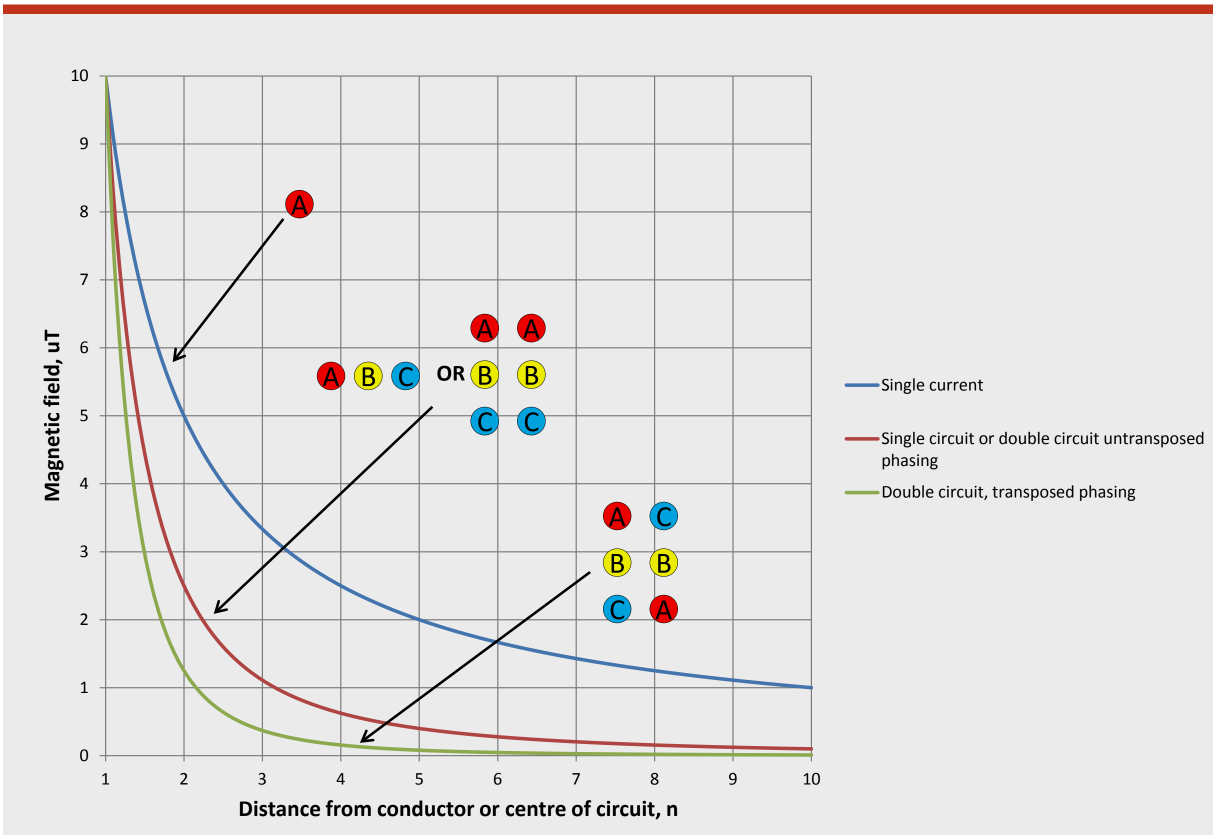
- single current – 1/n.
- single circuit or double circuit un-transposed – $1/n^2$.
- double circuit transposed or coil – $1/n^3$.

Figure 3-3 shows this rate of decrease from different sources. In practice, factors such as unequal currents, zero sequence currents and very close proximity to sources will alter these curves. Further, magnetic field profiles are typically shown horizontally along the ground (at 1m above ground) and perpendicular to the conductor rather than towards the conductors.

3.3 TYPICAL FIELD LEVELS IN THE ENVIRONMENT

While powerlines may create EMF above background levels[8] close to the line, household wiring, appliances and earth return currents tend to be the principal sources of magnetic fields in most homes. A person's exposure is a function of background fields in the home, environment and workplace and fields from sources such as, appliances, powerlines, earthing systems, substations, transport systems and anything that uses electricity.

FIGURE 3.3 RATE OF DECREASE OF MAGNETIC FIELDS FROM DIFFERENT SOURCES



* Note: Hypothetical examples where magnetic fields are 10µT at 1m from the source.

8 Typical values measured in areas away from electrical appliances are of the order of 0.01 – 0.2 uT (ARPANSA fact Sheet – Measuring Magnetic Fields).

Appliances

Magnetic field measurements associated with various appliances are shown in Table 3-1.

TABLE 3.1 MAGNETIC FIELD MEASUREMENTS RANGES THAT ARE ASSOCIATED WITH VARIOUS APPLIANCES.

Magnetic Field Source	Range of Measurement (in µT) (normal user distance)
Electric stove	0.2 – 3
Refrigerator	0.2 – 0.5
Electric kettle	0.2 – 1
Toaster	0.2 – 1
Television	0.02 – 0.2
Personal computer	0.2 – 2
Electric blanket	0.5 – 3
Hair dryer	1 – 7
Pedestal fan	0.02 – 0.2

* Note: Levels of magnetic fields may vary from the range of measurements shown.

Source: ARPANSA, Measuring magnetic fields.

Powerlines

Magnetic field measurements associated with overhead powerlines are shown in Table 3-2.

The magnetic field from power lines will vary with configuration, phasing and load. The effect of configuration and phasing is discussed in section 9.1. More information on electrical loading is provided in Appendix 4.

TABLE 3.2 TYPICAL VALUES OF MAGNETIC FIELDS MEASURED NEAR OVERHEAD POWERLINES.

Source[9]	Location of measurement (1m above the ground)	Range of measurements (µT)*
Distribution Line	directly underneath	0.2 – 3
Distribution Line	10m away	0.05 – 1
Transmission line	directly underneath	1 – 20
Transmission line	at edge of easement[10]	0.2 - 5

* Note: Levels of magnetic fields may vary from the range of measurements shown.

Source: *Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Measuring magnetic fields*.

Substations

Large substations such as zone and transmission substations vary greatly in size, configuration and loading. Key sources of magnetic fields within the substation include the transformer secondary terminations, cable runs to the switch room, capacitors, reactors, bus-bars, and incoming and outgoing feeders. In most cases the highest magnetic fields at the boundary come from the incoming and outgoing transmission lines.

For distribution substations, the key sources of magnetic fields within the substation tend to be the low voltage boards, busbars and transformer cables. In most cases the magnetic field has decreased to background levels within a few metres of the substation. For this reason distribution substations are not a significant source of exposure. Exceptions could include chamber type substations which are typically installed in or adjacent to a building. In these cases the magnetic field exposure will be dependent on the configuration and loading of the substation and uses of adjacent areas (including above and below the substation).

Padmount and distribution substations while varying in design and loading are relatively consistent compared to zone, transmission and chamber type substations. A small survey of 6 padmount substations in Sydney showed average levels ranging from 5.3µT (25cms away), 0.2µT (3m away), to 0.06µT (5m away). Readings were taken on the sides parallel to the property line. Given the small sample size and issues discussed above, the readings should be considered indicative only.

3.4 MAGNETIC FIELD SOURCES AROUND THE HOME

As noted above, electrical appliances in the home produce EMF. In most cases, fields from appliances have decreased to background levels within one or two metres from the appliance. Magnetic fields from appliances generally decrease with the inverse cube of distance from the source.

The highest fields tend to come from motors or transformers designed for lightweight appliances. The peak field in very close proximity to some appliances can be an order of magnitude greater than those shown in Table 3-1. Examples of such appliances include electric shavers, hair dryers and fish tank pumps.

9 In Australia, distribution lines have voltage level of up to 33,000 V. Transmission lines have voltage levels above 33,000 V up to 500,000V.

10 Easement widths vary and depend on a number of factors. Typical transmission line easement widths are provided in *AS/NZS7000 - Informative Appendix DD* as 30-40m (110/132kV), 30-50m (220kV), 50-60m (275kV), 60m (330kV), 65m (400kV) and 75m (500kV).

Other sources of elevated exposure could include items such as the meter box or electric blankets. The meter box where all current enters and leaves the house can have an elevated magnetic field to within a few metres of the box. These sources could result in elevated exposure if for example the bed head is near the meter box or the electric blanket is left on while in use.

Elevated fields may also occur in proximity to the Multiple Earth Neutral (MEN) system which used in Australia. With MEN systems, the earth and neutral are connected at the meter box and this is required for safety reasons. Some neutral current will return to the substation through the ground. This path could include the earth conductor, the ground and metallic services such as water pipes. As the earth return current is away from the active and neutral conductors, the fields from these net currents decrease with the inverse of the distance (see Figure 3-3) and can sometimes be a significant source. The earth return current can increase if the service line neutral connection becomes loose or broken (see Figure 3-4).

General household wiring typically produces low magnetic fields as the active and neutral wires are run together and the fields largely cancel out. However, there are exceptions:

» circuits that are wired so that the current flows in cables that are not close together.

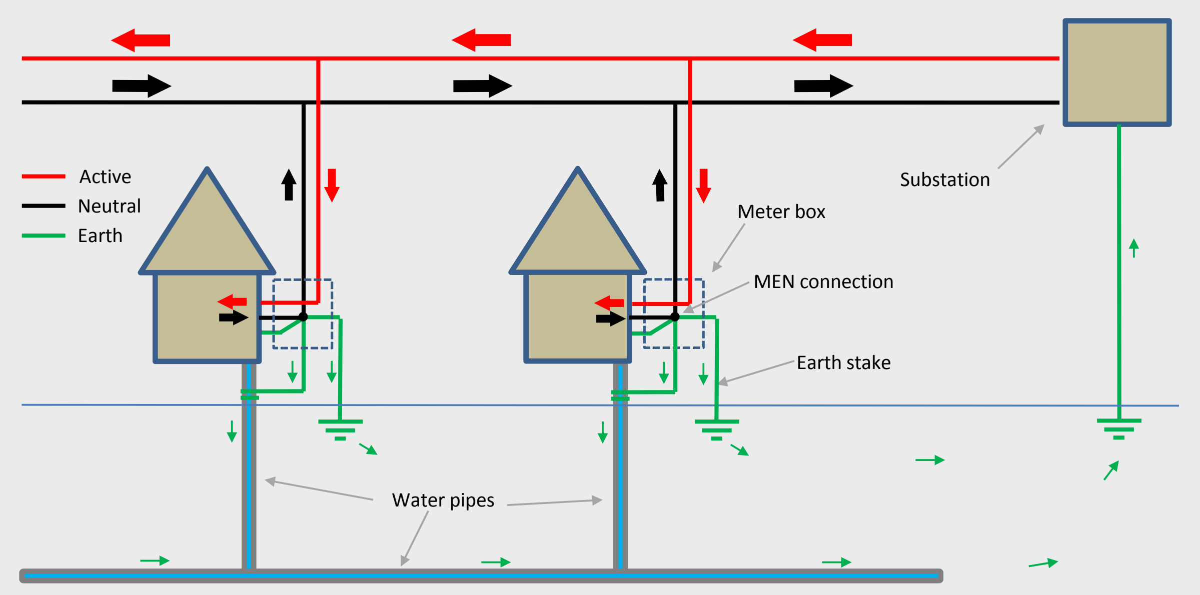
» some older types of underfloor heating (most new systems are designed with the active and neutral together).

» two-way switching of lights where the cables are not installed together (see Figure 3-5).

» accidental connections between the neutral and earth within the home. This could be because of unauthorised wiring, corrosion, incorrect wiring of an appliance or damage to the neutral insulation.

While not strictly sources around the home, electrical transport systems and mobile phones can also be other sources of elevated fields. While mobile phones transmit radiofrequency energy, their batteries produce pulses of current to power the transmission. These pulses of current produce magnetic fields at similar frequencies to 50Hz.

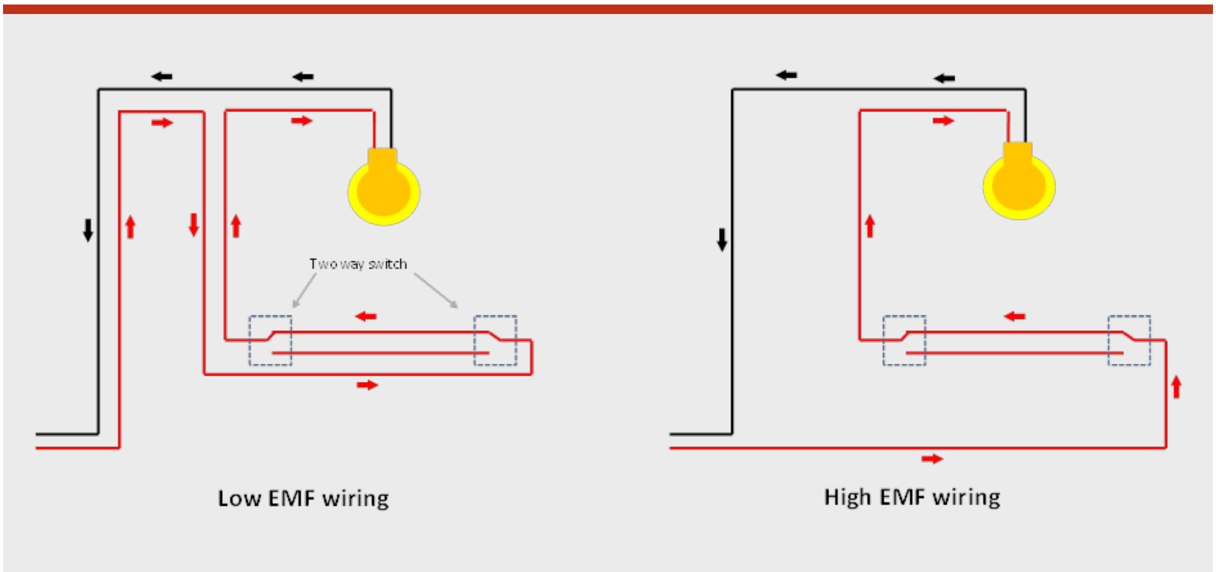
FIGURE 3.4 EXAMPLE OF MEN SYSTEM WITH EARTH RETURN CURRENT



* Earth currents are typically a very small fraction of the active and neutral currents

IMPORTANT NOTE: The MEN system performs a critical safety function. Unauthorised modifications to any aspect of the earthing system in an attempt to reduce magnetic fields could create a potentially fatal electrical hazard. All electrical work must be performed by a licenced electrician in accordance with specific rules and regulations. Further, if the neutral conductor becomes loose or broken, 'tingles' or electric shocks may be felt when touching appliances, taps or water pipes and if this is the case these should be reported immediately and the appliances/pipes not touched until checked by the network operator or a licenced electrician.

FIGURE 3.5 LOW EMF AND HIGH EMF WIRING OF TWO WAY SWITCHES



3.5 OCCUPATIONAL EMF ENVIRONMENTS

The magnitude of EMF produced by electrical equipment is dependent of the size of the source, its configuration, the voltage and current, and proximity.

Examples of situations where elevated magnetic fields could be encountered include close proximity to:

» air cored reactors (substation workers),

» busbars, low voltage boards, transformer secondary terminations, motors (substation),

» cables carrying large currents especially in pits and tunnels (substation workers, jointers),

» conductors carrying large currents (line workers and electric furnace workers),

» appliances with transformers and motors,

» high current testing (testers), and

» earthing conductors carrying large currents (substation workers),

Examples of situations where elevated electric fields could be encountered include:

» directly under 220kV and greater overhead power transmission lines,

» directly under substation busbars (substation workers), and

» close proximity to high voltage conductors (live line workers).

FURTHER INFORMATION

ARPANSA Fact Sheet - Measuring magnetic fields. See more at **www.arpansa.gov.au**

WHO What are electromagnetic fields. See more at **www.who.int**

UK National Grid EMF Information website. See more **www.emfs.info**

FIGURE 3.6 EXAMPLES OF ELEVATED MAGNETIC FIELD ENVIRONMENTS

Air cored reactors

Cable tunnels

Transformer secondaries

Live line work (elevated electric fields also)

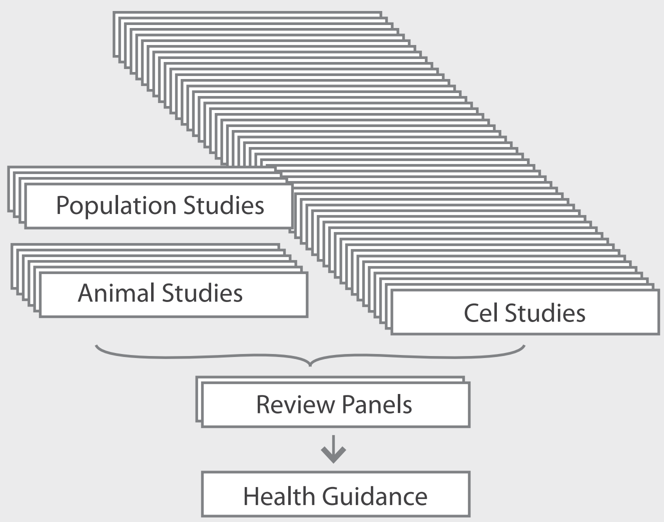
Cable pits and basements

Busbars, LV boards

4. THE SCIENCE OF EMF AND HEALTH

THE QUESTION OF EMF AND HEALTH HAS BEEN THE SUBJECT OF A SIGNIFICANT AMOUNT OF RESEARCH SINCE THE 1970'S. THIS LARGE BODY OF SCIENTIFIC RESEARCH INCLUDES BOTH EPIDEMIOLOGICAL (POPULATION) AND LABORATORY (AT BOTH A CELLULAR AND AN ORGANISM LEVEL) STUDIES.

Research into EMF and health is a complex area involving many disciplines, from biology, physics and chemistry to medicine, biophysics and epidemiology.



EMF at levels well above the recognised international exposure guidelines can cause both synaptic effects perceived as magneto-phosphenes in the sensitive retinal tissue (magnetic fields) and micro-shocks (electric fields). The exposure guidelines are in place to protect against these biological effects (see Section 5).

No single study considered in isolation will provide a meaningful answer to the question of whether or not EMF can cause or contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. Over the years, governments and regulatory agencies around the world have commissioned many independent scientific review panels to provide such overall assessments.

4.1 CONCLUSIONS FROM PUBLIC HEALTH AUTHORITIES

As part of the Health and Aging Portfolio, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government agency charged with the responsibility for protecting the health and safety of people, and the environment, from EMF.

ARPANSA[11] advises that:

> "The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health"

> "There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher than normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed."

11 ARPANSA Electricity and Health, ARPANSA Extremely Low Frequency Electric and Magnetic Fields www.arpansa.gov.au

These findings are consistent with the views of other credible public health authorities. For example, the World Health Organization (WHO)[12] advises that:

"Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."

Similarly, the U.S. National Cancer Institute concludes that

"Currently, researchers conclude that there is little evidence that exposure to ELF-EMFs from power lines causes leukemia, brain tumors, or any other cancers in children."

"No mechanism by which ELF-EMFs could cause cancer has been identified. Unlike high-energy (ionizing) radiation, ELF-EMFs are low energy and non-ionizing and cannot damage DNA or cells directly."

"Studies of animals exposed to ELF-EMFs have not provided any indications that ELF-EMF exposure is associated with cancer, and no mechanism has been identified by which such fields could cause cancer."

Health Canada, the Canadian national public health authority advises that

"There have been many studies on the possible health effects from exposure to EMFs at ELFs. While it is known that EMFs can cause weak electric currents to flow through the human body, the intensity of these currents is too low to cause any known health effects. Some studies have suggested a possible link between exposure to ELF magnetic fields and certain types of childhood cancer, but at present this association is not established."

"The International Agency for Research on Cancer (IARC) has classified ELF magnetic fields as "possibly carcinogenic to humans". The IARC classification of ELF magnetic fields reflects the fact that some limited evidence exists that ELF magnetic fields might be a risk factor for childhood leukemia. However, the vast majority of scientific research to date does not support a link between ELF magnetic field exposure and human cancers. At present, the evidence of a possible link between ELF magnetic field exposure and cancer risk is far from conclusive and more research is needed to clarify this "possible" link."

International Commission On Non-Ionizing Radiation Protection - 2010[13]

"It is the view of ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukemia is too weak to form the basis for exposure guidelines. In particular, if the relationship is not causal, then no benefit to health will accrue from reducing exposure."

FURTHER INFORMATION

ARPANSA EMF Fact sheets
Electricity and Health, Extremely Low Frequency Electric and Magnetic Fields.
See more at **www.arpansa.gov.au**

ENA, 2014, "Electric and Magnetic Fields – What We Know".

WHO EMF Fact sheets – About electromagnetic fields. See more at **www.who.int**

ICNIRP. See more at **www.icnirp.org**

U.S. National Cancer Institute. See more at **www.cancer.gov**

Health Canada. See more at **healthycanadians.gc.ca**

12 WHO What are electromagnetic fields? www.who.int

13 2010 International Commission on Non Ionizing Radiation Protection, Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz - 100 kHz). Health Physics 99(6):818-836

5. EMF GUIDELINES AND EXPOSURE LIMITS

THE TWO INTERNATIONALLY RECOGNISED EXPOSURE GUIDELINES ARE ICNIRP AND IEEE.

» International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2010.

» International Committee on Electromagnetic Safety, Institute of Electrical and Electronics Engineers (IEEE) in the USA 2002.

ARPANSA's advice[14] is *"The ICNIRP ELF guidelines are consistent with ARPANSA's understanding of the scientific basis for the protection of people from exposure to ELF EMF."*

Whilst ARPANSA directly references ICNIRP 2010 as a guideline for exposure, the IEEE guideline provides an alternate set of guideline limits applicable to electric and magnetic field exposure. These provide a technically sound reference which could be applied to specialised exposure environments and different parts of the human body. Such situations could include live line and bare hand maintenance methods on distribution, transmission and substation assets for example.

The WHO (2007) advises:

> "Health effects related to short-term, high-level exposure have been established and form the basis of two international exposure limit guidelines (ICNIRP, 1998; IEEE, 2002). At present, these bodies consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits."

> "…..it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."

The above exposure guidelines express limits in terms of Basic Restrictions and Reference Levels for both magnetic field and electric fields under General Public and Occupational exposure conditions. For both Basic Restrictions and Reference Levels the limits are instantaneous and there is no time averaging.

Magnetic field exposure limits are intended to prevent the occurrence of synaptic effects perceived as magneto-phosphenes in the sensitive retinal tissue. While this phenomenon is not itself considered an adverse health effect, it is related to synaptic effects in specialised neural tissue, and since similar effects could possibly occur elsewhere in the central nervous system, particularly the brain, expert groups have advised that exposure involving the head should be below this level.

Electric field exposure limits are intended to protect against synaptic effects (ICNIRP) and micro-shocks (IEEE). Micro-shocks may involve a spark discharge that occurs either immediately before making contact with a grounded conductor, or when a grounded person touches a charged isolated conductor. The public exposure level is similar to that experienced from spark discharges when touching, for example, a door handle after acquiring static from crossing a carpet or getting out of a car seat.

Occupational exposure is defined as follows:

ICNIRP 2010:

> "Occupational exposure in these guidelines refers to adults exposed to time-varying electric, and magnetic fields from 1 Hz to 10 MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job activities. By contrast, the term general population refers to individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities. In many cases, members of the public are unaware of their exposure to EMF. These considerations underlie the adoption of more stringent exposure restrictions for the public than for workers while they are occupationally exposed."

14 ARPANSA, Extremely low frequency electric and magnetic fields www.arpansa.gov.au

IEEE 2002:

"An area that is accessible to those who are aware of the potential for exposure as a concomitant of employment, to individuals cognizant of exposure and potential adverse effects, or where exposure is the incidental result of passage through areas posted with warnings, or where the environment is not accessible to the general public and those individuals having access are aware of the potential for adverse effects."

Basic restrictions

Basic restrictions are the fundamental limits on exposure and are based on the internal electric currents or fields that cause established biological effects. The basic restrictions are given in terms of the electric fields and currents induced in the body by the external fields. If Basic Restrictions are not exceeded, there will be protection against the established biological effects.

The Basic Restrictions include safety factors to ensure that, even in extreme circumstances, the thresholds for these health effects are not reached. These safety factors also allow for uncertainties as to where these thresholds actually lie. The physical quantity used to specify the Basic Restrictions is the tissue induced electric field. The Basic Restrictions relating to 50Hz are shown in Table 5-1.

Reference Levels

The Basic Restrictions in the ICNIRP and IEEE Guidelines are specified through quantities that are often difficult and, in many cases, impractical to measure. Therefore, Reference Levels of exposure to the external fields, which are simpler to measure, are provided as an alternative means of showing compliance with the Basic Restrictions. The Reference Levels have been conservatively formulated such that compliance with the Reference Levels will ensure compliance with the Basic Restrictions. If measured exposures are higher than Reference Levels then a more detailed analysis would be necessary to demonstrate compliance with the Basic Restrictions.

Table 5-2 and Table 5-3 specify the Reference Levels for exposure to magnetic fields and electric fields respectively at 50 Hz.

5.1 SUMMARY OF BASIC RESTRICTIONS

The following table summaries the basic restrictions for IEEE and ICNIRP.

TABLE 5-1 BASIC RESTRICTIONS AT 50HZ FOR IEEE AND ICNIRP.

	IEEE 2002	ICNIRP2010
GENERAL PUBLIC		
Exposure to head	0.0147 V/m	0.02 V/m
Exposure elsewhere	0.943 V/m (heart) 2.10 V/m (hands, wrists, feet) 0.701 V/m (other tissue)	0.4 V/m (rest of body)
OCCUPATIONAL		
Exposure to head	0.0443 V/m	0.1 V/m
Exposure to rest of body	0.943 V/m (heart) 2.10 V/m (hands, wrists, feet, other tissue)	0.8 V/m (rest of body)

5.2 SUMMARY OF REFERENCE LEVELS

The following tables summarise the magnetic field exposure Reference Levels for IEEE and ICNIRP.

TABLE 5-2 MAGNETIC FIELD REFERENCE LEVELS AT 50HZ FOR IEEE AND ICNIRP.

	IEEE 2002	ICNIRP 2010
GENERAL PUBLIC		
Exposure general	Not specified	200 µT*
Exposure to head and torso	904 µT	Not specified
Exposure to arms and legs	75,800 µT	Not specified
OCCUPATIONAL		
Exposure general	Not specified	1,000 uT*
Exposure to head and torso	2,710 µT	Not specified
Exposure to arms and legs	75,800 µT	Not specified

* ICNIRP advises that it is reasonable in certain circumstances for workers to experience transient effects such as magneto-phosphenes and possible minor changes in some brain functions, since they are not believed to result in long-term or pathological health effects. Exposure of all parts of the body in these circumstances should be limited in order to avoid peripheral and central myelinated nerve stimulation[15]. In this regard the EU Directive 2013/35/EU[16] includes low action levels (ICNIRP levels) and high action levels of 6,000µT and 18,000µT (limbs). Action levels can be exceeded if certain measures are in place such as assessments, action plans and access to information. The measures required depend on the level.

15 ICNIRP 2010 guidelines for limiting exposure to time-varying Electric and magnetic fields (1 hz to 100 khz)

16 The EU Directive 2013 has "exposure limits values" (ELV, the internal quantity, equivalent to ICNIRP's "basic restriction") and "action levels" (the external field, equivalent to ICNIRP's "reference level"). It has two sets of each: the "health" ELV and corresponding "high" action level, and the "sensory" ELV and corresponding "low" action level.

The following table summarises the electric field Reference Levels for relevant Australian and international exposure guidelines.

TABLE 5-3 ELECTRIC FIELD REFERENCE LEVELS AT 50HZ FOR IEEE AND ICNIRP

	IEEE 2002	ICNIRP 2010
GENERAL PUBLIC		
Exposure	5 kV/m 10kV /m (within right of way)	5 kV/m
OCCUPATIONAL		
Exposure	10 kV/m 20kV /m (within right of way)	10 kV/m

FURTHER INFORMATION

ICNIRP Guidelines – 2010 – For Limiting Exposure to Time – Varying Electric and Magnetic Fields
(1 HZ – 100 KHZ).
See more at **www.icnirp.org**

IEEE C95.6™-2002 – Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz - See more at: **www.ices-emfsafety.org/**

Wood, AW, 2008, Extremely low frequency (ELF) Electric and Magnetic Fields Exposure Limits: Rationale for Basic Restrictions used in the Development of an Australian Standard. Bioelectromagnetics 2008, 1-15

6. ASSESSING COMPLIANCE WITH EXPOSURE LIMITS

ENA's policy includes designing and operating electricity generation, transmission and distribution systems in compliance with relevant Australian exposure guidelines and consistent with the concept of Prudent Avoidance. Relevant Australian and international health guidelines are discussed in Section 5.

The concept of prudent avoidance is discussed in Section 7.

In general, electric and magnetic fields from electricity assets will be well below the Reference Levels in these guidelines and specific compliance assessments will not be required. Exceptions could include specific occupational activities in close proximity to assets such as very highly loaded conductors, air cored reactors or air cored transformers. For this reason, the rest of this section focuses on occupational exposure.

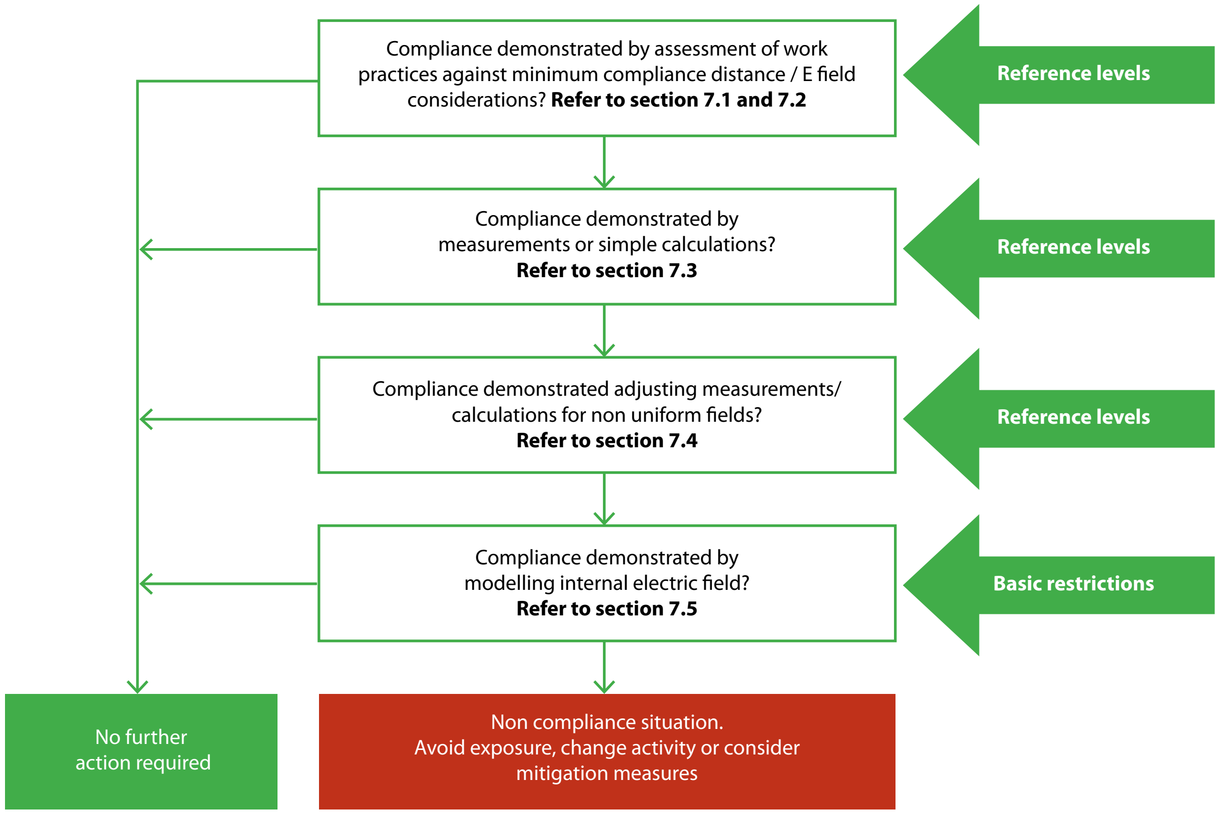
A compliance assessment can be used to demonstrate compliance with relevant Australian and international guidelines and, in particular, the Reference Levels or Basic Restrictions.

Where an assessment is required, it could be in the form of:

- review of work practices against minimum compliance distances,
- measurements or simple calculations or modelling to demonstrate compliance against the Reference Levels, or
- modelling to demonstrate compliance against the Basic Restrictions.

The overall process for a compliance assessment is shown in Figure 6-1.

FIGURE 6.1 PROCESS FOR ASSESSING COMPLIANCE WITH EXPOSURE LIMITS



6.1 MAGNETIC FIELD SOURCES – MINIMUM COMPLIANCE DISTANCES

The methodology in Section 6.1 and Section 6.2 is taken from BS EN 50499:2008 – Procedure for the assessment of the exposure of workers to electromagnetic fields.

Conductors

Compliance with Reference Levels (see Section 5.2) can be demonstrated by showing that people are at a distance larger than the minimum compliance distance as shown in Table 6-1. The minimum distance is calculated by the following equation:

Dmin = 2 I / BLim where D is the distance in metres, I is the current in Amps and BLim is the exposure limit in microtesla.

The above approach can be conservatively applied to three phase circuits, bundled circuits and multiple circuits. Where there are multiple circuits and the separation of conductors is small, an assessment of the net current can be used.

WORKED EXAMPLE:

An assessment is undertaken to determine the compliance distance to a three phase cable in relation to the ICNIRP occupational exposure limit. The exposure limit for occupational exposure is 1,000 µT (ICNIRP 2010).

It can be seen from Table 6-1 that a current of 1,000A corresponds with a minimum compliance distance of 0.2m from the centre of the single conductor for BLim = 1,000 µT. As stated above, this is a conservative calculation for 3 phase cables.

Therefore exposure to any three phase cable (or single conductor) carrying up to 1,000A is intrinsically compliant with the ICNIRP exposure limit of 1,000 µTregardless of distance to the source.

Where the minimum compliance distances in Table 6-1 cannot be maintained, the following could be considered:

1. Apply mitigation measures to reduce exposure (see Section 9),
2. Change work practices to allow for the use of an alternative Reference Level (see Section 5.2) or
3. Undertake further detailed assessment (see Figure 6-1).

TABLE 6-1 MINIMUM COMPLIANCE DISTANCE TO THE CENTRE OF A SINGLE CONDUCTOR (ICNIRP REFERENCE LEVELS).

Current in conductor A	Distance to exposure limit (BLim = 200µT) m	Distance to exposure limit (BLim = 1,000µT) m
100	0.1 (Compliant*)	0.02 (Compliant*)
200	0.2 (Compliant*)	0.04 (Compliant*)
500	0.5	0.1 (Compliant*)
1,000	1.0	0.2 (Compliant*)
1,500	1.5	0.3
2,000	2.0	0.4
2,500	2.5	0.5
5,000	5.0	1.0

* For distances closer than 0.2m, BS EN 50499:2008 (with BLim = 500 µT) states:

Closer to the conductor, considerations relating to the non-uniformity of the field (see EN 62226-1), the diameter of conductor necessary to carry the current and numerical computation of induced current density in the body for uniform field (Dimbylow, 2005), have the consequence that for currents up to 500 A the exposure limit will always be complied with however close together the body and conductor are.

Note: The IEEE 2002 Standard has Reference Levels of 904 µT (public) and 2,710 µT (occupational) and a limit of 75,800 µTfor limbs. Minimum compliance distances for these Reference Levels are not shown in the table above. See Section 5 for more information on exposure limits.

Equipment

Very few pieces of equipment can produce magnetic fields in excess of the Reference Levels at a distance of 0.2m or more. Such items could include air cored transformers or reactors. Items where this is likely to happen will need to be assessed by calculations, measurements or modelling.

Conventional iron-cored devices have low external magnetic field leakage which will not normally be sufficient to exceed the Reference Levels.

6.2 ELECTRIC FIELD SOURCES - CONSIDERATIONS

Overhead bare conductors with a voltage over 200kV, may under some circumstances produce an electric field in excess of the Reference Levels. This is particularly the case for live line workers in close proximity to the very high voltage conductors.

Such situations are typically managed with Faraday suits (occupational exposure) and the provision of information, earthing, and screening (public exposure).

The management of these situations will depend on the construction, geography and nature of exposure and specific rules cannot be prescribed in this Handbook.

FIGURE 6.2 EMF METER

6.3 CALCULATIONS OR MEASUREMENTS OF EXTERNAL FIELDS

Calculations or measurements to demonstrate compliance with guidelines should be made by an appropriately qualified and experienced person or authority.

Calculations are the preferred method of assessment for situations involving simple elements such as powerlines. Calculations have the advantage of enabling the assessor to define and control input variables and to assess a range of loading conditions rather than being limited to the particular conditions at the time.

Measurements can be useful for assessing complex situations such as those associated with live line work, cable pits and LV boards. In these cases, extrapolation may be required to take account of the maximum potential load of the circuits.

For an overhead line the minimum design clearances should be used.

Further information about measuring EMF is contained in Appendix 3.

6.3.1 Loading conditions for exposure assessment calculations

The loading used for calculations in the context of compliance with occupational guideline exposure limits should be the worst case over the foreseeable life of the asset. In most cases this will require use of the short term emergency loading. Measurements should be extrapolated to this loading, although certain assumptions and specialist knowledge may be required where there is complex or multiple sources.

More information on electrical loading is provided in Appendix 4.

6.3.2 Exposure limit reference point

Where the field is considered to be generally uniform, the electric or magnetic field level at the point of interest should be measured at 1 m above the ground. This is a generally accepted practice and is supported by standards such as IEEE, 2010, IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz.

Where exposure occurs in very close proximity to high current, non-uniform/complex fields, the reference point should be in those areas reasonably accessible. Such situations may include live-line work, high power testing, or work in cable pits/ basements and tunnels.

In these cases, 'reasonably accessible' should take into account factors such as working procedures, barriers, and any specific factors relevant to the assessment. In most cases a distance of 0.2m from the source within the area of exposure is a conservative approach for performing measurements/calculations (see Section 6.1).

For many occupational activities, placing the meter in the chest or waist pockets is considered a practical, efficient, and reliable means of estimating maximum magnetic-field exposures in electric utility environments.

6.4 ADJUSTMENTS FOR HIGHLY LOCALISED NON-UNIFORM FIELDS

Where the maximum calculated or measured fields exceed the Reference Levels and the fields are highly localised, the following methods could be considered to assess compliance.

1. Monitor using a spatial averaging meter (Section 6.4.1).
2. Applying the magnetic field induction factor (Section 6.4.2).

Where the results of these methods exceed the Reference Levels then modelling of the internal electric field could be considered (Section 6.5).

FIGURE 6.3 HOLADAY HI-3604 SURVEY METER

6.4.1 Spatially averaging meter

The Holaday HI-3604 is one of the commercially available magnetic field meters which has a sensing coil with a diameter of 16.5cm (radius 8.25 cm), which is about the same diameter as the head.

The Holaday HI-3604 has been shown to provide a very good correspondence between its measured magnetic field and the induced electric field from a single phase cable for head exposure. As such the Holaday meter provides a very good surrogate for induced electric field compliance for single cables, but may slightly underestimate compliance distances for cable bundles with balanced current.[17]

Note that the magnetic sensor coil inside the Holaday HI 3604 is a single axis coil and is around 2cm from the nearest edge of the paddle. These factors should be taken into account when making measurements.

6.4.2 Magnetic field induction factor method

Maximum exposure measurements in non-uniform fields are higher than their equivalent uniform field exposures. Where measurements or calculations exceed the Reference Levels, the following approach may be applied.

Note: this method is not suitable when undertaking measurements using the Holaday meter.

However, before adopting this approach, the work environment in question should be surveyed to demonstrate that they can, in fact, be characterized by fields that decrease inversely with the distance or more rapidly. Where there are multiple conductors (such as a cable pit) the environment can generally be categorised by fields that decrease inversely with the distance or faster provided that the cable diameters are greater than 3cm[18].

To determine compliance using this technique, it is necessary to calculate the equivalent uniform magnetic field and compare this against the relevant Reference Level.

The equivalent uniform magnetic field that produces the same peak magnetic field as a non-uniform field with a known maximum field can be derived using induction factors[19].

17 Anderson, V, 2009, B field compliance for 50 Hz live line work, Swinburne University, 2 September 2009

18 Anderson, V, 2009, B field compliance for 50 Hz live line work, Swinburne University, 2 September 2009

19 Bracken, TD, and Dawson, T, 2004, Evaluation of Non-uniform 60 Hz Magnetic-Field Exposures for Compliance with Guidelines, J Occ Envir Hyg, 1, 629 – 638

The derivation requires the following information:

1. maximum measured/calculated exposure (MF),
2. distance from the assumed line source where the maximum exposure occurs (d),
3. relevant normalised induction factor F(d) based on distance from a line source (see Figure 6.4), and
4. relevant Reference Level (RL) (see Section 5.2).

To calculate the Equivalent Uniform Field, multiply the maximum exposure (MF) by the Normalised Induction Factor F(d) (see Figure 6.4). This can then be compared against the relevant Reference Level (RL).

Compliance is achieved if the following holds true:

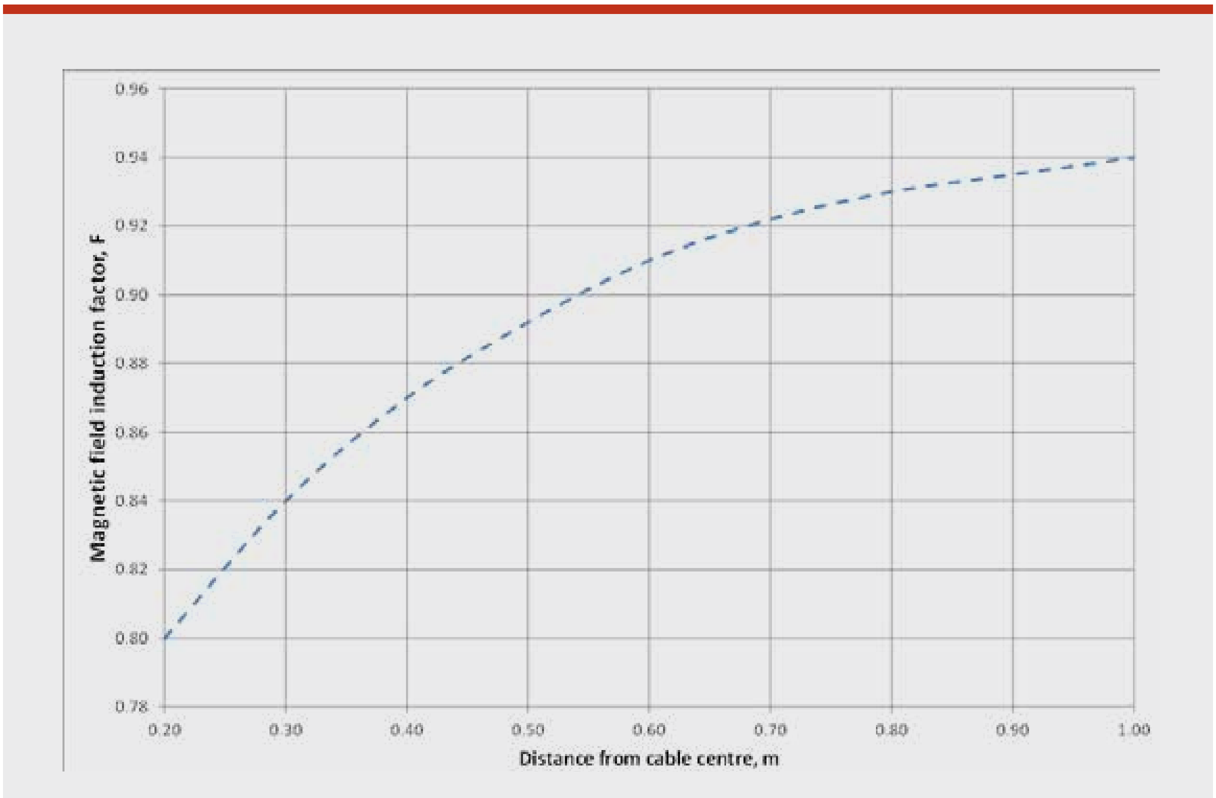
RL > MF x F(d)

As stated by Bracken and Dawson (2004):

> "Normalized induction factors referenced to surface maximum field represent a stable method for comparing non-uniform maximum fields at the surface of the body with field limits for uniform fields. Their use accurately incorporates a comparison of the peak induced electric field with the basic restriction."

The procedures developed here apply to non-uniform field exposures where the magnetic field decreases as the inverse of distance or more rapidly. Under these conditions the maximum fields at the surface of the body that will meet the basic restriction criteria of guidelines are greater than those for uniform field exposures.

FIGURE 6.4 NORMALISED INDUCTION FACTOR TO CALCULATE THE EQUIVALENT UNIFORM FIELD AFTER BRACKEN AND DAWSON (2004)



Ref: Bracken, TD, and Dawson T, 2004, Evaluation of Non-uniform 60 Hz Magnetic-Field Exposures for Compliance with Guidelines, J Occ Envir Hyg, 1, 629 – 638

> **WORKED EXAMPLE:**
>
> An activity requires the head to come within 30cm of a very highly loaded single core cable. Theoretical calculations show that the magnetic field (decreasing at 1/d) is 500 µTat 30cm from the cable. Using the magnetic field induction factor, it can be shown that the equivalent uniform field is 0.84 x 5,000 = 420 µT.

6.5 MODELLING INTERNAL ELECTRIC FIELD

Where measurements or simple calculations have been unable to establish compliance, approaches involving modelling of the internal electric field for comparison with the Basic Restriction could be considered.

If compliance is to be demonstrated by comparison with Basic Restrictions, the combined effect of both electric and magnetic external fields should be taken into account.

6.5.1 Simple modelling

Simple modelling calculations can be undertaken in accordance with appropriate IEC Standards, eg IEC 62226.

A comprehensive study using simple modelling has been performed by Anderson (2009) using the IEC 62226 Model. This has provided calculations of internal electric and magnetic field compliance distances for the configuration of a horizontal wire conductor or two balanced parallel wires and a vertical human body.

These results have been used to determine the compliant conditions and may be useful for determining compliance in other more specific situations.

6.5.2 Complex modelling

Where compliance cannot be demonstrated using measurements, calculations or simple modelling, compliance with the Basic Restrictions may need to be demonstrated via a complex modelling approach. Approaches could include complete numerical (voxel) models of appropriate representative body shapes. Advice from experts in this field should be sought. Papers using this approach have been published from various overseas research centres, for example the work of Peter Dimbylow at the UK Health Protection Agency.

Dosimetry modelling by Dimbylow (2005) has been used to calculate the external electric and magnetic fields required to exceed the ICNIRP 2010 Basic Restrictions (see Table 6-2).

FIGURE 6.5 SIMPLE MODELLING

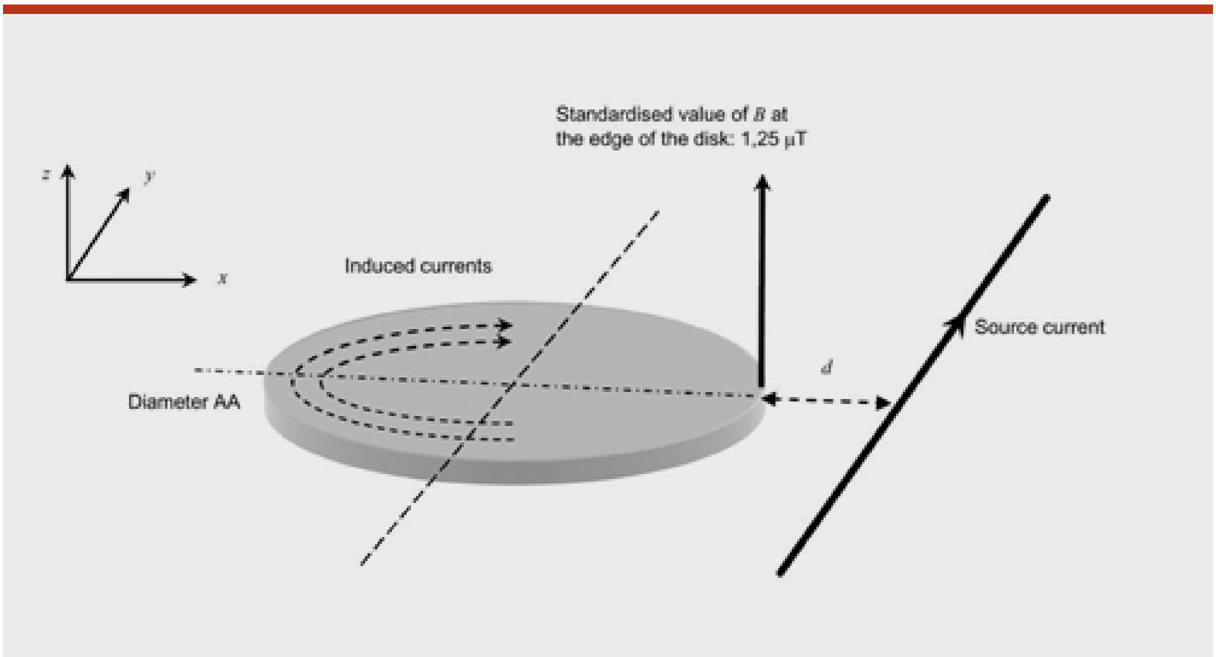


TABLE 6.2 DOSIMETRY FOR ICNIRP 2010 EXPOSURE GUIDELINES.

	ICNIRP Reference Level	Dosimetric modelling	
GENERAL PUBLIC		Dosimetric conversion factor	Calculated external field
Magnetic field	200 µT	33 mV/m / mT	606 µT
Electric field	5 kV/m	2.02 mV/m / kV/m	9.9 kV/m
OCCUPATIONAL			
Magnetic field	1,000 µT	33 mV/m / mT	3,030 µT
Electric field	10 kV/m	33.1 mV/m / kV/m	24.2 kV/m

While the Dimbylow modelling confirms that the INCIRP Reference Levels are indeed conservatively formulated, the first step should always be to demonstrate compliance with the exposure limits by conventional means and where practicable, manage exposure by engineering or administrative controls. When compliance with the exposure limits cannot be demonstrated by conventional calculations and measurements means, then the Dimbylow method could be considered.

FURTHER INFORMATION

Anderson, V, 2009, B field compliance for 50 Hz live line work, Swinburne University, 2 September 2009

ARPANSA EMF Fact sheet - Measuring Magnetic Fields. See more at www.arpansa.gov.au

Bracken, TD, and Dawson, T, 2004, Evaluation of Non-uniform 60 Hz Magnetic-Field Exposures for Compliance with Guidelines, J Occ Envir Hyg, 1, 629 – 638

BS EN 50499:2008 – Procedure for the assessment of the exposure of workers to electromagnetic fields

Dawson, TW, Caputa, K and Stuchley, MA, 1999, Numerical evaluation of 60 Hz magnetic induction in the human body in complex occupational environments. Phys Med Biol, 44, 1025-1040

Dawson, TW, Caputa, K and Stuchley, MA, 2002, Magnetic field exposures for UK live-line workers. Phys Med Biol, 47, 995-1012

Dimbylow, P and Findlay, R, 2009, The effects of body posture, anatomy, age and pregnancy on the calculation of induced current densities at 50 Hz, Rad Prot Dos, advanced access published 23 December 2009

Dimbylow, P, 2005, Development of pregnant female voxel phantom, NAOMI< and its application to calculations of induced current densities and electric fields from applied low frequency magnetic and electric fields, Phys Med Biol 50 1047-1070

Dimbylow, P, 2006, Development of pregnant female, hybrid voxel-mathematical models and their application to the dosimetry of applied magnetic and electric fields at 50Hz. Phys Med Biol 51, 2383-2394

IEEE C95.3.1™-2010 – Measurements & Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz - See more at: http://standards.ICES.org/

UK Department of Energy and Climate Change - 2012 - Power Lines: Demonstrating compliance with EMF public exposure guidelines - A voluntary Code of Practice – See more at www.gov.uk

IEC 62226-2-1, Exposure to electric and magnetic fields in the low to intermediate frequency range-Methods for calculating current density and internal electric fields in the human body. Part 2-1 Exposure to magnetic fields - 2D models.

IEC 61786, Measurement of low frequency magnetic and electric fields with regard to exposure to human beings – special requirements for instruments and guidance for measurements.

IEC 62110 Electric and magnetic field levels generated by AC power systems - Measurement procedures with regard to public exposure.

IEC 62311, Assessment of electronic and electrical equipment related to human exposure for electromagnetic fields (0-300Ghz)

7. PRUDENT AVOIDANCE / PRECAUTION

SINCE THE LATE 1980S, MANY REVIEWS OF THE SCIENTIFIC LITERATURE HAVE BEEN PUBLISHED BY AUTHORITATIVE BODIES.

There have also been a number of Inquiries such as those by Sir Harry Gibbs in NSW[20] and Professor Hedley Peach in Victoria[21]. These reviews and inquiries have consistently found that:

- adverse health effects have not been established.
- the possibility cannot be ruled out.
- if there is a risk, it is more likely to be associated with the magnetic field than the electric field.

Both Sir Harry Gibbs and Professor Peach recommended a policy of prudent avoidance, which Sir Harry Gibbs described in the following terms:

> "…. [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …"

Prudent avoidance does not mean there is an established risk that needs to be avoided. It means that if there is uncertainty, then there are certain types of avoidance (no cost / very low cost measures) that could be prudent. These recommendations have been adopted by the ENA and other electricity transmission and distribution businesses.

7.1 ENA POSITION

The Energy Networks Association (ENA) is the peak national body for Australia's energy networks. ENA represents gas and electricity distribution, and electricity transmission businesses in Australia on a range of national energy policy issues.

ENA is committed to taking a leadership role on relevant environmental issues including power frequency EMFs. ENA and its members are committed to the health and safety of the community, including their own employees.

ENA's position is that adverse health effects from EMFs have not been established based on findings of science reviews conducted by credible authorities. ENA recognises that that some members of the public nonetheless continue to have concerns about EMFs and is committed to addressing it by the implementation of appropriate policies and practices.

ENA is committed to a responsible resolution of the issue where government, the community and the electricity supply industry have reached public policy consensus consistent with the science.

Policy statement

1. ENA recommends to its members that they design and operate their electricity generation, transmission and distribution systems in compliance with recognised international EMF exposure guidelines and to continue following an approach consistent with the concept of prudent avoidance.
2. ENA will closely monitor engineering and scientific research, including reviews by scientific panels, policy and exposure guideline developments, and overseas policy development, especially with regard to the precautionary approach.
3. ENA will communicate with all stakeholders including assisting its members in conducting community and employee education programs, distributing information material including newsletters, brochures, booklets and the like, liaising with the media and responding to enquiries from members of the public.
4. ENA will cooperate with any bodies established by governments in Australia to investigate and report about power frequency electric and magnetic fields.

---

20 Gibbs, Sir Harry (1991). Inquiry into community needs and high voltage transmission line development. Report to the NSW Minister for Minerals and Energy. Sydney, NSW: Department of Minerals and Energy, February 1991.

21 Peach H.G., Bonwick W.J. and Wyse T. (1992). Report of the Panel on Electromagnetic Fields and Health to the Victorian Government (Peach Panel Report). Melbourne, Victoria: September, 1992. 2 volumes: Report; Appendices

7.2 PRECAUTION – WORLD HEALTH ORGANIZATION

In 2007, the WHO published their Extremely Low Frequency [ELF] Fields – Environmental Health Criteria Monograph No. 238. In relation to overall guidance to member states, WHO Organisation has addressed the notion of prudence or precaution on several occasions, including in its 2007 publication Extremely Low Frequency Fields, which states:

> "…..the use of precautionary approaches is warranted. However, it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."

It also states:

> "[E]lectric power brings obvious health, social and economic benefits, and precautionary approaches should not compromise these benefits. Furthermore, given both the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia, and the limited impact on public health if there is a link, the benefits of exposure reduction on health are unclear. Thus the costs of precautionary measures should be very low."

The Monograph further emphasises that "Even when allowing for the legitimate desire of society to err on the side of safety, it is likely that it will be difficult to justify more than very low-cost measures to reduce exposure to ELF fields."

In the implementation of precaution, care should be taken not to over-state the risk and unnecessarily raise concern. WHO advise that precaution measures "should not compromise the essential health, social and economic benefits of electric power".

For most practical purposes, very low cost precaution as defined by WHO is consistent with the industry's long standing policy of prudent avoidance.

7.3 SUMMARY OF PRUDENT AVOIDANCE / PRECAUTION PRINCIPLES

In summary, both prudent avoidance and the precautionary approach involve implementing no cost and very low cost measures that reduce exposure while not unduly compromising other issues.

The following key guiding principles can be applied to prudent avoidance / precaution in relation to EMF.

- Prudent avoidance / precaution involves monitoring research; reviewing policies in the light of the most up to date research findings (with particular emphasis on the findings of credible scientific review panels); providing awareness training for electricity supply business employees and keeping them informed and sharing information freely with the community.
- Measures to reduce exposure should be used if they can be implemented at 'no cost' or 'very low cost' and provided they do not unduly compromise other issues.
- Prudent avoidance / precaution does not operate in isolation but rather is one of many issues that need to be given due consideration in the design and operation of the electricity supply system.
- There is no reliable scientific basis for the adoption of arbitrary low exposure limits or setbacks or for a specific exposure level at which precaution should apply.
- Where exposure is consistent with typical background levels[22], the potential for further reductions is limited.
- Due to the large additional cost, undergrounding powerlines for reasons of EMF alone is clearly outside the scope of prudent avoidance / precaution.
- It cannot be said that the above measures will result in a demonstrable health benefit.

FURTHER INFORMATION

WHO What are electromagnetic fields.
See more at **www.who.int**

ENA EMF Policy. See more at
www.ena.asn.au

22 Typical values measured in areas away from electrical appliances are of the order of 0.01 – 0.2 uT (ARPANSA fact Sheet – Measuring Magnetic Fields).

8. IMPLEMENTING PRUDENT AVOIDANCE

ENA'S POLICY INCLUDES DESIGNING AND OPERATING ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION SYSTEMS IN COMPLIANCE WITH RELEVANT AUSTRALIAN GUIDELINES AND IN AN APPROACH CONSISTENT WITH PRUDENT AVOIDANCE.

No cost and very low cost measures that reduce exposure while not unduly compromising other issues should be adopted.

In most cases the application of prudent avoidance can be implemented on a project or incorporated into network standards without the need for a specific assessment. Specific assessments may be undertaken for major projects where a greater range of potential reduction options are available, or where specific investigations or environmental planning approval processes require such an assessment.

Where a specific assessment is required, the following guidance is provided to assist in that assessment.

This section assumes there will be compliance with the exposure limits (see Section 6).

8.1 GENERAL GUIDANCE ON APPLYING PRUDENT AVOIDANCE

The guidance below is provided to assist in evaluating prudent avoidance measures where a specific assessment or further guidance is required.

8.1.1 Potential locations of interest

From a practical perspective, the focus of public attention to EMF issues and therefore areas considered more relevant in a precautionary context would include schools, childcare centres, and other places where children congregate, homes and residential areas.

The specific case of people with medical implants is dealt with in Section 10.

8.1.2 Exposure assessment

Determining actual exposure is complicated as magnetic fields from electrical infrastructure change in accordance with daily and seasonal loading profiles. Further, there may be multiple sources, sources change over time, and people are not stationary. Fortunately such a detailed assessment is not necessary for a prudent avoidance assessment.

Where there are existing magnetic fields of random orientation (such as appliances, ground currents, household wiring etc.) the largest source will dominate the result. This is because fields are vectors and it is not a simple matter of adding the fields. Further the application of prudent avoidance involves assessing exposure from what is proposed. For these reasons it is normal practice for such an assessment to ignore these other sources.

The focus of an exposure assessment in the context of prudent avoidance is on determining magnetic field exposure sufficient to be able to determine whether there are no cost and very low cost measures that reduce exposure while not unduly compromising other issues. This can often be achieved without the need for complex calculations and, in many cases, without calculations at all.

Loading conditions for prudent avoidance calculations

Where specific calculations are required the following guidance is provided.

With prudent avoidance assessments, which address the ability to reduce fields with no cost or very low cost measures, the reduction in exposure arising from potential measures is more relevant than the highest predicted magnetic fields (as would be the case for exposure limit assessments).

According to WHO (Ref 3):

> "In the absence of a known biophysical mechanism, which would yield a known etiologically relevant metric of exposure, the metric of choice used in most epidemiological studies has been the time-weighted average."

While loads of substations and powerlines will generally increase over time after commissioning, a conservative approach which takes into account daily and seasonal variations would be to calculate the time-weighted-average (TWA) over a complete year using loads shortly after commissioning and also in the year representing the maximum foreseeable projected TWA.

Where available loading information does not permit the calculation of TWA, it may be necessary to exercise judgement, based on the best available information to derive a typical load that will occur on a line for the largest portion of a year which represents at least a conservative approximation of TWA. This would not be the maximum possible load or seasonal maximum that would occur for only a small portion of the year.

More information on electrical loading is provided in Appendix 4.

Ground clearance for overhead lines

Where specific calculations are required the following guidance is provided.

A conservative estimate of ground clearance (or average conductor height) for prudent avoidance assessments would be to assume 2/3 of the calculated sag for a typical span under typical ambient conditions for the year representing the maximum foreseeable projected loads. There may be specific circumstances that justify alternative methods.

Prudent avoidance assessment reference points

When undertaking a prudent avoidance assessment, the primary reference points for calculations should be those areas where people, especially children, spend prolonged periods of time. As the epidemiological studies typically use exposure within the home (often a child's bedroom), and in the absence of data suggesting otherwise, a conservative approach for residential areas is to select the reference point as being the nearest part of any habitable room from the source. There may be specific circumstances that justify alternative methods.

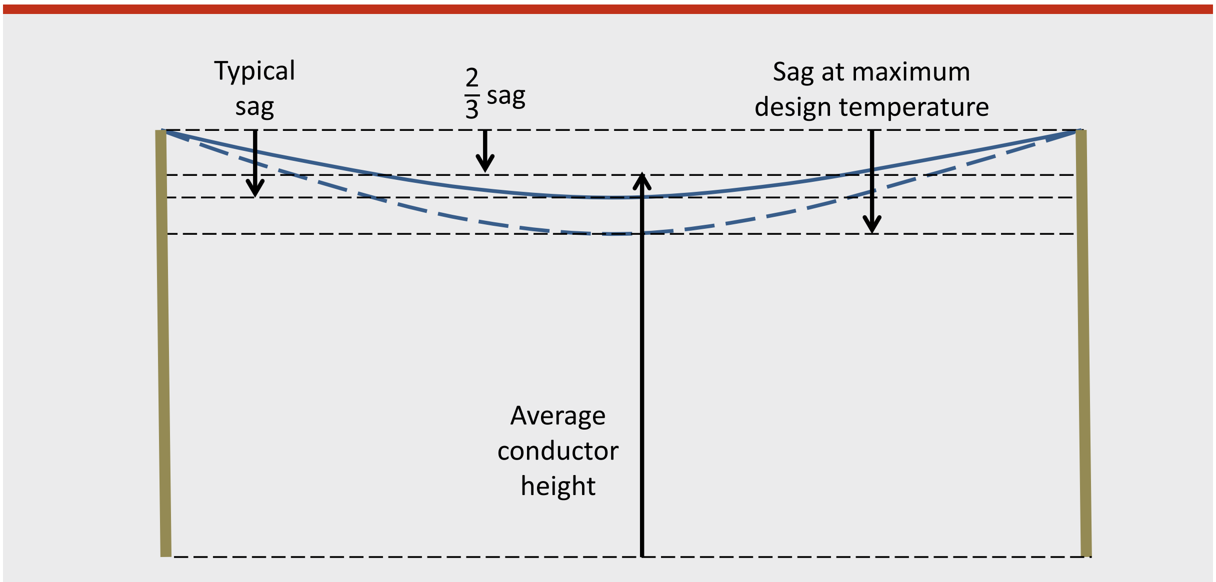
It is important not to over complicate the assessment or lose sight of the purpose – which is to determine no cost and very low cost measures that reduce exposure while not unduly compromising other issues.

The exception to this is non compliance with exposure limits (see Section 6). If the average exposure is less than or equal to typical background magnetic field levels, no further assessment is required.

8.1.3 Possible ways to reduce exposure

Exposure reduction can involve siting measures, which result in increased separation from sources and/or field reduction measures. Methods for mitigating magnetic fields are described in Section 9.

FIGURE 8.1 AVERAGE CONDUCTOR HEIGHT CALCULATIONS



8.1.4 Consideration of other issues

Measures to reduce magnetic field exposure must be considered against numerous other objectives and constraints of the project including:

- worker safety,
- the location of the power source and the load to be supplied,
- availability of suitable sites,
- ease of construction and access,
- reliability,
- cost (prudent avoidance / precautionary measures should be no cost / very low cost),
- conductor heating,
- the nature of the terrain,
- maintenance requirements,
- visual amenity,
- provision for future development,
- legal requirements, and
- environmental impacts.

The goal of any project is to achieve the best balance of all of the project's objectives, taking into account relevant social, technical, financial and environmental considerations.

8.1.5 Cost-benefit analysis

Sir Harry Gibbs and Professor Peach recommended a policy of prudence or prudent avoidance, which Sir Harry Gibbs described in the following terms:

> "…. [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …"

The WHO, in its Environmental Health Criteria monograph on EMF, advises that:

> "Provided that the health, social and economic benefits are not compromised, implementing very low cost precautionary procedures to reduce exposure is reasonable and warranted' [WHO 2007]."

If the available mitigation measures cannot be implemented at no cost or very low cost then no further action is required.

No cost and very low cost measures that reduce exposure while not unduly compromising other issues should be adopted.

Worked examples are shown in Appendix 2.

FURTHER INFORMATION

TNSP Operational Line Ratings - March 2009

UK Department of Energy and Climate Change - 2012 - Optimum Phasing of high voltage double-circuit Power Lines A voluntary Code of Practice – See more at **www.gov.uk**

9. METHODS TO MITIGATE MAGNETIC FIELDS

This section describes options for mitigating magnetic fields from both powerlines and substations. Whether such measures fall within prudent avoidance would depend upon their effectiveness, the project objectives and constraints, the cost to implement and ultimately, the project specific circumstances (see Section 7).

The mitigation measures described in this section are summarised in Appendix 1 to provide an overview of options that may be available for consideration.

There are several approaches that could be considered to mitigate magnetic fields from electrical infrastructure. The following three generic measures are generally the most practicable:

- Increasing the distance from source.
- Modifying the physical arrangement of the source:
- reducing the conductor spacing,
- rearranging equipment layout and equipment orientation, and
- for low voltage, bundling the neutral conductor with other phases
- Modifying the load:
- optimally phasing and balancing circuits,
- optimally configuring downstream loads,
- applying demand management, and
- for low voltage, balancing phases and minimise residual currents.

Additional measures which are less likely to satisfy the cost and convenience criteria which apply to precautionary measures but may be considered include:

- Incorporating a suitable shielding barrier between the source and the receiver.
- Active and Passive compensation.

9.1 OVERHEAD POWERLINES

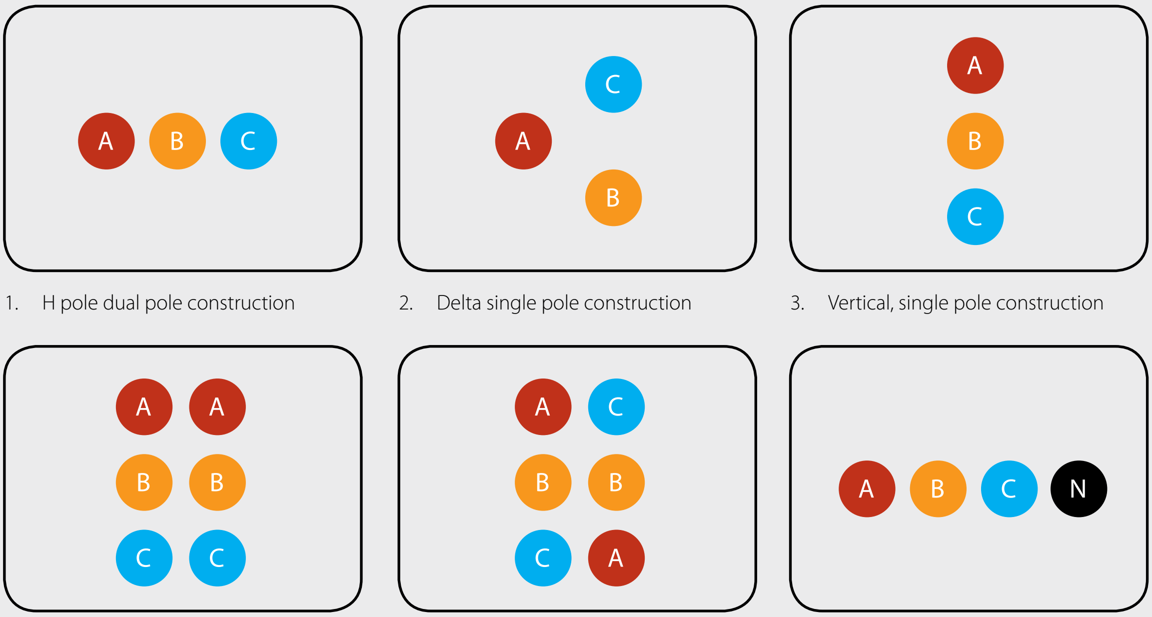
The calculations shown in this section are indicative only and based on 132kV configurations unless specified otherwise. Phase separation, conductor heights and other significant factors such as line load will vary depending on component suppliers and project specifics. The following construction types are referred to in the calculations.

9.1.1 Distance

Where the line is to be sited in a road reserve, consideration can be given to selecting sides of the road which are less populated or utilising existing easements. Deviations in the route will need careful consideration of project cost and project constraints and objectives.

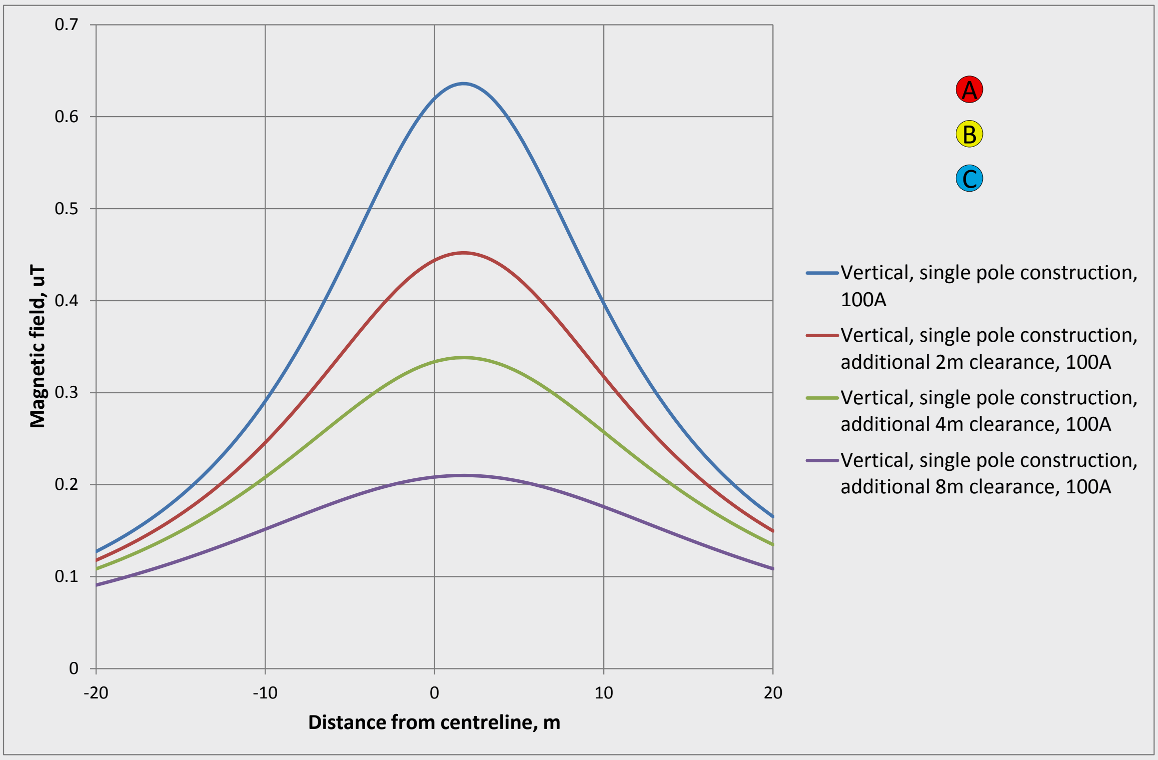
Raising the height of supporting structures or towers will generally reduce the magnetic field strength directly under the line as a result of increased distance from the ground. However, the benefit of this measure is reduced with distance from the powerlines. This effect is shown in Figure 10-2. The increased cost, maintenance and visual presence associated with the increased structure height may limit this technique. In some cases, raising the height may increase the field at some locations.

FIGURE 9.1 DIFFERENT OVERHEAD CONSTRUCTION CONFIGURATIONS



1. H pole dual pole construction
2. Delta single pole construction
3. Vertical, single pole construction
4. Double circuit construction, same phasing
5. Double circuit construction, reverse phasing (transposed) Spilt phasing
6. Low voltage (415V) construction

FIGURE 9.2 EFFECT OF RAISING THE CONDUCTOR HEIGHT



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

9.1.2 Conductor spacing

The magnetic field produced by a 3-phase powerlines is a result of the vector summation of magnetic fields produced by the electric current in the conductors. As the phases of the powerline are moved closer together, there is an increased cancellation effect due to the interaction between the magnetic fields produced by each phase current.

An excellent example of this is Aerial Bundled Conductor (ABC) where the insulated cables are twisted together and strung overhead.

There is a practical limit to the reduction in spacing that can be achieved for open wire or air-insulated construction, due to flashover and reliability considerations, and in some cases, the safe approach distance for live-line maintenance work. Further, for overhead lines above 200 kV, moving phases closer together can cause an increase in the electric field on the conductor surface which could lead to an increase in corona noise and possible noise complaints.

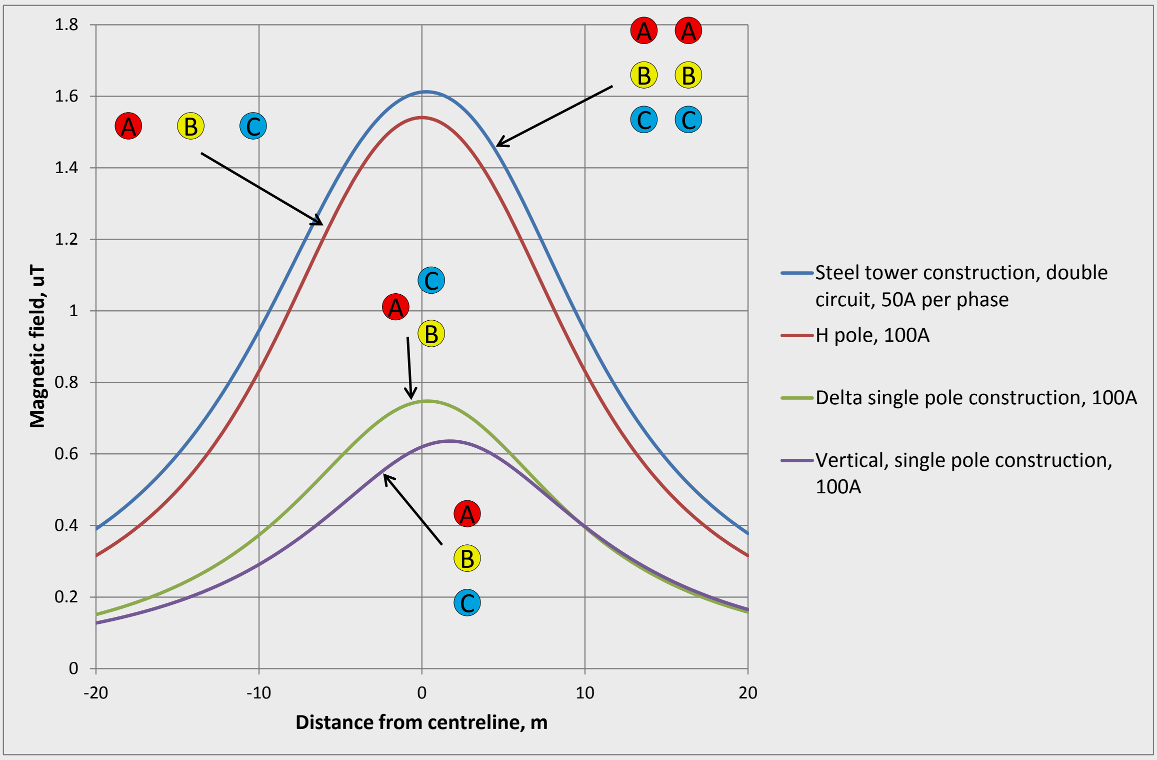
The effect of varying the conductor spacing is shown by comparing the magnetic field profiles from different open wire construction types. Steel tower construction typically has conductors further from the ground, but has large phase separations, resulting in a wider profile. Delta and vertical construction have the smallest phase separation resulting in narrower and smaller profiles (see Figure 9-3).

Delta construction generally produces the lowest fields at a distance from the powerline due to better cancellation effect.

Vertical construction generally produces the lowest fields directly below the powerline as it requires taller poles to maintain the minimum conductor-to-ground clearances.

Vertical construction can involve increased cost and increased visual presence (height) compared to delta construction. However, vertical construction can provide benefits where tree clearing needs to be minimised and in places where the road reserve is too narrow for delta construction.

FIGURE 9.3 MAGNETIC FIELD PROFILES FOR DIFFERENT OVERHEAD LINE CONFIGURATIONS AT 1M ABOVE GROUND LEVEL



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

Horizontal construction (H pole) produces higher fields than vertical or delta configurations due to all conductors being close to the ground.

9.1.3 Phase arrangement

For double circuit lines, it may be possible to arrange the phases to maximise the magnetic field cancellation.

A particular case of arranging the phases is the reverse phasing (low reactance) double circuit vertical configuration (see Figure 9-4).

The maximum effectiveness of this measure depends on the relative magnitude of the load current in each circuit, direction of load flow, and the relative angle shift between the circuit currents.

9.1.4 Split Phasing

Another application of field cancellation through phase configuration is 'split phasing' where a single circuit (three conductors in total) is constructed as two parallel circuits by splitting each phase into two conductors (six conductors in total). For maximum cancellation the conductors of one circuit are arranged in a reverse phased configuration in respect to the other circuit.

Split phasing typically has limited applications as it involves increased cost (larger poles, additional conductors, more components and in some cases wider easements) and increased physical and visual presence (i.e. height, width, potentially greater vegetation clearing, greater bulk of components and additional wires).

The effectiveness of this measure is shown in Figure 9.5.

9.1.5 Voltage, current and power

The magnetic field strength is directly proportional to the magnitude of the current flowing in the conductor. The higher the current is, the higher the magnetic field strength.

Higher voltage powerlines, which are normally used to transfer large amounts of power over large distances, can transfer the same amount of power with less current than a lower voltage powerline. As a result, for a similar power transfer, a powerline operating at a higher voltage will produce a lower magnetic field than a line operating at a lower voltage. It is a common misconception that higher voltage powerlines automatically equate to higher magnetic fields.

The choice of voltage is determined by network and other requirements.

9.1.6 Shielding

Shielding is the erection of a barrier between source and receiver to reduce the field strength at the receiver. Due to costs, it is unlikely that shielding will be consistent with a prudent avoidance / precautionary approach.

For all practical purposes there are no means to shield magnetic fields from overhead lines. In special applications, shielding of areas and individual pieces of equipment is possible using structures or enclosures made from special metals, however, these are expensive and limited in application.

9.1.7 Passive and active compensation

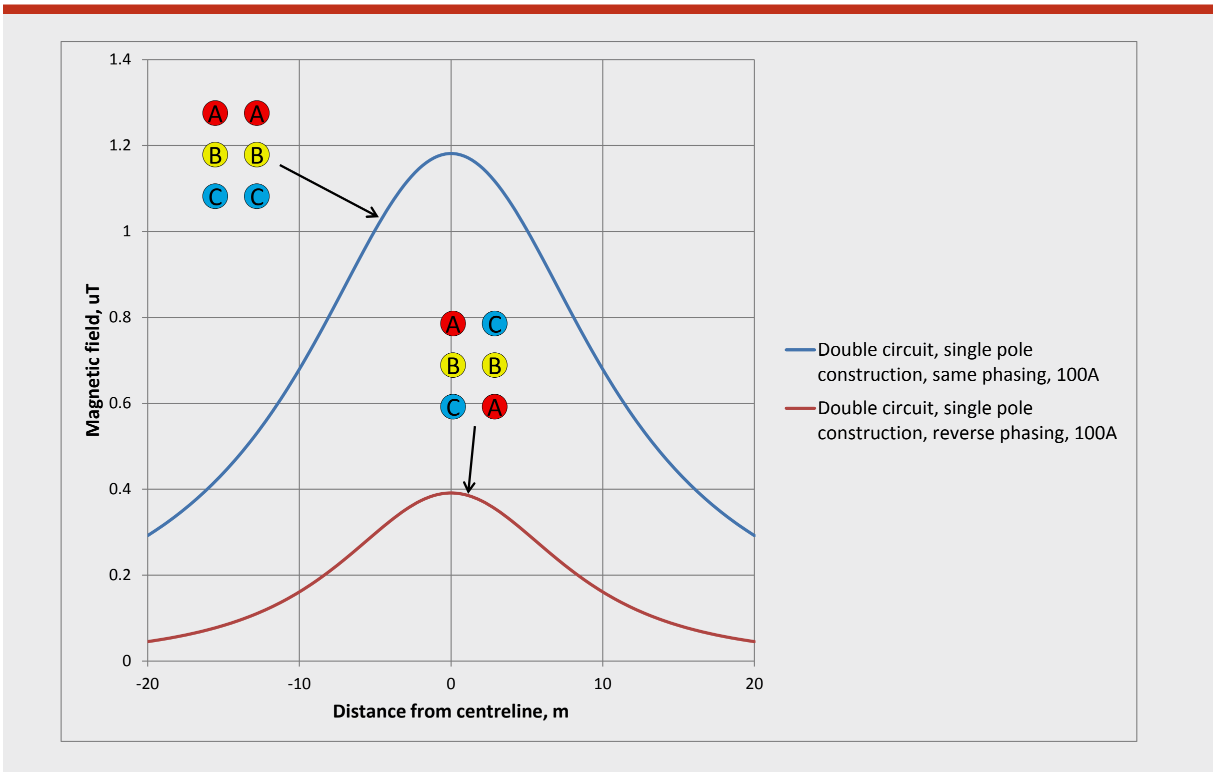
Passive compensation is based on the principle of using induction from a powerline in parallel wires which are either earthed or connected into an elongated loop. Due to the Faraday law of electromagnetic induction, a current is induced in these wires, and flows in the opposite direction to the direction of the current in the powerline. As a result, the magnetic field produced by the induced current opposes the magnetic field produced by the powerline, resulting in a net reduction.

In practice the achievable reduction from passive compensation is limited and restricted to a particular area. It is also possible that the field will be increased elsewhere. Other factors that need consideration include line losses, the possible need for capacitors and ongoing maintenance.

Active compensation is based on the same principle as passive compensation, but its effectiveness is enhanced by boosting the magnitude of the induced current by means of a separate power supply. By controlling the magnitude and phase angle of the current from the power supply, this method of EMF mitigation can provide improved, but more expensive, magnetic field compensation.

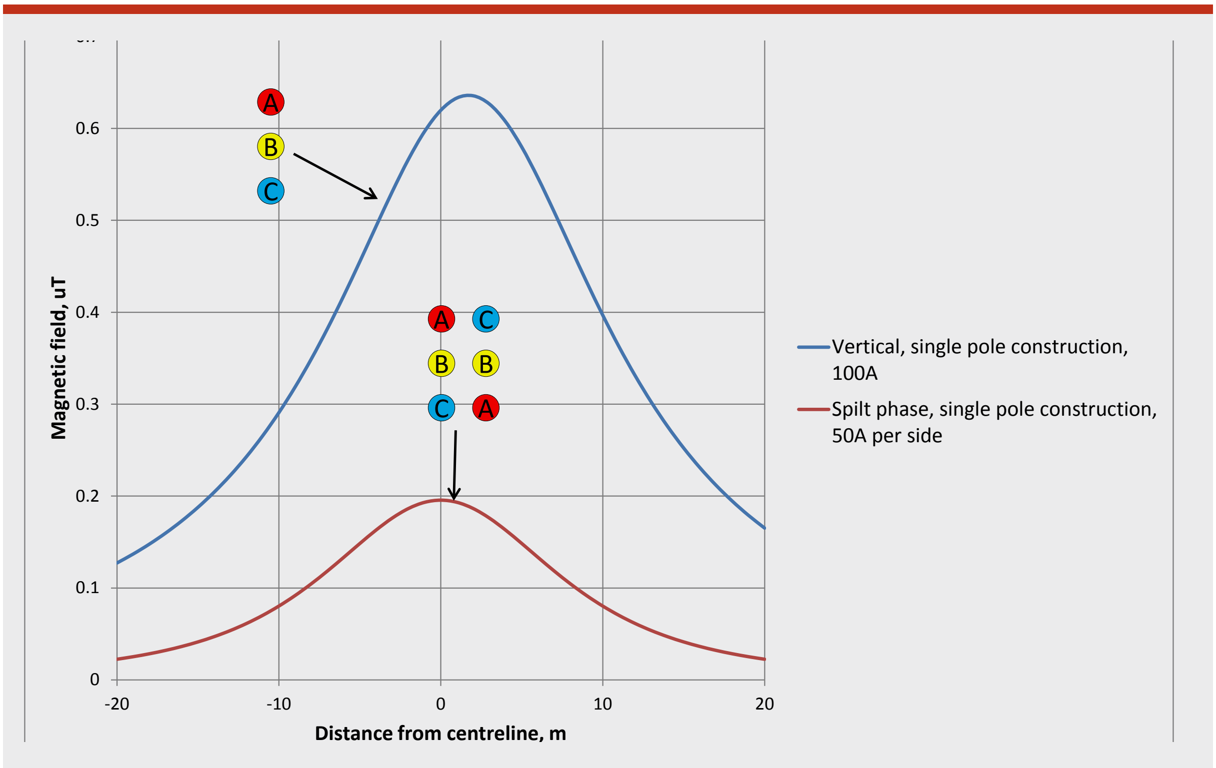
Due to cost, safety, operation, maintenance and visual amenity issues associated with the use of passive or active loops, other than in exceptional circumstances, it is unlikely that either of these two methods of EMF mitigation would satisfy the no cost / very low cost prudent avoidance / precaution criteria.

FIGURE 9.4 EFFECT OF PHASING ON A DOUBLE CIRCUIT LINE



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

FIGURE 9.5 EFFECT OF SPLIT PHASING



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

9.1.8 Undergrounding is not consistent with prudent avoidance

Because undergrounding is usually far more expensive than overhead construction, it is normally outside the scope of prudent avoidance / precaution in the context of an overhead powerline.

On the issue of undergrounding, the Gibbs Report specifically stated that, "because of its additional cost, undergrounding solely for the purpose of avoiding a possible risk to health should not be adopted"[23]. Undergrounding can result in higher magnetic fields directly above the cables.

The application of prudent avoidance / precaution for proposed underground cables is discussed in Section 9.2.

9.1.9 Distribution overhead lines

Generally, the reduction measures outlined above also apply to low voltage lines. In addition the following measures can be considered for low voltage lines to reduce the magnetic fields:

Bundle conductor configuration to significantly reduce the field profile (eg aerial bundled conductors - ABC) ABC can offer a significant reduction in the magnetic field compared to open wire construction. This is especially the case in locations on upper floors of buildings adjacent to the powerlines.

» A twisted bundled conductor will further reduce magnetic field.

» Place the neutral conductor with the phase conductors for insulated lines and cables.

» Minimise stray currents and residual currents by eliminating alternate paths for neutral current (magnetic fields from stray/residual currents decrease less rapidly than the fields from lines). Due to the use of multiple earth neutral (MEN) systems for neutral earthing, it is inevitable that some portion of the neutral current will flow through metallic water pipes and through neutrals of interconnected distributors. This will result in stray or residual current. (see Figure 9-6)

» Balance loads across all phases to reduce neutral currents (magnetic fields from unbalanced currents decreases less rapidly than the fields from lines with balanced currents). Unless harmonic currents are also suppressed, this measure might have limited success as some harmonic currents are returning to the source through the neutral.

» Avoid phase-by-phase grouping of single conductors in parallel circuits.

Predicting magnetic fields from low voltage lines is complicated by the fact that low voltage lines typically have harmonics, unbalanced loads and a residual (earth return) current. The residual current is a portion of the neutral current that is returning to the supply point via alternative paths such as remote earth or through some electrically conductive services including buried metallic pipes, metallic fences, rails, structural steel of buildings and sheaths of communication cables. These alternative return paths for the neutral current are part of the MEN system. Many appliances are also single phase and can have loads which are resistive, inductive or even capacitive. This means that the electrical angles between the three phase currents may not be equal to 120 degrees. Further, load from the low voltage lines decreases towards the end of the distributor as load is tapped off along its length. Noting the complexities above, example profiles for a low voltage line, balanced, unbalanced and unbalanced with a residual current are shown in Figure 9-6.

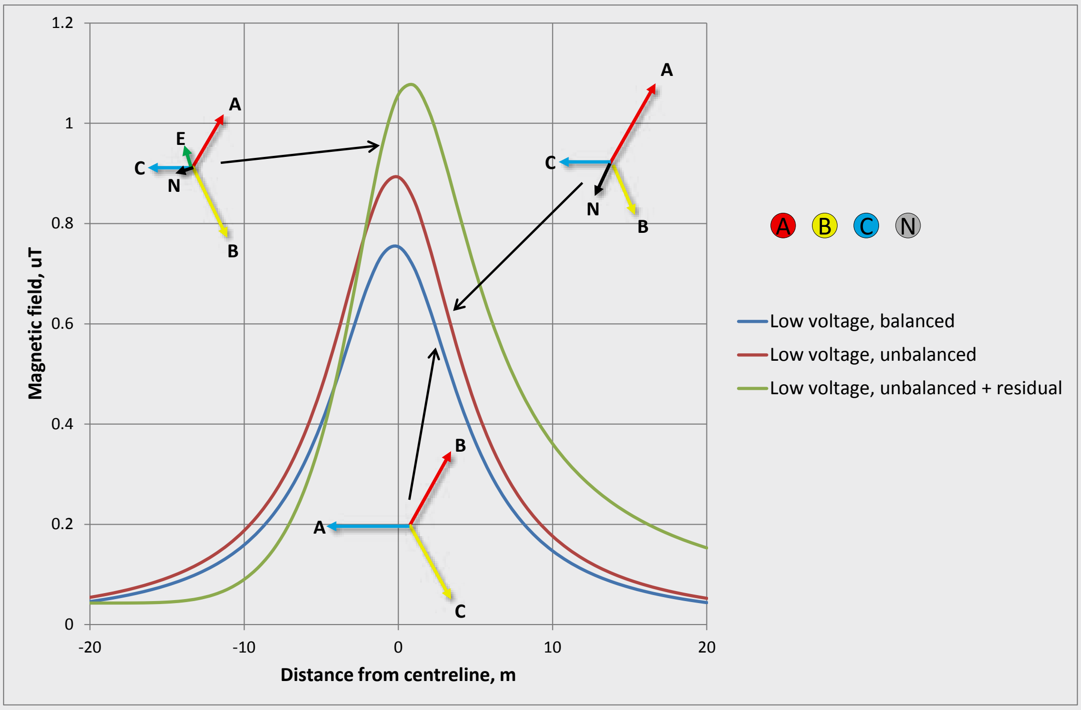
9.2 UNDERGROUND CABLES

The magnetic field directly above an underground cable is comparable to, and sometimes greater, than that from an equivalent overhead line. However, it drops off more rapidly with distance (see Figure 9-3 vs Figure 9-8).

While the magnetic field directly above the cables could be comparable or higher than for the overhead equivalent, due to the fact that cables are frequently located in roadways or footpaths, people's exposure is generally of short duration and transient in nature.

23 Gibbs, Sir Harry (1991). Inquiry into community needs and high voltage transmission line development. Report to the NSW Minister for Minerals and Energy. Sydney, NSW: Department of Minerals and Energy, February 1991

FIGURE 9.6 MAGNETIC FIELD PROFILES ASSOCIATED WITH LOW VOLTAGE CONSTRUCTION



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline, nature of the loading and earthing system. Calculations include only 50Hz currents and assume the electrical angles between the three phases are 120 degrees.

In the context of prudent avoidance / precaution, the options for further material reductions at the point of exposure are generally limited, but there may be some situations where additional measures can be justified.

The calculations shown in this section are indicative only and based on 132kV configurations. Phase separation, cable depths and other factors will vary depending on component suppliers and project specifics. The following construction types are referred to in the calculations.

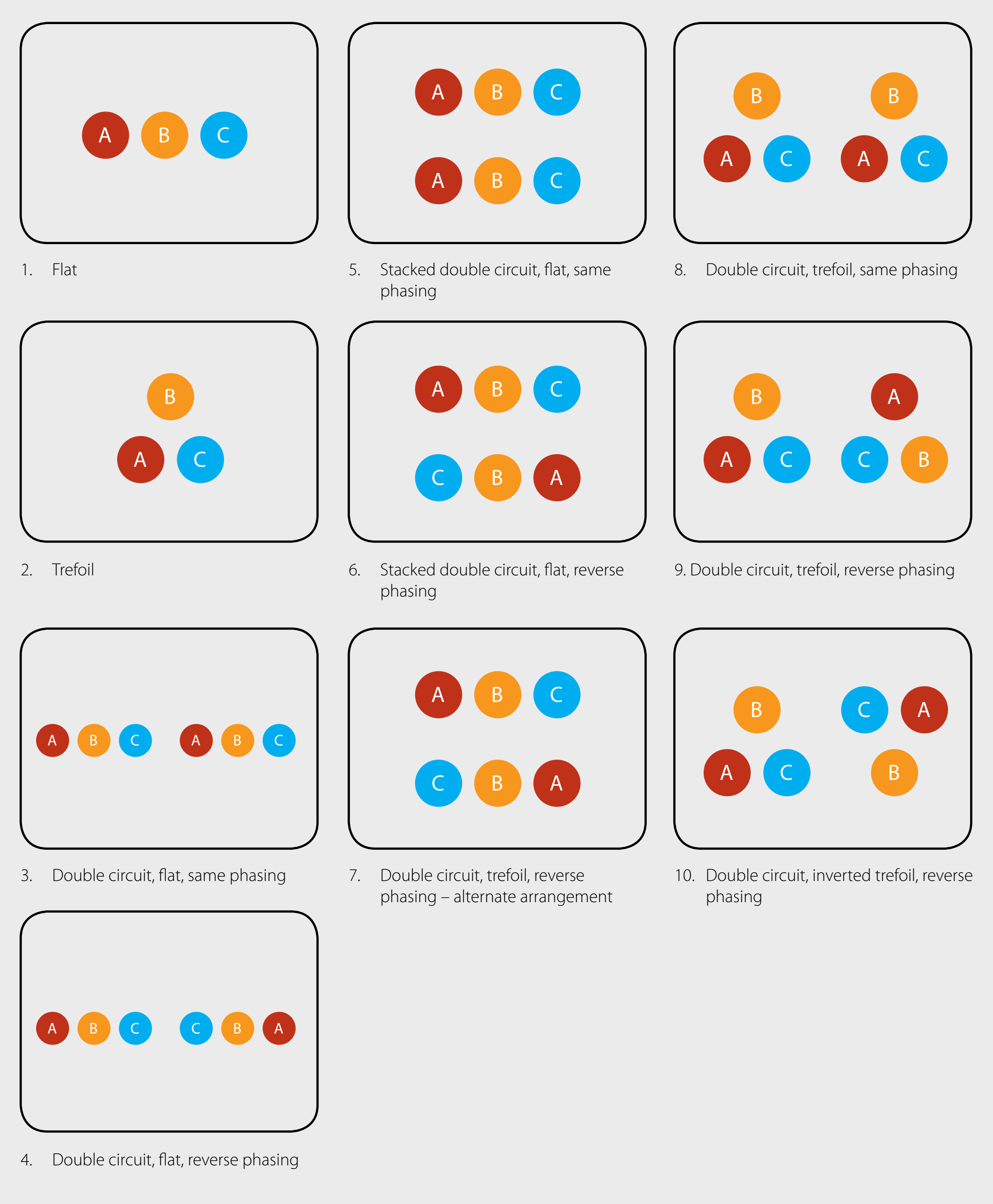
9.2.1 Distance

The extent of magnetic field reduction with distance from underground cables can be seen in all figures within this section. When the cable is to be installed in a roadway, consideration could be given to selecting sides of the road which are less populated, installation within the carriageway, or in some cases, alternative routes. Installing the trench in the centre of the road may maximise distance to all properties, however, consideration should be given to additional cost, reinstatement and traffic impacts.

Alternative routes (unless comparable in cost) are rarely justified on EMF grounds alone given the typically low exposures and therefore limited opportunities for further material reductions.

Increasing the depth of cables may result in some field reduction directly above the cables, but generally results in a significant increase in cost, impacts on cable ratings and a negligible difference beyond a few metres away from the cables.

FIGURE 9.7 DIFFERENT UNDERGROUND CONSTRUCTION CONFIGURATIONS



9.2.2 Voltage

See Section 9.1.5.

9.2.3 Conductor spacing

As for overhead lines, as the phases are moved closer together, there is increased phase-to-phase cancellation of the magnetic field and the total resultant field strength decreases.

This method is particularly effective for underground cables as the conductors are insulated and are therefore not limited by flashover. However, conductor spacing and in some cases application is limited by thermal ratings.

Options include trefoil, multicore cables and triplex (twisted three core cables).

9.2.4 Phase arrangement

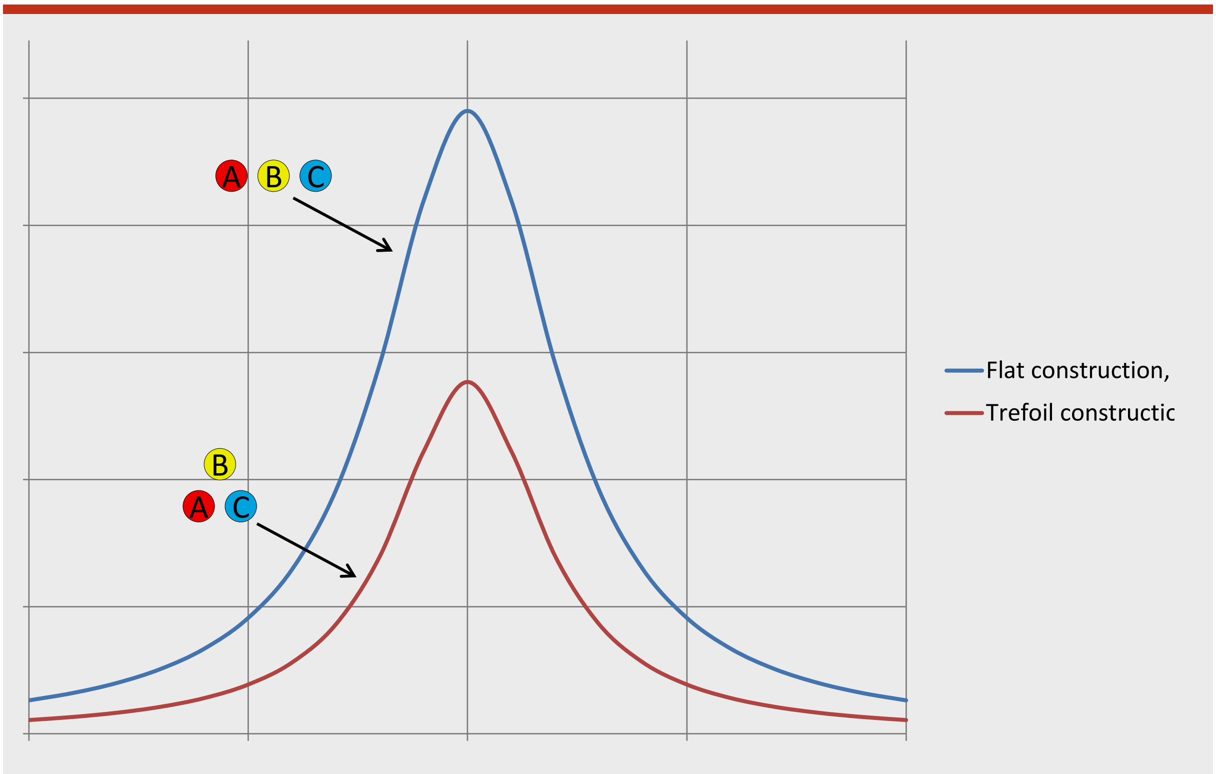
For double circuit lines, it may be possible to arrange the phases to maximise the magnetic field cancellation.

Where undergrounding involves a double circuit flat arrangement consideration could be given to phasing the circuits so that the EMF profile is lowest with both circuits operating and yet still minimal when one circuit is out of service (see Figure 9-9).

A particular case for dual circuits involves arranging the phases such that one circuit is an inverted trefoil with reverse phasing (see Figure 9-10). This arrangement can result in a significant reduction in magnetic field at a distance from the cables. Again, conductor spacing and in some cases application is limited by thermal ratings.

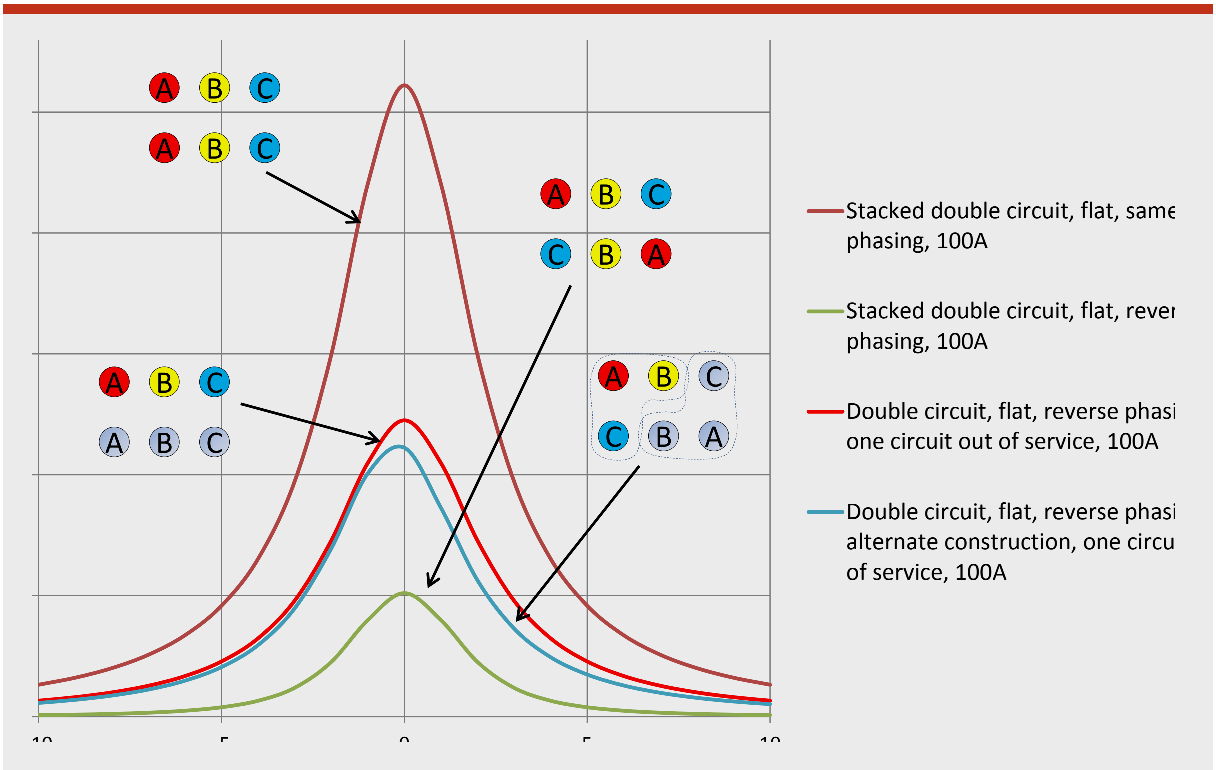
Another particular case involves transitions from trefoil to flat in dual circuits. In these cases it may be possible to change the phasing to maintain optimum phasing.

FIGURE 9.8 FLAT VERSUS TREFOIL CONSTRUCTION



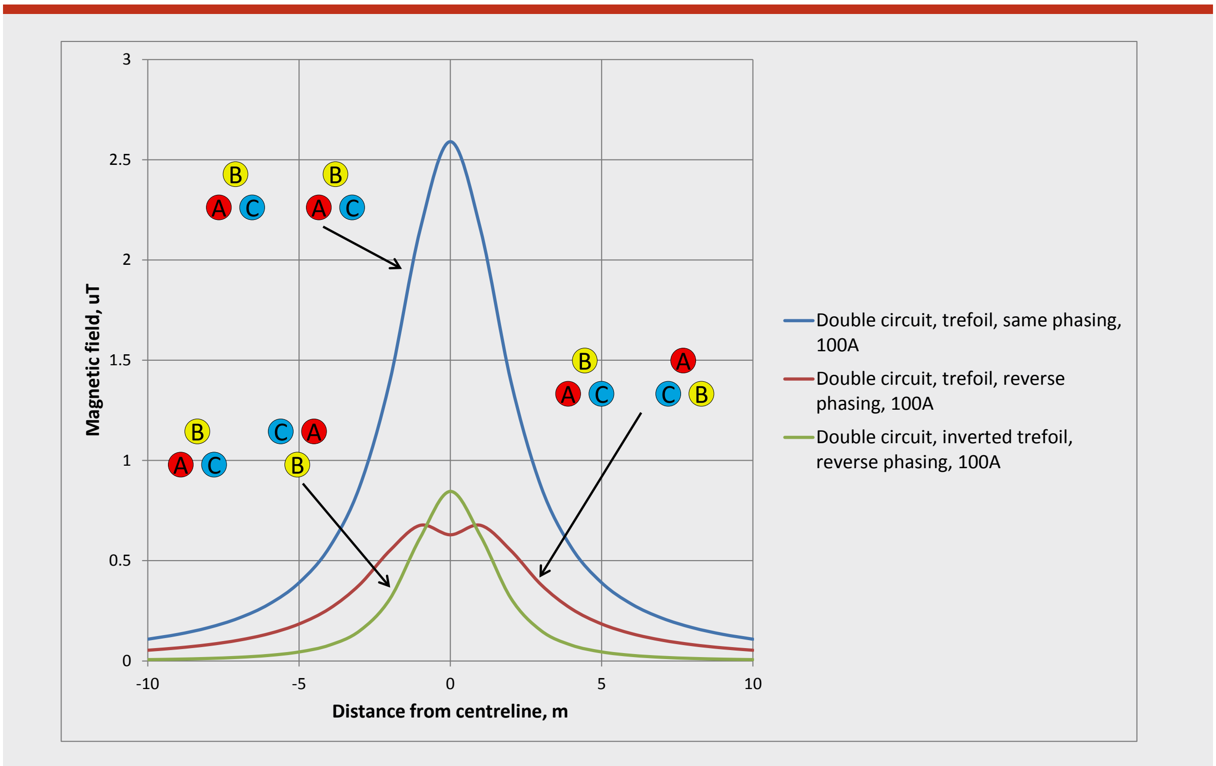
Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

FIGURE 9.9 DOUBLE CIRCUIT, FLAT CONSTRUCTION



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

FIGURE 9.10 DOUBLE CIRCUIT TREFOIL CONSTRUCTION



*Note: Hypothetical examples. Actual field levels will depend on specifics of the powerline.

9.2.5 Shielding

Although shielding of underground cables is theoretically possible, consideration needs to be given to de-rating of cables, access to cables after a fault, corrosion of shielding materials, cost of construction and ultimately the scope for any further field reduction, given the already compact cable arrangement.

In limited cases the installation of a passive shielding loop can be effective in reducing the magnetic field at a particular point. See Section 9.1.7 for additional detail on passive shielding.

In extreme cases consideration could be given to bonding cable sheaths together at each end. However, this method is usually not possible due to de-rating effects and resulting consequences.

9.3 SUBSTATIONS

Predicting magnetic field profiles for substations is a complex exercise given the multitude of time varying sources orientated in multiple directions. As a result, the magnetic field profile is highly dependent on the particular circumstances. The following measures are general in nature and could be further explored as part of a site specific assessment.

9.3.1 Distance

The areas of focus for magnetic field reductions are those areas accessible to the public. For substations, this location is generally the security fence line.

No cost/very low cost magnetic field reduction may be accomplished in a variety of ways, including substation siting, location and orientation of equipment, busbars and cabling, and location of access ways, buildings. Considerations include:

» Substation siting taking into consideration land use, land size, existing easements, proximity to load centre and proximity to powerline routes. While EMF should be a consideration in site selection, land availability, acquisition costs and proximity to feeders are often the dominant factors.

» Locating substations close to the load centre and existing feeders to minimise losses and the need for longer or more powerlines.

» Locating major magnetic field sources within the substation to increase separation distances. Key magnetic field sources include the transformer secondary terminations, cable runs to the switch room, capacitors, reactors, busbars, and incoming and outgoing feeders.

» Minimising fields from incoming and outgoing powerlines as discussed above.

» Locating areas with the lowest magnetic fields closest to the boundaries (eg control rooms, equipment rooms, amenities, fire stairs, lifts, walkways, transformer roadway, oil containment, air vents/ducts and pilot isolation rooms).

» Planning the substation layout with its LV side further away from the location of interest than its HV side. (The HV side currents are substantially smaller than the LV side and, hence the HV equipment generally has a smaller associated magnetic field).

» Orienting equipment so that magnetic fields are minimised.

9.3.2 Conductor spacing and busbar arrangement

The magnetic field strength at ground level is a result of the addition of the magnetic field vectors of the various current carrying conductors. As the phases are moved closer together, there is increased phase-to-phase cancellation of the magnetic field and the total resultant field strength decreases.

Due to flashover and reliability considerations for the circuit, there is a practical limit to the reduction in spacing that can be achieved for exposed conductor construction. A reduction in conductor spacing can also impact on worker safety and could result in the need for extended planned outages to facilitate maintenance work.

For overhead busbars, horizontal or vertical configurations typically have larger phase spacing and hence produce higher fields under the busbar than triangular or delta configurations.

For underground cables/busbars a compact arrangement generally produces a lower magnetic field profile. Example considerations include:

» Avoid direct ceiling/floor mounting of heavy current cables, open type busbars or disconnector switches, depending on adjoin uses.

- Locate cable trays away from walls/ceilings/floors depending on adjoining uses.
- Use triangular or delta bus configurations.
- Use compact arrangement of underground cables/busbars.

The use of compact gas insulated or vacuum switchgear as compared to open or enclosed air insulated switchgear results in significantly lower magnetic fields due to a substantial reduction in phase separation distances. A degree of shielding is also afforded by gas filled enclosures.

9.3.3 Phase configuration

The phasing relationship between all busbars and equipment in the substation will affect the magnetic field strength at any particular location.

Selective use of some phase configurations can be used as a field cancellation technique. Examples can include placing equipment back to back, grouping busbars/cables, and reverse phasing cables.

9.3.4 Voltage

While a higher voltage substation could produce lower magnetic field levels than a lower voltage substation, the choice of voltage is determined by network and other requirements.

9.3.5 Shielding

Shielding is the erection of a barrier between source and subject to reduce the field strength at the subject.

Magnetic fields can be shielded by ferromagnetic or conductive materials. However, the available methods can be complex, costly and can have the opposite effect by concentrating magnetic fields. Due to its high cost, shielding usually falls outside the scope of no cost / very low cost prudent avoidance / precaution.

The use of compact gas insulated or metal clad switchgear offers a degree of shielding.

In limited cases the installation of a passive shielding loop can be effective in reducing the magnetic field at a particular point. See Section 9.1.7 for additional detail on passive shielding.

9.4 LOW VOLTAGE DISTRIBUTION SUBSTATIONS

The measures described above also generally apply to low voltage substations. In addition the following measures could be considered:

- Design busbars to minimise separation between phases and the neutral bus.
- Use multicore or trefoil cables in preference to three single phase cables.
- Minimise stray currents and residual currents by eliminating alternate paths for neutral current (magnetic fields from stray/residual currents decreases less rapidly than the fields from lines) Due to the multiple earth neutral (MEN) systems of the neutral earthing, it is inevitable that some portion of the neutral current will flow through metallic water pipes and through neutrals of interconnected distributors. This will result in stray or residual current.
- Balance loads across all phases to reduce neutral currents (magnetic fields from unbalanced currents decrease less with distance than the fields from lines with balanced currents).
- Avoid phase-by-phase grouping of single core cables in parallel circuits.
- Orientate the LV end of the substation furthest from the receiver.
- Install and appropriately group the LV cables between transformers and switchboard and consumer mains cables.

FURTHER INFORMATION

CIGRE - 2009 - TB 373 Mitigation Techniques Of Power-Frequency Magnetic Fields Originated From Electric Power Systems. See more at **www.e-cigre.org/**

ENA ER G92 Issue 1 - Guidelines for Best Practice in relation to Electric and Magnetic Fields (EMFs) in the Design and Management of Low Voltage Distribution Networks. See more at **www.energynetworks.org**

10. MEDICAL IMPLANTS

There are many types of implanted cardiac pacemakers and other medical implants and in some circumstances these devices may be susceptible to interference from external fields, including radio-frequency fields and power-frequency EMF.

While there are many different manufacturers and models of pacemakers, more recently manufactured devices tend to be designed to shield against external influences. Many pacemakers are designed to 'fail safe' by reverting to fixed-rate operation when they sense the presence of interference above a certain level. The field strengths necessary to induce such behavior vary from one pacemaker model to another.

Generally, standards place an obligation on designers and manufacturers of medical implants to make them immune to interference in up to the public Reference Levels as set by ICNIRP. One such example is CENELEC, the European electrical standards organisation, BS EN 45502 - Active implantable medical devices. As regulations, standards and devices vary depending on the manufacturer and country of origin and distribution, advice should always be sought from the manufacturer or medical professional.

The following are examples of medical implants that may be susceptible to electromagnetic interference:

- cardiac pacemakers and defibrillators,
- leads associated with devices such as pacemakers,
- insulin or other drug infusion pumps,
- continual glucose monitoring,
- spinal cord stimulators (for back pain),
- cochlear implants,
- neuro-stimulators (e.g. for epilepsy, parkinsonism or incontinence), and
- metallic implants.

As the susceptibility of medical implants to EMF interference can differ, there is a need for a case-by-case risk management approach in consultation with the wearer's treating physician.

10.1 MEDICAL IMPLANT RISK MANAGEMENT

For occupational exposure, a risk management approach needs to be adopted, by implementing procedures to identify workers at risk due to fitment of medical implants, and characterising their EMF exposure from the electrical network. Once identified, an assessment can be conducted in consultation with the recipient's doctor to manage the occupational exposure to EMF of workers with medical implants and ensure that exposures are less than those which may interfere with the implant's normal operation.

Control measures can be implemented, advising the worker of any necessary restrictions or changes of their work practices to protect them from unwanted EMF exposure. Risk assessments need to be conducted on a case-by-case basis to determine the likely susceptibility of medical implants whilst performing particular tasks and the severity of the consequences should the medical implants fail or experience interference.

As part of the pre-employment induction process for working on an electrical network, raising awareness of the risk and a confidential check for medical implants should be completed to identify those persons who might have medical implants.

Workers fitted with medical implants should discuss their work and working environment with their doctor and provide the network business with a letter from their doctor describing the circumstances in which the proper functioning of the medical implant or implant may be at risk.

Having involved parties informed will allow for a risk management approach to be adopted that assesses the individual's circumstances so that an effective safety management strategy can be developed.

For general public exposure risk assessment requirements, the recipient should be referred to their treating physician and manufacturer and advice provided on typical exposures.

FURTHER INFORMATION

ARPANSA EMF Fact sheet - Measuring Magnetic Fields. See more at **www.arpansa.gov.au**

Refer to treating physician and medical implant manufacturer.

11. SIGNAGE

Signage although discretionary, may be used as one means of controlling exposure situations where there is risk of micro shocks, interference to medical implants[24] (See Section 10), and areas where levels could exceed the Reference Levels. Signage is only one tool to manage such risks and that many of these risks can be effectively managed by other means such as engineering and administrative controls.

Generally, signage is not considered to be a practical prudent avoidance / precaution measure for utilities, given the ubiquitous nature of electricity distribution and usage.

Where appropriate, signage should generally meet the requirements of Australian Standard AS1319 – 1994 Safety Signs for the Occupational Environment which has a category for "Warning" signs. Some examples of signage wording are shown in Figures 11-1 and 11.2. However, the actual wording chosen needs to have regard to the nature of the area to which the sign applies and the management controls in place.

FIGURE 11.1 EXAMPLE WORDING FOR SIGNAGE WHERE ELECTRIC OR MAGNETIC FIELD LEVELS MAY CAUSE INTERFERENCE TO MEDICAL IMPLANTS (SEE SECTION 10)

WARNING

MEDICAL IMPLANTS

ELECTRIC AND MAGNETIC FIELDS MAY INTERFERE WITH IMPLANTS

SEEK MEDICAL ADVICE BEFORE ENTERING

FIGURE 11.2 EXAMPLE OF SIGNAGE WHERE ELECTRIC OR MAGNETIC FIELD LEVELS MAY EXCEED REFERENCE LEVELS

WARNING

HIGH MAGNETIC FIELD AREA

NO UNAUTHORISED ENTRY

WARNING

ELEVATED ELECTRIC FIELDS IN THIS AREA MAY CAUSE MINOR SHOCKS SIMILAR TO STATIC ELECTRICITY

THIS MAY BE NOTICEABLE FOR SOME PEOPLE

FOR FURTHER INFORMATION CALL …

24 Medical implants may have been manufactured when ICNIRP 1998 guidelines were in force. These guidelines have a public exposure limit of 100µT

12. EMF COMMUNICATION

Communication and sharing of information with the community is a key element of EMF management for utilities. A number of relevant principles and ideas are set out below:

- When EMF issues arise, respond promptly and thoughtfully.
- Have available EMF materials such as a policy position and factsheets:
  - ENA's brochure Electric and Magnetic Fields – What we know
  - ENA EMF Policy Statement
  - ARPANSA Facts Sheets
  - WHO Fact Sheet
- Keep EMF materials accurate, current and consistent.
- Align messages with ARPANSA's public position. This alignment will provide a sound basis for positions and practices.
- Consider an EMF measurement program as a means of responding to customer inquiries. Ensure that the measurements are reported in their context, consistent with advice from ARPANSA. Providers of reading material should be both knowledgeable of the consensus science and approachable. Details of the preferred measurement technique and instrumentation for making measurements are available in a measurement protocol developed by ARPANSA.[25]
- Think about the levels of response in your organisation. Ensure that all staff that interface with the public understand the nature of public concern, have credible EMF materials available, are familiar with them and provide consistent and accurate communications.
- Maintain a role within the company that keeps abreast of the health science, the policy position of regulators and best practices and can support the front line staff when required. The person in this key communication role should be able to address any deeper concerns with credibility and understanding.
- Seek assistance from the ENA EMF Reference Group.

FURTHER INFORMATION

ARPANSA 2002 - Measurement of Residential Power Frequency Fields. See **www.arpansa.gov.au**

WHO – 2002 - Establishing a Dialogue on Risks from Electromagnetic Fields. See more at **www.who.int**

IAP2 Public Participation Spectrum. See more at **www.iap2.org.au**

25 Karipidis, K, 2002, Measurement of Residential Power Frequency Fields.

13. REFERENCES

Anderson, V, 2009, B field compliance for 50 Hz live line work, Swinburne University, 2 September 2009

Australian Standard AS1319 – 1994 Safety Signs for the Occupational Environment

ARPANSA, 2015, Fact Sheet – Electricity and Health

ARPANSA, 2015, Fact Sheet – Measuring Magnetic Fields

ARPANSA, 2015, Extremely Low Frequency Electric and Magnetic Fields

Bracken, TD, and Dawson, T, 2004, Evaluation of Non- uniform 60 Hz Magnetic-Field Exposures for Compliance with Guidelines, J Occ Envir Hyg, 1, 629 – 638

BS EN 45502:2015 - Implants For Surgery - Active Implantable Medical Devices

BS EN 50499:2008 – Procedure for the assessment of the exposure of workers to electromagnetic fields

CIGRE 2009b, Mitigation techniques of Power-frequency Magnetic Fields Originated from Electric Power Systems No 373, Working Group C4.204 February 2009

Dawson, TW, Caputa, K and Stuchley, MA, 1999, Numerical evaluation of 60 Hz magnetic induction in the human body in complex occupational environments. Phys Med Biol, 44, 1025-1040

Dawson, TW, Caputa, K and Stuchley, MA, 2002, Magnetic field exposures for UK live-line workers. Phys Med Biol, 47, 995-1012

Dimbylow, P and Findlay, R, 2009, The effects of body posture, anatomy, age and pregnancy on the calculation of induced current densities at 50 Hz, Rad Prot Dos, advanced access published 23 December 2009

Dimbylow, P, 2005, Development of pregnant female voxel phantom, NAOMI< and its application to calculations of induced current densities and electric fields from applied low frequency magnetic and electric fields, Phys Med Biol 50 1047-1070

Dimbylow, P, 2006, Development of pregnant female, hybrid voxel-mathematical models and their application to the dosimetry of applied magnetic and electric fields at 50Hz. Phys Med Biol 51, 2383-2394

ENA, 2014, Policy Statement on Electric and Magnetic Fields (EMF).

ENA, 2014, "Electric and Magnetic Fields – What We Know".

ENA ER G92 Issue 1 - Guidelines for Best Practice in relation to Electric and Magnetic Fields (EMFs) in the Design and Management of Low Voltage Distribution Networks

ENA UK, 2012, Power Lines: Demonstrating compliance with EMF public exposure guidelines-A Voluntary Code of Practice, March 2012

Gibbs, Sir Harry (1991). Inquiry into community needs and high voltage transmission line development. Report to the NSW Minister for Minerals and Energy. Sydney, NSW: Department of Minerals and Energy, February 1991.

IARC, 2002, Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields

ICNIRP, 1998, Guidelines for limiting exposure to time varying electric, magnetic fields and electromagnetic fields (up to 300GHz) Health Physics 1998, 74, 494 – 522.

ICNIRP, 2010, Guidelines for limiting exposure to time varying electric and magnetic fields (1Hz to 100 kHz) Health Physics December 2010, 99, 818 – 836.

IEC 62226-2-1, Exposure to electric and magnetic fields in the low to intermediate frequency range-Methods for calculating current density and internal electric fields in the human body. Part 2-1 Exposure to magnetic fields - 2D models.

IEC 61786, Measurement of low frequency magnetic and electric fields with regard to exposure to human beings – special requirements for instruments and guidance for measurements.

IEC 62110 Electric and magnetic field levels generated by AC power systems - Measurement procedures with regard to public exposure.

IEC 62311, Assessment of electronic and electrical equipment related to human exposure for electromagnetic fields (0-300Ghz)

IEEE, 2002, Standard C95.6 IEEE Standard for Safety levels with respect to Human Exposure to Electromagnetic Fields 0-3kHz, 22 October 2002

IEEE, 2010, IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz

Karipidis, K, 2002, Measurement of Residential Power Frequency Fields

National Radiation Laboratory, New Zealand Ministry of Health – Electric and Magnetic Fields and Your Health 2008;

Peach H.G., Bonwick W.J. and Wyse T. (1992). Report of the Panel on Electromagnetic Fields and Health to the Victorian Government (Peach Panel Report). Melbourne, Victoria: September, 1992. 2 volumes: Report; Appendices.

Repacholi M, "Concern that 'EMF' magnetic fields from power lines cause cancer." Sci Total Environ (2012), doi:10.1016/j.scitotenv.2012.03.030, page 3. [citing PubMed]

UK Department of Energy and Climate Change - 2012 - Power Lines: Demonstrating compliance with EMF public exposure guidelines - A voluntary Code of Practice

WHO 2007, Extremely Low Frequency Fields – Environmental Health Criteria, Monograph No. 238 March 2007

WHO 2007, Electromagnetic fields and public health – Exposure to extremely low frequency fields. Fact Sheet 322 of June 2007

Wood, AW, 2008, Extremely low frequency (ELF) Electric and Magnetic Fields Exposure Limits: Rationale for Basic Restrictions used in the Development of an Australian Standard. Bioelectromagnetics 2008, 1-15

14. GLOSSARY

DEFINITIONS

Basic Restrictions

Limitations on the quantities that most closely match all known biophysical interaction mechanisms with tissue (source ICNIRP 2010). (measured in V/m).

Distribution voltages

Voltages less than or equal to 33kV

Electric and Magnetic Fields, (EMF) – (Sometimes referred to as electromagnetic fields)

Power frequency (50Hz) electric and/or magnetic fields in the environment. At this frequency, the electric and magnetic components are independent of one another. EMF should not be confused with 'electromagnetic radiation' (see below). Electric fields are measured in volts/metre (V/m). Magnetic Fields are measured in gauss (G) or tesla (T).

Electromagnetic Radiation

Electromagnetic radiation is a term used to describe the movement of electromagnetic energy through the propagation of a wave. This wave, which moves at the speed of light, is composed of electric and magnetic waves which oscillate (vibrate) in phase with, and perpendicular to, each other. This is in contrast to EMF, where the electric and magnetic components are essentially independent of one another.

ELF or Extremely Low Frequency

A frequency in the range 0 to 3000 Hz.

Exposure

The circumstance of being in the immediate presence of electric or magnetic fields, or having such fields cause electric currents to flow through the body or within the body.

Gauss (G)

A measure of magnetic flux density (also sometimes called magnetic field strength). It may appear on meters to measure magnetic field (gauss or milligauss). One gauss = 10^{-4} tesla (T), the SI unit for magnetic flux density. It is often convenient to use milligauss (mG) for EMF communication as most fields encountered in practice are on a scale of 1 to 1000, thereby obviating the need for small fractions.

Magnetic field

In this document the term 'magnetic field' is equivalent to 'magnetic flux density' (refer below).

Magnetic flux density (B)

A vector quantity that determines the force on a moving charge or charges (that is, on an electric current) within a magnetic field. Magnetic flux density is expressed in teslas (T). One gauss (deprecated unit) equals 10^{-4} T. The quantity commonly referred to in non-technical uses as magnetic field strength.

Magnetophosphenes

The sensation of flashes of light caused by induced electric currents stimulating the retina.

Micro-shock

A micro-shock is a sensation caused by a small electric spark discharge or arc occurring when a person, isolated from ground and exposed to a high electric field, approaches within a few millimetres of an earthed object. Alternatively, a person in contact with ground may experience a micro-shock when approaching an isolated charged conductor. Micro-shocks are due to the transfer of induced charge from the isolated to the grounded object.

Non-uniform field

A field that is not constant in amplitude, direction and relative phase over the dimensions of the body or body part under consideration. In the case of electric fields, the definition applies to an environmental field disturbed by the presence of the body.

Occupational exposure - ICNIRP

See Section 5.2.

Occupational exposure - IEEE

See Section 5.2.

Public exposure (also general public exposure)

Exposure that is not classified as occupational exposure.

Reference Levels

The rms and peak electric or magnetic fields and contact currents to which a person may be exposed without an adverse health effect and with acceptable safety factors. The Reference Levels for electric and magnetic fields in this document may be exceeded if it can be demonstrated that the Basic Restrictions are not exceeded. Thus it is a practical or "surrogate" parameter(s) that may be used for determining compliance with the Basic Restrictions (source ICNIRP 2010).

Safety factor

A factor used in deriving Basic Restrictions and Reference Levels that provides for the protection of exceptionally sensitive individuals, uncertainties concerning threshold effects due to pathological conditions or drug treatment, uncertainties in reaction thresholds, and uncertainties in induction models.

Tesla (T)

SI unit (International System of Unit) of magnetic flux density (also sometimes called magnetic field strength). One gauss = 10^{-4} tesla.

Transmission voltages

Voltages greater than 33kV

Uniform field

A field that is constant in amplitude, direction and relative phase over the dimensions of the body or body part under consideration. In the case of electric fields, the definition applies to an environmental field undisturbed by the presence of a body.

15. ACRONYMS AND ABBREVIATIONS

ABC	Aerial Bundled Conductor
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
BS	British Standard
CENELEC	European Committee for Electrotechnical Standardization
CIGRE	Council on Large Electric Systems
DC	Direct Current
ELF	Extremely low frequency
EMF	Electric and Magnetic Fields
EMR	Electromagnetic Radiation
ENA	Energy Networks Association
EU	European Union
G	Gauss
HV	High Voltage
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers (of USA)
kV	kilovolts
LV	Low Voltage
m	Milli ($x10^{-3}$)
MF	Magnetic Field
MEN	Multiple Earth Neutral
RF	Radio Frequency
RL	Reference Level
RMS	Root-mean-square
T	Tesla
TWA	Time Weighted Average
µ	Micro ($x10^{-6}$)
V	Volts
WHO	World Health Organization

APPENDIX 1 - MAGNETIC FIELD MITIGATION – SUMMARY OF OPTIONS

THE FOLLOWING SUMMARISES THE MAGNETIC FIELD REDUCTION MEASURES DISCUSSED IN SECTION 9.

OVERHEAD POWERLINES

The following measures may reduce magnetic field exposure depending on the project. Whether they fall within the meaning of no cost / very low cost prudent avoidance / precaution will depend on the specific circumstances (see Section 8). The measures are not mandatory and will need careful consideration of cost, effectiveness and other project objectives.

» Minimise loads by optimising network configuration.

» Install circuits on sides of the road which are less populated.

» Consider alternate routes.

» Utilise existing easements.

» Raise the height of conductors (eg. Increase height of supporting structures or use vertical construction).

» Minimise phase separation.

» Use a compact phase configuration such delta construction.

» Reverse phase dual circuit lines.

» Consider optimum conductor placements for dual voltage circuits (taking into account phase shift).

» Increase the balancing of loads between dual circuit feeders.

» Split phase sections of single circuit line.

» Use highest practicable voltage.

» Bundle conductors – distribution.

» Twist conductors (eg. ABC) – distribution.

» Minimise stray currents and residual currents – distribution.

» Balance loads across all phases to reduce neutral currents – distribution.

» Avoid phase-by-phase grouping of conductors in parallel circuits – distribution.

For further information see Section 9.1.

UNDERGROUND CABLES

The following measures may reduce magnetic field exposure depending on the project. Whether they fall within the meaning of no cost / very low cost prudent avoidance / precaution will depend on the specific circumstances (see Section 8). The measures are not mandatory and will need careful consideration of cost, effectiveness and other project objectives.

» Minimise loads by optimising network configuration.

» Install cables on sides of the road which are less populated.

» Consider installing cables within the roadway – transmission.

» Utilise existing easements.

» Minimise phase separation.

» Use compact trefoil arrangement of single core cables.

» Optimally arrange and phase of dual circuits (eg reverse phasing and inverted trefoil).

» Where a dual circuit flat arrangement is used, optimally phase dual circuits to allow for compact arrangement when one feeder is out of service.

» Increase the balancing of loads between dual circuit feeders.

» Where there are transitions from trefoil to flat, change phasing to maintain optimum phasing.

» Use highest practicable voltage.

» Use multicore or trefoil cables in preference to three single phase cables – distribution.

» Place neutral conductors with the associated phase conductors – distribution.

» Minimise stray currents and residual currents – distribution.

» Balance loads across all phases to reduce neutral currents – distribution.

» Avoid phase-by-phase grouping of single core cables in parallel circuits – distribution.

For further information see Section 9.2.

SUBSTATIONS

The following measures may reduce magnetic field exposure depending on the project. Whether they fall within the meaning of no cost / very low cost prudent avoidance / precaution will depend on the specific circumstances (see Section 8). The measures are not mandatory and will need careful consideration of cost, effectiveness and other project objectives.

» Minimise loads by optimising network configuration.

» Consider alternate sites for substation (taking into account incoming and outgoing feeders).

» Site substation close to load centre.

» Site substation close to line routes.

» Locate key magnetic field sources within the substation, to increase separation distances. Key magnetic field sources include the transformers and associated connections, cable runs to the switch room, capacitors, reactors, busbars, and incoming and outgoing feeders.

» Minimise fields from incoming and outgoing powerlines (as discussed above).

» Locate areas with the lowest magnetic fields closets to boundaries (eg control rooms, equipment rooms, amenities, fire stairs, lifts, walkways, transformer roadways, oil containment, air vents/ducts and pilot isolation rooms).

» Plan the substation layout with its LV side further away from the location of interest than its HV side.

» Orientate equipment with uneven field patterns so that the highest field side is turned away from the location of interest (the LV side usually has the highest fields).

» Avoid direct ceiling/floor mounting of heavy current cables, open type busbars or disconnector switches, depending on adjoining uses.

» Locate cable trays away from walls/ceilings/floors depending on adjoining uses.

» Consider triangular or delta bus configurations.

» Use compact arrangement of underground cables/busbars and secondary connections.

» Use of compact gas insulated or vacuum switchgear.

» Use selective use of phase configurations as a field cancellation technique (eg back to back, grouping busbars/cables, and reverse phasing cables).

» Use highest practicable voltage.

» Design busbars to minimise separation between phases and the neutral bus – distribution.

» Use multicore or trefoil cables in preference to three single phase cables – distribution.

» Place neutral conductors with the associated phase conductors – distribution.

» Minimise stray currents and residual currents – distribution.

» Balance loads across all phases to reduce neutral currents – distribution.

» Avoid phase-by-phase grouping of single core cables in parallel circuits – distribution.

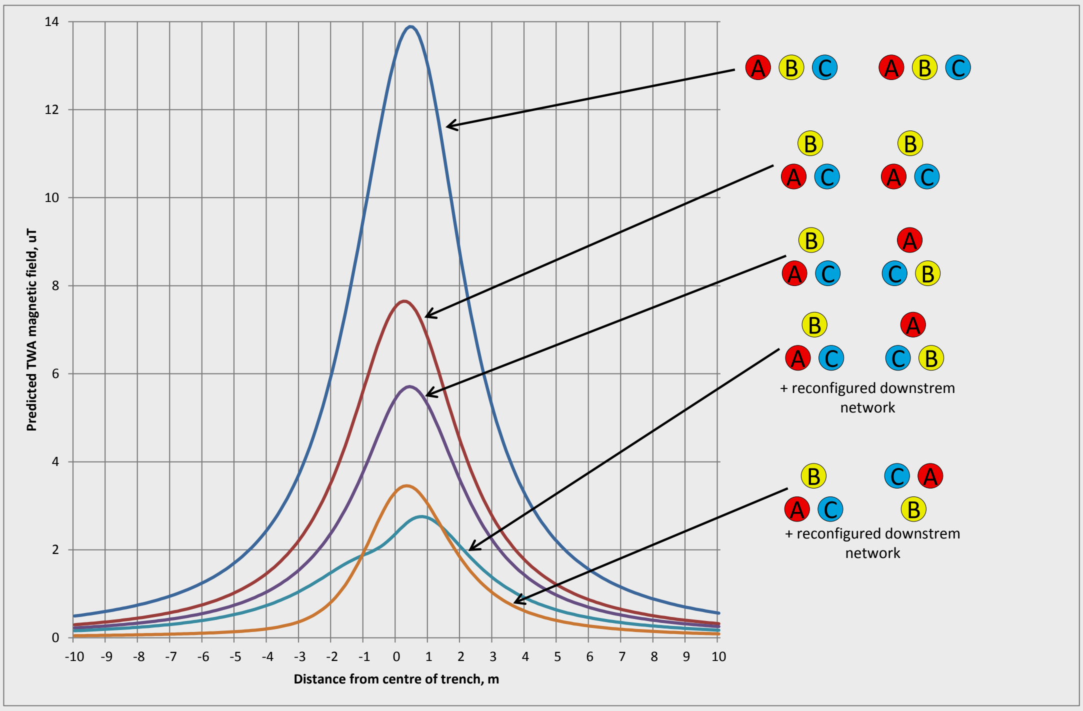
For further information see Sections 9.3 and 9.4.

APPENDIX 2 - WORKED EXAMPLES OF PRUDENT AVOIDANCE

THE FOLLOWING CASE STUDIES ARE PROVIDED AS EXAMPLES ONLY.

In practice the application of prudent avoidance / precaution will depend on the unique set of circumstances and must be considered on a case by case basis.

FIGURE A2.1



Double circuit underground transmission line

A 10km 132kV underground double circuit feeder was proposed to connect two substations. The cables were to be installed within the roadway and run through predominately residential areas.

No cost/very low cost measures such as trefoil and optimising the phasing could be implemented in this case without any material impact on cable rating and were shown to be able to reduce the field levels by around 50% at the nearest habitable rooms from the cables (compared to standard flat formation).

Despite the low magnetic field levels compared to an equivalent overhead line, some members of the community raised concerns and in response to these concerns, measures were investigated to further reduce the magnetic fields.

A further no cost/very low cost measure included changing switching points on the downstream network to improve the balancing of the feeders. This increased the overall reduction to around 70%.

Inverting one of the trefoils was shown to increase the overall reduction to around 85% (see Figure 9-7). This measure was investigated from a ratings and constructability viewpoint and found to be feasible for this project. Implementing this measure would incur an additional cost for a new mould to hold the inverted trefoil.

A number of alternative routes were also evaluated. These were considered to unduly compromise other issues in the context of this project because of environmental impacts, construction risk and cost. All other proposed measures were adopted.

In all, the proposed measures would achieve an overall reduction around 85% at the nearest habitable rooms. The cost for new mould was a very low one off cost and could be used for future projects.

New overhead 132kV powerline

A 10km, 132kV overhead line was proposed to connect two substations, traversing predominately residential areas. A compact delta construction was proposed for the length of the route.

The predicted ultimate TWA magnetic field at the nearest habitable rooms under ultimate loading conditions at the property boundaries in most cases was around 2 μT. This decreased to around 1 μT for most of the 100 residential buildings involved.

Undergrounding would reduce the magnetic field at the nearest residential buildings by around 85%, but the cost to underground was estimated to be an extra $12M (or 600%). This was clearly outside the scope of prudent avoidance / precaution.

A number of magnetic field reduction options such as spilt phasing and raising the height of the conductors with larger poles were put to the community. However, given the additional visual and amenity issues there was a strong community resistance to these measures.

An alternative route through bushland was considered, but it involved additional construction risk, environmental impacts, planning approval risk and an additional cost of $1M. For these reasons this route was considered to be outside the scope of prudent avoidance / precaution.

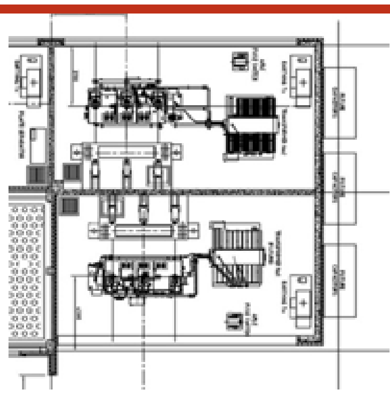
The only very low cost alternative routing for the powerline involved one short section which passed 10 houses. The additional cost for rerouting this section through a disused easement was $20k. Considering the project objectives, a decision was made to reroute this section.

New double circuit overhead 132kV powerline

A double circuit 7km 132kV overhead line was proposed to connect two substations. Initially only one circuit would be required with the second circuit required in 7 years based on current projections. The route was chosen after extensive community consultation and was considered the most appropriate taking into account all project objectives. The circuits would ultimately be reversed phased as a very low cost means of reducing the magnetic field.

The predicted ultimate TWA magnetic field at the nearest habitable rooms was around 0.5 μT. Without the reverse phasing this figure would be around 1.8 μT. With only one circuit operational (as would be the case for the first 7 years), the predicted magnetic field would be around 1.0 μT for the first 7 years.

A decision was made to adopt spilt phasing of the line for the first 7 years of operation (see Section 9.1.4). The cost of this measure was considered low in the context of the project and would result in a magnetic field reduction of around 80% for the first 7 years of operation.



New zone substation

A new zone substation was proposed in a residential area adjoining two residential properties. The key sources of magnetic fields within the substation were the transformers' secondary connections, cable runs, and capacitor banks. The predicted ultimate TWA magnetic field at the nearest habitable rooms ranged from 0.3 to 2.5 μT.

A number of measures were investigated to reduce the magnetic fields from the substation.

Placing the transformers back to back, thereby enabling the fields from the secondary cable risers to in part cancel each other out. The unique nature of the site involving two transformer runways enabled this measure to be undertaken at very low cost.

The cable runs from the transformers to the switch room were redesigned to group the cables in trefoil and use an optimum phasing arrangement.

The site layout was also redesigned to site the capacitor banks further away from habitable areas.

In all the proposed measures would achieve an overall reduction in excess of 50% at the substation boundary and over 60% at the nearest habitable area. The proposed measures were considered to be very low cost in the context of the project, had some technical advantages and took into account the concerns of the neighbouring residents.

Existing distribution line

The conductors from an existing overhead powerline are approximately 3 metres from a residential apartment. The measured fields range from 2-5 μT at the part of the apartment nearest to the powerline, decreasing to 1-3 μT at the centre of the nearest habitable rooms. The family of three has enquired about reducing the fields from the powerline.

To underground the line past the residence would cost around $40,000, given the current network configuration and work required. Bundling of the conductors would cost around $10,000, again given the current network configuration and work required.

Both of these reduction measures are outside the scope of 'very low cost' and hence could not be justified.

However, this case was unusual as it was noted that the fields are generally decreasing from the line at a rate of $1/d$ as opposed to $1/d^2$. This suggested that there was a high residual current in the line. Further testing revealed a loose neutral connection which was subsequently tightened. Testing showed that the field levels in the nearest habitable rooms had approximately halved.

New distribution substation

A new padmount substation was required in a residential area. There were a number of potential sites available to site the substation.

While not in the initially preferred location, a site was found away from residential buildings within a park. Given the low marginal cost, the negligible impact on technical requirements, and community preferences, a decision was made to site the substation within the park.

No magnetic field calculations were undertaken.

New chamber substation

At the request of a developer, a new chamber substation was proposed for a commercial development. An office area was located directly above the substation.

The predicted ultimate TWA magnetic field levels in the office area were generally in the range of 2-2.5 μT. One workstation had field levels of 8-10 μT as it was directly above the LV board. Being a new substation it was considered prudent to relocate and trefoil the medium voltage and low voltage cables away from the area directly below the office. This resulted in reducing the magnetic fields to 0.5-1 μT for all but one workstation. The developer chose the site for the substation and there were no very low cost alternative sites. It was also not practical to move the location for the LV board. The developer made a decision to rearrange the workstations as far as practical to reduce exposure. Mu metal shielding was considered, however, it was considered by the developer to outside the scope of prudent avoidance / precaution

Proposed development near an existing transmission line

A developer was proposing a new child care centre next to a transmission line. The field levels throughout the property typically ranged from 1.5-2.5 μT throughout the day, decreasing with distance from the line to an average of 0.2-0.6 μT at the furthest point on the property from the line. As the developer was not proposing to encroach onto the easement, the local council was the sole approving authority.

In early discussions, the council advised that they would want to see a consideration of prudent avoidance / precaution measures. They clarified that this meant a consideration of very low cost practical measures that could be implemented to reduce exposure for those who would spend most time at the centre.

As the development was in the early stages of design, a number of alternative layouts were still open for consideration by the developer. A layout was chosen which had the car park located closest to the line followed by the entry, storage areas and toilets. The sleeping and play areas were located furthest from the line.

As the development was in the early stages and given the nature of the site, the overall cost to the developer of these measures were minimal.

The council was satisfied that there was an appropriate application of prudent avoidance / precaution and approved the development.

APPENDIX 3 - EMF MEASUREMENT CONSIDERATIONS

THE FOLLOWING SECTIONS PROVIDE ADDITIONAL GUIDANCE FOR MEASURING ELECTRIC AND MAGNETIC FIELDS.

A3.1 ELECTRIC FIELD MEASUREMENT CONSIDERATIONS

Because electric fields are shielded by most objects, other than in flat open areas, they are rarely uniform. Accordingly, the context of the measurements needs to be understood and care needs to be taken in extrapolating from one situation to another.

Electric field measurement instruments in most cases are single-axis. The electric field adjacent to a conducting surface is normal to the surface, Therefore, the horizontal component of the electric field, particularly where it is generated by overhead lines, can be ignored close to the ground surface. Single-axis measurement (vertical component) is therefore sufficient near the ground.

Particular care must be taken in the presence of conducting objects or when the clearance of the conductor from the ground is small.

To reduce perturbation of a measured electric field as a result of the operator, the distance between the electric field measurement instrument and the operator should be at least 1.5 m and 3 m is recommended.

In order to take electric field level measurements representing the unperturbed field at a given location, the area should be free as far as possible from other powerlines, towers, trees, fences, tall grass, or other irregularities. It is preferred that the location should be relatively flat. It should be noted that the influence of vegetation on the electric field level can be significant. In general, field enhancement occurs above individual items of vegetation and field attenuation occurs near the sides. Field perturbation can depend markedly on the water content in the vegetation.

Electric field measurement may also be perturbed if the relative humidity is more than 70 % due to condensation effect on the probe and support. The ability of the field meter to work correctly under those conditions should be checked before measurement.

Electric field meters should be calibrated in accordance with manufacturer's recommendations.

A3.2 MAGNETIC FIELD MEASUREMENT CONSIDERATIONS

When taking magnetic field measurements, it must be remembered that they represent a point in time. At other times, the magnetic field in a particular area could be higher or lower than recorded in a single set of measurements. When measuring the fields associated with a utility asset, knowledge of the source(s), phasing and currents at the time of the measurements will assist in understanding the fields under other conditions.

In most cases it is preferable to undertake magnetic field measurements with a three-axis meter which calculates the resultant field. If a single-axis instrument is used, the following equation can be used to determine the resultant field (provided that the field level remains stable during the time taken to perform the measurements).

Resultant field = $(X^2+Y^2+Z^2)^{1/2}$

A single-axis instrument can be used to determine the direction of the field or undertake more detailed investigations as may be required for hidden sources. A single axis meter could also be used where the direction of the field is known and value of the semi-minor axis of the field ellipse is significantly smaller than that of the semi-major axis (such as a single current source or a 3-phase line where the line to ground distance is much larger than the phase-to-phase distance).

The following principles may be helpful when undertaking investigations and using a magnetic single axis meter or meter that measures X, Y and Z components.

The magnetic field lines for straight line sources will always lie in a vertical plane (X Z plane) perpendicular to the source (Y axis). There will be no Y component.

- The magnetic field direction for a single phase line source will be perpendicular to the radial and therefore horizontal (X component) under the line.
- The magnetic field direction for a horizontal 3ph line will be predominantly vertical (larger Z component) under the line approaching perpendicular to the radial at a distance from the source.
- The magnetic field direction for a vertical 3ph line will be predominantly horizontal (larger X component) under the line and approaching the radial at a distance from the source.
- The magnetic field direction for a delta 3ph line will be highly elliptical (both X and Z components) under the line and approach circular polarisation (similar X and Z components) at a distance from the source.
- The magnetic field direction for a vertical double circuit line (same phasing) will be predominantly horizontal (larger X component) under the line.
- The magnetic field direction for a vertical double circuit line (transposed phasing) will be predominantly vertical (larger Z component) under the line.
- The magnetic field from a single conductor will decrease with the inverse of the distance from source.
- The magnetic field from a three phase line and balanced double circuit (same phasing) will generally decrease with the square of the distance from the source.
- The magnetic field from a balanced double circuit (transposed phasing) will generally decrease with the cubed of the distance from the source.
- The magnetic field from a three phase line with residual current (i.e. three phases and neutral net balance is not zero) will, at a distance from the source, decrease with the inverse of the distance from source.

Magnetic fields from powerlines are typically measured horizontally along the ground. The distance to the source referred to above is the distance to the conductors.

When undertaking measurements the meter should be within calibration as recommended by the meter manufacturer. Further, where fields are highly non-uniform, have high harmonics or are changing rapidly, there should be an understanding of the meters sampling frequency, frequency response, sensor size and sensor location.

FIGURE A3.1 MAGNETIC SINGLE AXIS METER

APPENDIX 4 - ELECTRICAL LOADING

The electrical load and therefore the magnetic field on any powerline or substation (and some appliances) vary continually with time.

Figure A4-1 shows a sample of average residential electricity load profiles for different times of the day and year. An example of an annual load duration curve for a feeder is shown in Figure A4-2.

The situation is further complicated for distribution lines as load is usually progressively tapped off along the line, the loads are typically not balanced between phases and there is often a residual earth return current (see Section 9.1.9)

In addition, changes in load growth patterns or system requirements may alter future load flows on any line in the network. An example of load forecasts for a feeder is shown in Figure A4-3.

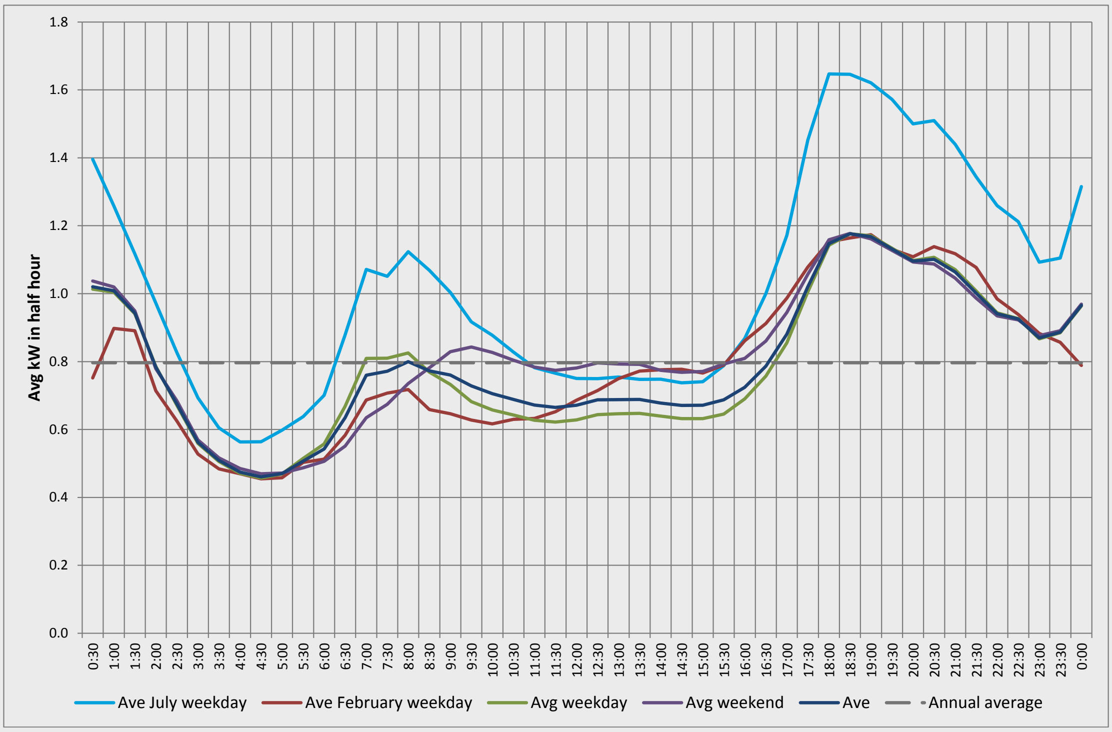
This means that any reference to a magnetic field level needs to make some assumptions regarding the conditions under which this value occurs.

Figure A4-4 shows different loading conditions for a powerline.

For compliance assessments against the exposure limits, the load of interest is typically the short term emergency rating (see Section 6.3).

For prudent avoidance / precaution assessments, the most relevant load is the TWA (see Section 8.1).

FIGURE A4.1 **TYPICAL RESIDENTIAL DAILY DISTRIBUTION LOAD PROFILES**



* Sourced from Ausgrid's Solar home electricity data - 1 July 2010 to 30 June 2011 (300 households)

FIGURE A4.2 EXAMPLE ANNUAL LOAD DURATION CURVE FOR A 132KV FEEDER

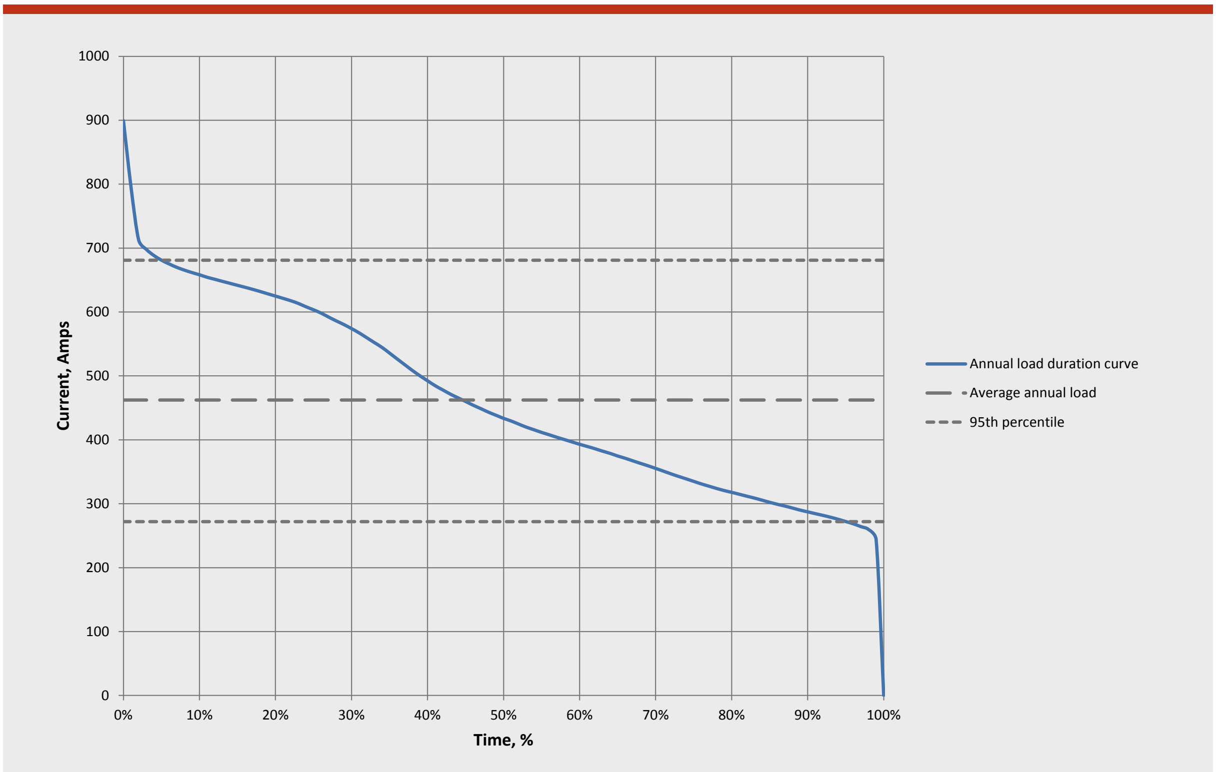


FIGURE A4.3 EXAMPLE LOAD FORECAST FOR A NEW OVERHEAD 33KV FEEDER

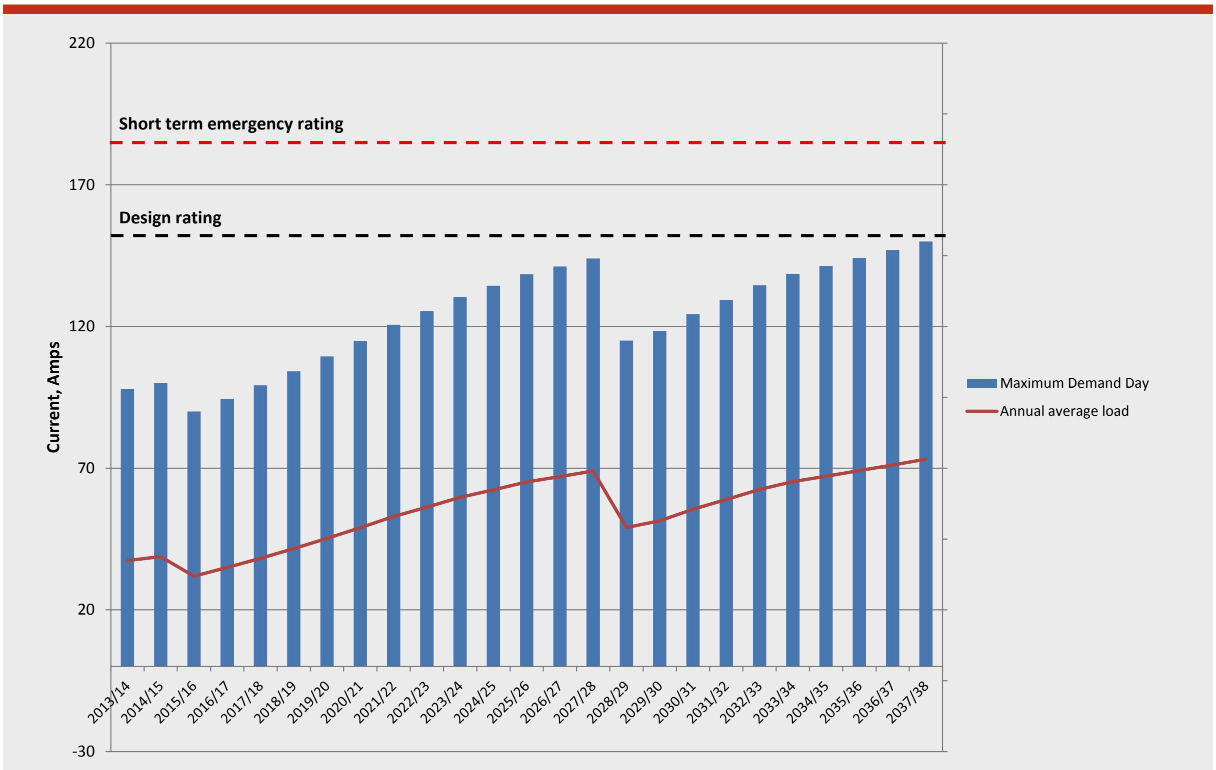
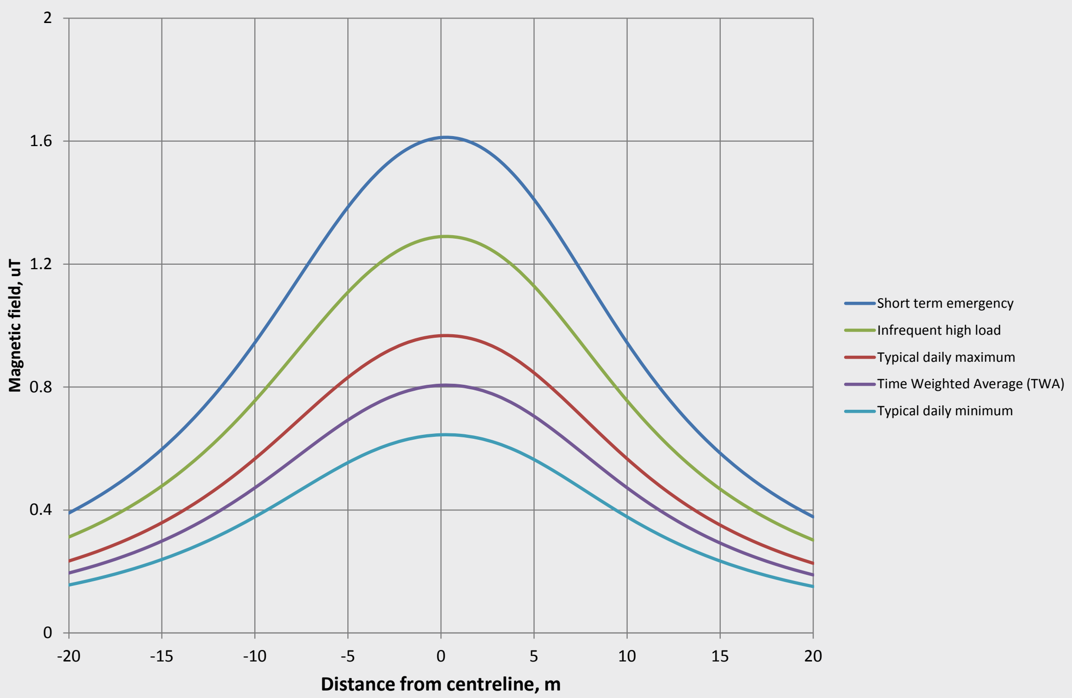


FIGURE A4.4 **EXAMPLE MAGNETIC FIELD PROFILES FOR A POWERLINE UNDER DIFFERENT LOADING CONDITIONS**



Short Time Emergency Load – Typically used when assessment compliance against the guidelines (see Section 6). This load could be the short time thermal limit and may in practice never be reached on a line.

Infrequent High Load – The yearly peak with the system substantially normal.

Typical Daily Maximum - The peak value reached for the line on a typical day

Time Weighted Average (TWA) Load – Typically used when assessing the application of prudent avoidance / precaution (see Section 7).

Typical Daily Minimum - The minimum value reached for the line on a typical day

PUBLISHED MARCH 2016

Energy Networks Association Ltd
P +61 2 6272 1555 **E** info@ena.asn.au
Level 1, 110 Giles St, Kingston ACT 2604
www.ena.asn.au