# Balickera Tunnel Remediation Works
# Species Impact Statement

## Hunter Water Corporation

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## DOCUMENT TRACKING

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# Abbreviations

| Abbreviation | Description |
|---|---|
| BC Act | NSW *Biodiversity Conservation Act 2016* |
| c.f. | compare |
| CER | Chief Executives Requirements |
| DAWE | Department of Agriculture, Water and the Environment |
| DPIE | NSW Department of Planning, Industry and Environment |
| EAH | Environment Agency Head |
| EEC | Endangered Ecological Community |
| ELA | Eco Logical Australia Pty Ltd |
| EOO | Extent of Occurrence |
| EP&A Act | NSW *Environmental Planning and Assessment Act 1979* |
| EPBC Act | Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* |
| FFA | Flora and Fauna Assessment |
| BMP | Biodiversity Management Plan |
| HBT | Hollow-bearing Tree |
| KTP | Key Threatening Process |
| LEP | Local Environmental Plan |
| LGA | Local Government Area |
| MMP | Microbat Management Plan |
| MNES | Matters of National Environmental Significance |
| NSW | New South Wales |
| NPW Act | NSW *National Parks and Wildlife Act 1974* |
| OEH | NSW Office of Environment and Heritage |
| OMP | Offset Management Plan |
| PCT | Plant Community Type |
| PSSC | Port Stephens Shire Council |
| SEPP | State Environmental Planning Policy |
| SIS | Species Impact Statement |
| TEC | Threatened Ecological Community |

# Definitions

| Abbreviation | Description |
|---|---|
| Abundance | Means a quantification of the population of the species or community |
| Activity | Has the same meaning as in the EP&A Act |
| Affected species | Means subject species likely to be affected by the proposal |
| Composition | Means both the plant and animal species present, and the physical structure of the ecological community |
| Conservation status | Is regarded as the degree of representation of a species or community in formal conservation reserves |
| Direct impacts | Are those that directly affect the habitat and individuals. They include, but are not limited to, death through predation, trampling, poisoning of the animal/plant itself and the removal of suitable habitat. |
| DP | Means deposited plan which is the plan number given to a subdivision that is registered by the Land Property Information |
| Extent | Is the physical area and/or the compositional components of the habitat removed and the degree to which each is affected |
| Habitat | The area occupied, or periodically or occasionally occupied, by any threatened species, population or ecological community and includes all the different aspects (both biotic and abiotic) used by species during the different stages of their life cycles. |
| Importance | Relates to the stages of the species' life cycles and how reproductive success may be affected. |
| Indirect impacts | Occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. |
| LGA | Means Local Government Area. |
| Life cycle | The series of stages of reproduction, growth, development, ageing and death of an organism. |
| Local occurrence | The ecological community or threatened species that occur within the study area. This may include adjacent areas if the study area forms part of a larger contiguous area of that ecological community or threatened species habitat, and the movement of individuals and exchange of genetic material across the boundary of the study area can be clearly demonstrated. |
| Local population | The population that occurs in the study area. The assessment of the local population may be extended to include individuals beyond the study area if it can be clearly demonstrated that contiguous or interconnecting parts of the population continue beyond the study area. |
| Local population of a threatened plant species | Comprises those individuals occurring in the study area or the cluster of individuals that extend into habitat adjoining and contiguous with the study area that could reasonably be expected to be cross-pollinating with those in the study area. |
| Local population of a resident fauna species | Comprises those individuals known or likely to occur in the study area, as well as any individuals occurring in adjoining areas (contiguous or otherwise) that are known or likely to utilise habitats in the study area. |
| Local population of migratory or | Comprises those individuals that are likely to occur in the study area from time to time. |

| Abbreviation | Description |
|---|---|
| nomadic fauna species | |
| Locality | Means the area within a five (5) kilometre radius of the study area. |
| Region | Means Bioregion |
| Risk of extinction | The likelihood that the local population will become extinct either in the short-term or in the long-term as a result of direct or indirect impacts on the viability of that population |
| Significant species | Means species not listed in the BC Act but considered to be of regional or local significance |
| Study area | Is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly |
| Subject site | Means the area which is proposed for the activity (direct impact area) |
| Subject species | Means those threatened and significant species, populations and ecological communities which are known or considered likely to occur in the study area |
| Threatening process | Has the same meaning as that contained in the BC Act; the definition is not limited to key threatening processes |
| Viable | The capacity to successfully complete each stage of the life cycle under normal conditions |

# Certification

This Species Impact Statement (SIS) has been prepared by Eco Logical Australia Pty Ltd (ELA) in accordance with the requirements of Sections 7.20 and 7.21 of the *Biodiversity Conservation Act 2016* (BC Act), Section 7.6 of the *Biodiversity Conservation Regulation* 2017, and the requirements issued on behalf of the Chief Executive (CE) of the then Office of Environment and Heritage (OEH) dated 29 March 2019 (**Appendix A**).

The SIS was prepared principally by Alicia Scanlon of ELA, on behalf of the applicant, Hunter Water Corporation (Hunter Water). The applicant has read and understands the implications of the recommendations made in the statement and accepts that the recommendations may be placed as conditions of consent or concurrence for the proposal.

**Alicia Scanlon, Ecologist (Microbat Specialist), Eco Logical Australia Pty Ltd**

"I Angus Seberry, being the applicant for the Balickera Tunnel Remediation Works, Balickera in the Port Stephens LGA have read and understood this Species Impact Statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the proposal".

**Angus Seberry**

**Manager Environment & Sustainability, Hunter Water Corporation**

# CER Checklist

| Matter | Yes/No | Comment |
|---|---|---|
| Has the SIS been signed by both its author and the applicant for consent/approval? | Yes | Certification |
| Has the description of the proposal included all associated activities and works, such as hazard reduction zones, access roads and road upgrades, utilities, etc? | Yes | Section 2.1 |
| Have all requested plans, maps and aerial photographs been provided? This includes any A1 or A0 sized proper survey plans prepared by a registered surveyor that clearly show the location and boundaries of any proposed offsets. | Yes | Maps and plans provided throughout. There are no registered surveyor maps as offsets are likely to be secured through payment into Biodiversity Conservation Fund. |
| Has the SIS determined the subject species by reviewing the suggested list in the CERs, other available information and survey results and assessing which species and ecological communities are to be impacted by the development? | Yes | Section 3 |
| Has the survey undertaken provided sufficient information to determine the likely impacts of the proposal on threatened species and ecological communities? | Yes | Section 4 |
| Have surveys been undertaken during the appropriate season(s) for the detection of the species that may possibly occur on site? | Yes | Section 4 |
| Have surveys been undertaken during appropriate weather conditions? | Yes | Section 4 |
| Have climatic conditions preceding the surveys (e.g. drought c.f. wet) affected the possibility of subject species being detected? | No | Section 4 |
| Have all specific survey methods, techniques and intensities requested in the CERs been followed completely? | Yes | Section 4 |
| Has the documentation of survey effort, locations and techniques provided sufficient information to determine the above? | Yes | Section 4 |
| Has the assessment of impacts included the impacts of ALL activities associated with the development, including fire hazard reduction requirements, access road upgrades, downstream and downslope impacts, detention basins, severing of fauna movement corridors, etc. | Yes | Section 6 |
| Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species' in the locality (locality is defined in the CERs)? | Yes | Section 6 |
| Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the locality? | Yes | Section 6 |

| Matter | Yes/No | Comment |
|---|---|---|
| Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species in the region? | Yes | Section 6 |
| Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the region? | Yes | Section 6 |
| Have alternatives to the proposal been discussed? Alternatives may include relocation of infrastructure or, for example, reducing minimum lot size so that a similar number of lots may be realised whilst retaining a larger conservation lot within a subdivision, or changing mining techniques. | Yes | Section 6.14 |
| Has the discussion of alternatives included assessment of the social and economic (not merely financial) aspects of these alternatives (particularly, of not proceeding)? | Yes | Section 6.14 |
| Has the discussion included an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the *Protection of the Environment Administration Act 1991*? | Yes | Section 6.14 |
| Have all proposals for compensatory actions (e.g. purchase of similar vegetation / habitat or revegetation of habitat, where appropriate) been discussed with the relevant landowners/manager? | Yes | Section 8 |
| Is there documented agreement for sale or revegetation activities? | N/A | N/A |
| Is there agreement to change zoning or enter into a covenant on title in order to secure the conservation of the properties being purchased or revegetated? | N/A | N/A |
| If translocation is proposed, has the impact of the translocation on the recipient site(s) been assessed? | N/A | N/A |
| Is there a 'Plan of Management' or similar titled document? | Yes | Appendix I |
| Has the SIS utilised relevant information from published draft and final recovery plans? If no plan has been published, but it is known that one is being prepared, has the SIS utilised advice from the NPWS as to the likely contents of that recovery plan (liaison to obtain this advice may have been specified in the CERs)? For example, would the proposal result in the loss of a local population or remnant that a recovery plan describes as being of particular importance to the conservation of the species, population or ecological community? | Yes | Section 6 |
| If a BAM Calculator assessment has been done for the proposal have the following been provided: copies of credit reports, copies of field datasheets, and copies of a checklist that includes all data used in the credit calculator and the underlying assumptions, such as how local vegetation communities were assigned to Plant Community Types? | Yes | Section 8.3 |
| Has the SIS discussed the relationship of the proposal to any listed Key Threatening Processes (e.g. does the proposal result in the need for High | Yes | Section 6 |

| Matter | Yes/No | Comment |
|---|---|---|
| Frequency Fire as a fire hazard reduction measure, or does it result in the Clearing of Native Vegetation)? | | |
| Has the SIS discussed the relationship of the proposal to any published Threat Abatement Plan (e.g. does the proposal result in an increased threat in a manner that is specifically at odds with a published plan)? | Yes | Section 6 |
| Has a revised test of significance been included? | Yes | Appendix H |
| Has the ‘Additional Information’ specified in section 9 of the CERs been provided? | Yes | As per below |
| Have the qualifications and experience of those involved in the surveys been included? | Yes | Section 4.5 |
| Have other approvals which are required for the development or activity been documented? | Yes | Section 2.3.2 |
| Any licensing requirements (e.g. s.2.11 under BC Act). | N/A | Not required |

# Executive summary

## INTRODUCTION

This Species Impact Statement (SIS) has been prepared by Eco Logical Australia Pty Ltd (ELA) on behalf of Hunter Water Corporation (Hunter Water) for the Balickera Tunnel Remediation works at Balickera, NSW (the proposal). The Balickera Tunnel was constructed in 1962 and is the main means to transfer water from the Williams River to Grahamstown Dam–the Lower Hunter Region's primary drinking water supply.

## CONTEXTUAL INFORMATION

The proposal includes:

- construction of a coffer dam at the downstream end of the tunnel to facilitate dewatering
- internal tunnel remediation works - replacement of existing bolts, spot bolting as required with dental concrete at isolated locations, and the application of fibre-reinforced shotcrete extending from the roof to the base of the tunnel walls
- establishment of equipment laydowns
- upgrades to existing roads to provide access for construction and maintenance vehicles.

The tunnel is a known roost site for three threatened microbat species; Little Bent-winged Bat (*Miniopterus australis*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*) and Southern Myotis (*Myotis macropus*). This SIS aims to identify potential impacts to threatened species and provides appropriate avoidance, amelioration and mitigation measures for any adverse impacts on the threatened species resulting from the proposal.

This SIS has been prepared under Section 7.2 of the NSW *Biodiversity Conservation Act 2016* (BC Act) and in accordance with the requirements of Section 7.6 of the NSW *Biodiversity Conservation Regulation* 2017 (BC Regulation) and the Chief Executives Requirements (CERs) issued for the proposal.

## INITIAL ASSESSMENT AND RESULTS

The subject species, those species, populations or communities that are known or considered likely to occur in the study area for this SIS, have been determined with reference to the CERs, information held within databases of threatened species records, and targeted surveys within the subject site, study area and locality by ELA and others between 1995 and 2021.

Species known or likely to occur in the study area were assessed as subject species to determine their use of the study area and likelihood of being affected by the proposal. In general, those subject species which were not recorded within the study area despite targeted survey, and which are not species that are difficult to detect, or which would use the site infrequently, were considered unlikely to be affected by the proposal and were not the subject of further assessment. The following subject species underwent further assessment as affected species in accordance with Section 7.6(2)(b) of the *BC Regulation* on the basis that they were considered likely to be affected by the proposal:

- Little Bent-winged Bat (*Miniopterus australis*)
- Large Bent-winged Bat (*Miniopterus orianae oceanensis* (syn. *Miniopterus schreibersii oceanensis*))

- Southern Myotis (*Myotis macropus*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)
- Koala (*Phascolarctos cinereus*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Little Lorikeet (*Glossopsitta pusilla*)
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*)
- Powerful Owl (*Ninox strenua*)
- Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)
- Masked Owl (*Tyto novaehollandiae*).

### ASSESSMENT OF LIKELY IMPACTS

Further assessment in accordance with Section 7.6(2) (c-f) of the *BC Regulation* and the CERs included:

- an assessment of the local and regional abundance for each of these species
- an assessment of habitat within the region including specific habitat features
- habitat utilisation
- the conservation status of the species
- an assessment of the likely effect of the proposal at the local and regional scale.

Consideration of these factors for each of the affected species was used to guide revised assessments of significance in accordance with Section 7.3 of the BC Act (‘test of significance’), to inform the consent authority in determining the proposal.

The tests of significance conducted for species likely and known to be affected by the proposal considered direct impacts, including temporary tunnel exclusion, modification to bat roosting habitat, and removal of approximately 0.05 ha of native vegetation associated with upgrading existing access tracks. They also considered potential indirect impacts including disturbance from noise, lighting and dust, and greater susceptibility to weeds, pests, competition and disease.

Special consideration was given to the assessment for Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis under this SIS. The SIS surveys corroborated the findings of earlier surveys for microbats completed at Balickera Tunnel including the original Fauna Impact Statement for the proposed Stage 2 augmentation of Grahamstown Dam (Ecotone 1995). The study area contains important roosting habitat for all three threatened microbat species. It is assumed that it continues to contain breeding habitat for Southern Myotis (as identified by Ecotone in 1995), based upon the results of ultrasonic surveys undertaken for this SIS. The majority of the roost sites within the tunnel are within 500 m of the upstream portal. The roost sites comprise both natural rock surface (main Little Bent-winged Bat roosts) and vertical holes in the concrete lined sections. Ultrasonic surveys for this SIS indicate that bats preferentially exit / enter the tunnel from the upstream portal.

It was concluded that the proposed tunnel remediation works would constitute a significant impact if the development was approved without any commitment from Hunter Water to ameliorate, mitigate or compensate for the impacts. The proposal will result in high level disturbances and could result in death / injury to bats roosting in the tunnel from heavy plant and machinery operations, noise, light, vibrations, dust, and human traffic within the tunnel. The proposal will involve permanent changes to the vertical holes present in the concrete lined sections of the tunnel through the application of a layer of shotcrete. These holes are used by Southern Myotis as roosting and breeding habitat and as roosting habitat by small numbers of Little and Large Bent-winged Bats. Some areas of Little and Large Bent-winged Bat roosting habitat located on the natural rock surfaces will also be permanently changed through the application of shotcrete and additional rock bolting. The microbat management plan (MMP) sets out provisions in detail for documenting the location and measurements (area, contouring) of roosting habitat. Detailed documentation of roosting habitat has not been able to be completed because access to the internal area of the tunnel is prohibited for safety reasons. The MMP includes specifications on how to recreate the roosting habitat from shotcrete that will be quality checked by a suitably qualified ecologist prior to project completion.

Detailed assessments for other affected fauna species identified that the study area contained suitable foraging habitat for these species. Suitable foraging and roosting/breeding habitat is widely spread in the locality and region, including within conservation reserves, which is easily accessible by these mobile species. The removal of 0.05 ha of foraging habitat within the subject site is unlikely to constitute a significant impact upon these species.

### AMELIORATIVE MEASURES

These impacts to the three affected bat species and the important roosting habitat within the tunnel will be ameliorated by excluding all bats from the tunnel for the period immediately prior to, and during the tunnel remediation works. The exclusion will also be scheduled to coincide with the time of year when the least number of bats reside within the tunnel and when food resources are at high levels so that any remaining bats are best able to cope with the energetic costs of any disturbance. Some of the natural rock surfaces and vertical holes in concrete lined sections used as roosting habitat will be permanently changed following the application of shotcrete and rock bolting. The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species at the conclusion of the tunnel remediation works, either in original format or a combination of original format and replicated roosts.

Excluding microbats from the tunnel for a maximum period of five months poses a residual, but reduced risk of death / injury to bats in comparison to the level of risk associated with the proposal being undertaken without microbat exclusion. Roosting habitat for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis, as well as well as breeding habitat for Southern Myotis will be temporarily unavailable during the proposed works. At least 75% of the roosting habitat within the tunnel will be available once works have been completed, either in original form or as recreated habitat. Bats displaced from the important roost sites must find alternative roost sites that are not already at capacity that are within nightly flight range of the excluded roosts within Balickera tunnel. Several alternative Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis roosts have been located within, or at the limit of the nightly flight range of these three bat species. Alternative roosts that were able to be visually inspected were occupied but not at capacity at the time of survey (September 2020).

Alternative roosting habitat in the form of bat boxes installed beneath suitable nearby structures at least one month prior to the proposed exclusion will minimise the impacts associated with exclusion to Southern Myotis. This species is known to readily inhabit and breed within bat boxes placed in carefully selected locations that align with the preference for this species to roost directly over water (Campbell 2009, ELA 2011, ELA 2012, GeoLINK 2015).

Impacts to Little Bent-winged Bats and Large Bent-winged Bats displaced by the exclusion are more difficult to mitigate. The exclusion will be scheduled to occur over summer when the numbers of Little Bent-winged and Large Bent-winged Bats are at their lowest, although the tunnel has been found previously to be inhabited by Little Bent-winged Bats and Southern Myotis year round. Summer is also a time when both Bent-winged Bat species migrate to summer maternity roosts and individuals may more readily relocate. The availability of insect prey is also at high levels over summer providing a buffer to bats that may expend more energy searching for and flying to alternative roost sites or incurring increased flight times between alternative roosts and foraging areas.

### COMPENSATORY STRATEGIES

Despite the suite of amelioration and mitigation measures proposed, the success of the temporary exclusion and post works habitation of the tunnel by Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis contains an element of risk. A level of uncertainty warrants the application of the precautionary principle. Because of this, an agreement to set aside funds to offset the loss of the roosting habitat, if it should eventuate that the bats do not return by the completion of the two year operational phase monitoring and attain the specified occupancy targets, has also been recommended. Under the current BC Act Biodiversity Offset Scheme, there is no provision for calculating the value of offsets for ‘prescribed impacts’ such as to threatened microbat roosting or breeding habitat within artificial structures.

Offsets required to compensate for the residual direct impacts of the proposal to native vegetation have been calculated using the BAM Credit Calculator (BAM-C) in accordance with the Biodiversity Assessment Method (BAM). The required offset will be achieved by retiring all credits as calculated by the BAM-C in accordance with the Biodiversity Offsets Scheme under the BC Act.

# 1. Introduction

Eco Logical Australia Pty Ltd (ELA) was contracted by Hunter Water Corporation (Hunter Water) to prepare a Species Impact Statement (SIS) to support the Review of Environmental Factors (REF) for remediation works within the Balickera Tunnel at Balickera, NSW. This SIS has been prepared in accordance with the project specific Chief Executives Requirements' (CERs) for an SIS, issued by the NSW Office of Environment and Heritage (OEH) on 29 March 2019 (Appendix A).

## 1.1 Purpose of report

The purpose of this SIS is to:

- allow the applicant to identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the proposal
- assist consent and determining authorities in the assessment of an activity under Division 5.1 of the EP&A Act
- assist the Environment Agency Head in deciding whether or not concurrence should be granted for the purposes of Division 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

## 1.2 Compliance with CERs

The CER requirements and the section within which they are addressed in this SIS are outlined in Table 1-1.

**Table 1-1: CER compliance**

| CERs Section | CER Heading | SIS Section | SIS Heading |
|---|---|---|---|
| 1 | Form and content of the SIS | 1.3 | Form of the Species Impact Statement |
| 2 | Contextual information | 2 | Contextual information |
| 2.1 | Description of proposal, subject site and study area | 2 | Contextual information |
| 2.2 | Provision of relevant maps and plans | 2.2 | Subject site, study area and regional context |
| 2.3 | Land tenure information | 2.2.8 | Land tenure |
| 3 | Initial assessment | 3 | Initial assessment |
| 3.1 | Identifying subject species | 3.1 | Subject species |
| 4 | Survey | 4 | Survey methods |
| 4.1 | Requirement to survey | 4 | Survey methods |

| CERs Section | CER Heading | SIS Section | SIS Heading |
|---|---|---|---|
| 4.2 | Documentation of survey effort and technique | 4.2 | Survey methods |
| | | 4.3 | Summary of survey effort |
| 4.3 | Survey results | 5 | Results |
| 4.4 | Subject species habitat mapping | 5.2 | Habitat assessment |
| 4.5 | General report structure | N/A | N/A |
| 5 | Assessment of likely impacts on threatened species | 6 | Assessment of likely impacts |
| 5.1 | Assessment of species likely to be affected | 6 | Assessment of likely impacts |
| 5.2 | Discussion of conservation significance | 6 | Assessment of likely impacts |
| 5.3 | Discussion of local and regional abundance | 6 | Assessment of likely impacts |
| 5.4 | Assessment of habitat | 6 | Assessment of likely impacts |
| 5.5 | Assessment of the effect of the action on threatened species | 6 | Assessment of likely impacts |
| 5.6 | Description of feasible alternatives | 7.1 | Description of feasible alternatives |
| 6 | Assessment of likely impacts on ecological communities | 5.1.1 | Threatened ecological communities |
| 6.1 | Assessment of ecological communities likely to be affected | 5.1.1 | Threatened ecological communities |
| 6.2 | Discussion of conservation status | N/A | N/A |
| 6.3 | Assessment of habitat | N/A | N/A |
| 6.4 | Assessment of the effect of the action | N/A | N/A |
| 6.5 | Description of feasible alternatives | N/A | N/A |
| 7 | Ameliorative measures | 7 | Ameliorative measures |
| 7.1 | Description of ameliorative measures | 7.3 | Ameliorative measures |
| 8 | Test of significance of likely effect of proposed action | Appendix H | Test of Significance |
| 9 | Additional information | Various | As listed below |
| 9.1 | Qualifications and experience | 4.5 | Qualifications and experience |

| CERs Section | CER Heading | SIS Section | SIS Heading |
|---|---|---|---|
| 9.2 | Other approvals required for the development of activity | 2.3 | Other relevant legislation and approvals required |
| 9.3 | Licensing matters relating to the survey | 4.6 | Licencing |
| 9.4 | Section 7.20(4) reports | 6 | Assessment of likely impacts |
| Project Specific CERs | Personnel | Certification<br>4.5 | Certification<br>Experience and qualifications |
| Project Specific CERs | Species details | 5 | Results |
| Project Specific CERs | Construction details | 2.1<br>7.1 | Description of the proposal<br>Description of feasible alternatives |
| Project Specific CERs | Impacts | 6 | Assessment of likely impacts |
| Project Specific CERs | Mitigation measures | 7 | Ameliorative measures |

## 1.3 Form of the Species Impact Statement

In accordance with Section 7.20 (1) of the BC Act:

- A species impact statement must be in writing signed by the principal author of the statement and by the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires).

## 1.4 Matters to be addressed

The BC Act provides that the SIS must meet all the matters specified in section 7.20 of the Act and any additional requirements in the *Biodiversity Conservation Regulation 2017* (BC Regulation). The requirements outlined in the BC Regulation were replicated within the CERs along with specific requirements relevant to the proposal. Previous surveys and assessments that are relevant to the locality may be used to assist in addressing these requirements.

## 1.5 Project Background

The Balickera Tunnel is located in the Balickera Canal off Italia Road in Balickera, NSW, approximately 50 km north of Newcastle. The Balickera Tunnel was constructed in 1962 and is the main means to transfer water from the Williams River to Grahamstown Dam–the Lower Hunter Region's primary drinking water supply. The tunnel is approximately 1.2 km long and 4.3 m wide and contains a combination of natural rock and concrete-lined sections. Approximately 380 m of the tunnel is concrete lined, with eight separate concrete lined sections (including the two portals) spread throughout the tunnel. Locations in the tunnel are delineated by chainages (in this case corresponding to metres) beginning at CH 0 and ending at CH 1217.5, as numbered from the upstream portal, and by the type of substrate present, concrete lined or natural rock surface. There are 106 vertical cylindrical holes with a diameter of 20 cm within the concrete lined sections, some of which have cavities into the rock behind the concrete lining. Many of these are used as roost sites by microbats, along with certain parts of the natural rock surface itself. This report relies upon chainages supplied by numerous contractors collected during separate surveys and it is noted that there are discrepancies between the chainages provided by each of the contractors. Final chainages and therefore the exact location of the two main bat roosts on natural rock surface and the 106 vertical cylindrical holes must be ground truthed during geotechnical inspections carried out prior to commencement of works, in consultation with the project ecologist appointed to implement the microbat management plan (MMP).

A geological inspection carried out in 2007 identified that the rock bolts were severely corroded and substantial over-break (rock excavated beyond planned extent) was evident in some sections of the tunnel. Due to the corroded rock bolts and over-break, there is potential for rock falls. Tunnel remediation works are proposed to ensure the Balickera Canal can continue operation.

The Balickera Tunnel also currently provides known roosting and breeding habitat for microchiropteran bats, including the following three threatened species:

- Little Bent-winged Bat (*Miniopterus australis*) (roosting habitat only)
- Southern Myotis (*Myotis macropus*) (roosting and breeding habitat)
- Large Bent-winged Bat (*Miniopterus orianae oceanensis*) (roosting habitat only).

The proposed restoration works were considered likely to have a significant impact on the threatened species known to utilise the tunnel. This was based on the nature of the proposal and existing understanding of tunnel usage recorded for three threatened microbat species from previous studies by Ecotone (1995, 2000) Biosis (2017) and GHD (2018). In accordance with Section 7.8 (4) of the BC Act, Hunter Water has elected to prepare an SIS to assess the likely significant impact on threatened species.

# 2. Contextual information

## 2.1 Description of the proposal

### 2.1.1 Tunnel remediation works

The remediation works proposed for the tunnel will improve its structural condition to meet a 100-year design life requirement, improve the operating performance and reduce the risk of future maintenance and inspection works due to rock fall. To achieve the design life, the remediation measures propose to install a new shotcrete / concrete lining in the existing concrete lined sections and to install new rock bolts and / or new shotcrete / concrete lining in low rock quality areas along the unlined (natural rock) sections.

Specifically, the proposed remediation methodology (to be confirmed as part of the detailed design) can be separated into natural rock, concrete lined and tunnel portal categories with proposed remediation methodologies for each outlined below.

#### *2.1.1.1 Natural rock sections*

1. From supported ground, the rock surface over the next advance length is to be cleaned and scaled by high pressure water jetting.
2. Site geotechnical engineer to map the exposed rock face and set out the required support in accordance with the design.
3. Site geotechnical engineer to confirm location of microbat roosting habitat with project ecologist. Remediation works to critical areas of microbat roosting habitat will be avoided, where possible.
4. Detailed measurements will be taken of microbat roosting habitat that cannot be avoided during remediation works. These will be used to contour and shape the shotcrete applied to the location of the impacted microbat roosting habitat to replicate the original features. The resultant surface created must be approved by the project ecologist.
5. Dependent upon the quality classification of the rock, one of the following remediation approaches will be utilised, and any microbat habitat recreated, where required:
    - Application of dental shotcrete combined with spot rock bolting of identified rock wedges
    - Application of dental shotcrete, installation of patterned rock bolting with 1.7 m radial spacing and 1.5 m longitudinal spacing and spot rock bolting of identified rock wedges
    - Installation of patterned rock bolting with 1.1 m radial spacing and 1.5 m longitudinal spacing and spot rock bolting of identified rock wedges
    - Application of 100 mm thick steel fibre reinforced (SFR) shotcrete with mass concrete invert.

Where rock quality is poor, the existing rock support is highly degraded and presents an unacceptably high risk of collapse. There are short stretches of poor quality rock spread throughout the natural rock sections of the tunnel. One of these is found between chainage CH 178 and CH 263, corresponding to where the main Little Bent-winged Bat roosting habitat is located.

#### *2.1.1.2 Concrete lined tunnel sections*

1. Confirm through inspection and engineering assessment that the existing lining has sufficient useful life to undertake the rehabilitation works in a safe manner.

2. Undertake a condition assessment of the structure, testing to determine thickness of existing concrete lining and estimate concrete strength.
3. Site geotechnical engineer to confirm location of microbat roosting habitat with project ecologist. Remediation works to critical areas of microbat roosting habitat will be avoided, where possible.
4. Detailed measurements will be taken of microbat roosting habitat that cannot be avoided during remediation works. These will be used to contour and shape the shotcrete applied to the location of the impacted microbat roosting habitat to replicate the original features. The resultant surface created must be approved by the project ecologist.
5. Concrete lining to be cleaned and the surface aggregate exposed by high pressure water jetting.
6. Apply 150 mm of SFR shotcrete to tunnel roof and side walls and recreate microbat roosting habitat, where required.
7. Cast a new concrete invert for additional durability and robustness.

##### *2.1.1.3 Portal zone*

1. Confirm through inspection and engineering assessment that the existing lining has sufficient useful life to undertake the rehabilitation works in a safe manner.
2. Undertake a condition assessment of the structure, testing to determine thickness of existing concrete lining and estimate concrete strength.
3. Site geotechnical engineer to confirm location of microbat roosting habitat with project ecologist. Remediation works to critical areas of microbat roosting habitat will be avoided, where possible.
4. Detailed measurements will be taken of microbat roosting habitat that cannot be avoided during remediation works. These will be used to contour and shape the shotcrete applied to the location of the impacted microbat roosting habitat to replicate the original features. The resultant surface created must be approved by the project ecologist.
5. Concrete lining to be cleaned and the surface aggregate exposed by high pressure water jetting.
6. Cast new 200 mm thick concrete lining with reinforcement bar at 200 mm spacing and recreate microbat habitat, where required.

Shotcrete will provide a surface that promotes microbat attachment as it is roughened in comparison to cast concrete. Recreation of microbat roosting habitat through the application of shotcrete will aim to mimic the contours, size and shape of the original roosting habitat located on natural rock surfaces, without compromising the structural integrity of the shotcrete. It will also involve preservation / recreation of at least 40 of the 106 cylindrical 20 cm diameter vertical holes found within the concrete lined sections, ensuring that the structural integrity of the shotcrete lining is maintained. Approximately 20% of the existing natural rock surface of the tunnel is anticipated to be sprayed with shotcrete.

The works will be carried out from both ends of the tunnel at the same time, progressing in 3 m sections and operating 24 hours a day. The bats would be excluded from the tunnel for the duration of internal tunnel works (a maximum of five months) using exclusion curtains and a secondary external barrier placed at either end of the tunnel. The details of the proposed exclusion are presented in a microbat management plan (MMP) in Appendix I.

### 2.1.2 Coffer dam

A coffer dam is required to allow dewatering of the Balickera Canal to facilitate tunnel remediation works. The coffer dam will isolate the canal from Grahamstown Dam. Dewatering upstream of the coffer dam (and lock-out of Balickera pump station pumps) will provide safe access for plant and personnel to the canal and tunnel.

The coffer dam is proposed to be located 200 m downstream of the downstream tunnel portal and will be constructed of general fill placed on the upstream and downstream shoulders, separated by a compacted clay fill zone. The upstream and downstream batters on the structure will be 2. 5H:1V. The coffer dam will have a crest width of 7 m, constructed at a level 300 mm above the Grahamstown Dam normal full supply level of RL 13.1 m AHD.

Following construction of the temporary coffer dam the tunnel will be dewatered using pumps (initially operating 24 hours per day, then intermittently when water accumulates in the tunnel) to transfer water from upstream of the coffer dam to the downstream, Grahamstown Dam, side.

Access to the coffer dam is provided through minor upgrades to the existing access tracks on the southern side of the canal. No traffic can access the crest of the coffer dam and no works will occur on the northern side.

### 2.1.3 Access tracks and site compounds

Existing access tracks will be upgraded to facilitate heavy rigid vehicle movements for construction and ongoing operation. A layer of 150 mm road base will be applied to existing tracks where required. Access to the upstream portal will utilise an existing access track and ramp into the canal. Access to the downstream portal will require minor earthworks to create a ramp down the existing canal embankment from the existing access track into the canal. Track widening is required to allow vehicle access at one corner of the existing access in the downstream portion of the study area.

Three site compounds will be located in existing cleared areas (Figure 2-1). The main compound will be in the upstream section of the study area near the Balickera Pumping Station (Figure 2-2). Two secondary compounds are proposed, one near each tunnel portal (Figure 2-2 and Figure 2-3).

### 2.1.4 Construction timing

Access track upgrades, establishment of compounds, coffer dam construction and dewatering will occur prior to tunnel remediation works as part of site establishment. These works are expected to take up to eight weeks and be completed during normal construction hours, except for dewatering which will operate 24 hours per day until dewatering is complete and then intermittently during tunnel remediation.

Tunnel remediation works will occur from both ends of the tunnel. Construction will occur 24 hours a day, seven days a week. Out of hours work is required to minimise the length of time bats are excluded from the tunnel and to minimise the length of time the tunnel is offline.

Tunnel remediation works may take up to five months. The internal tunnel remediation works are proposed as a single event to begin in December and extend until the end of April at the latest. This period has been selected to minimise impacts on bat populations in the tunnel.

## 2.2 Subject site, study area and regional context

### 2.2.1 Subject site and study area

The subject site refers to the area directly affected by the proposal. The subject site shown on Figure 2-1 to Figure 2-3, covers 2.32 ha and includes the following infrastructure:

- Balickera Tunnel
- Balickera Canal (upstream and downstream)
- Coffer dam to be constructed within the Balickera Canal 200 m downstream of the tunnel
- Access tracks
- Site compound areas.

The study area refers to the subject site and any additional areas which are likely to be affected by the proposal either directly or indirectly. The study area is shown on Figure 2-4 and includes the subject site and adjacent areas that will be directly or indirectly affected by the proposal.

The study area covers approximately 17.7 ha and includes approximately 2.7 km of the Balickera Canal and Balickera Tunnel and consists of three sections:

- Upstream section (8.8 ha) which includes the canal and surrounding areas for ancillary facilities and access tracks
- Downstream section (8.8 ha) which includes the canal and surrounding areas for ancillary facilities, access tracks and coffer dam
- Balickera Tunnel which is 1.2 km long.

The land within the study area is maintained and operated by Hunter Water for the Balickera Canal. Photographs of the canal, tunnel portals and surrounds are shown in Plate 1 - Plate 7. The upstream portion of the study area includes Balickera Park, which is open for recreation to the public (Plate 8). The Balickera Canal is fenced with cyclone fencing and existing tracks are maintained along both sides of the Balickera Canal. In the downstream portion of the study area the canal is surrounded by mature forest regeneration, managed for protection of the water catchment, and existing access tracks are maintained.

Water levels within Balickera Canal and ultimately Grahamstown Dam are controlled via the Balickera Pumping Station located in the northern extent of the study area. The pumping station is generally in a closed position, blocking water flow. The control strategy for the pumping station automatically runs pumps to take advantage of available river flow from the Williams River when the dam is below 12.6 m Australian Height Datum (AHD). The control strategy automatically prevents the inlet water level to the tunnel from exceeding 13.6 mAHD. At 13.6 mAHD approximately 300 m of the tunnel is flooded (i.e. 5 or 6 pumps running, upstream at 13.6 mAHD and downstream at 12.8 mAHD).

When Grahamstown Dam is at spill level (no pumping), approximately 210 m of the downstream end of the tunnel is flooded and the dam level is at 12.8 mAHD. When the dam is at 1 in 10 flood level (no pumping), approximately 400 m of the tunnel is flooded and the dam level is at 13.1 mAHD. When the dam is at 1 in 100 flood level (no pumping), approximately 530 m of the tunnel is flooded and the dam level is at 13.3 mAHD.

The water level in Balickera Canal downstream of the pumping station fluctuates based on the water level in Grahamstown Dam and on the current pumping regime. When all pumps are operating at full capacity the water level can rise within the tunnel over a matter of hours such that the downstream portal and the internal area of the tunnel for approximately 300 m becomes submerged. Similarly, when the water level in the dam is at, or very near capacity approximately 210 m of the downstream section of the tunnel including the downstream portal is submerged. Under these scenario's the majority of the microbat roosting habitat within the tunnel remains available as it is located towards the upstream portal. Even under flood conditions roosting habitat in the upper 600 m of the tunnel will be available to microbats. Microbats are prevented from exiting and entering the tunnel via the downstream portal at these times but continue to roost and exit / enter freely via the upstream portal. Thus the roosting habitat is safe from inundation regardless of water levels in the canal / tunnel and available for use by bats at all times. The downstream portal is infrequently flooded but has been submerged 13 times over the past 14 years (since the Grahamstown Dam operating level was raised to the current setting). The maximum dam level during this period was 13.12 mAHD on 6 Jan 2016, which would have flooded approximately 400 m of the tunnel. The length of time the portal is flooded depends on rainfall conditions, but during periods of constant rainfall (such as experienced under La Nina climatic events), the downstream portal can remain submerged for months at a time.

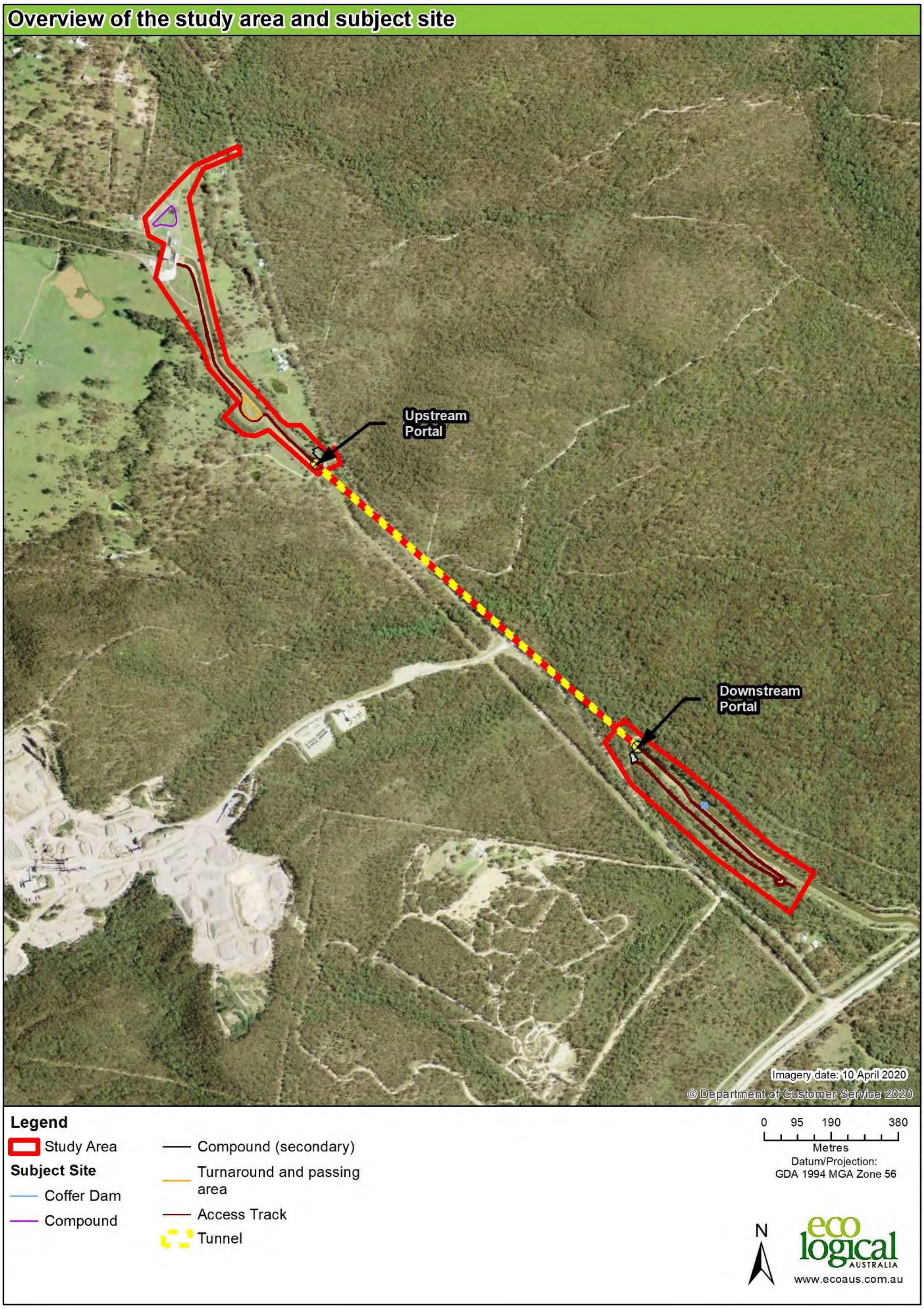



**Figure 2-1: Study area and subject site overview**

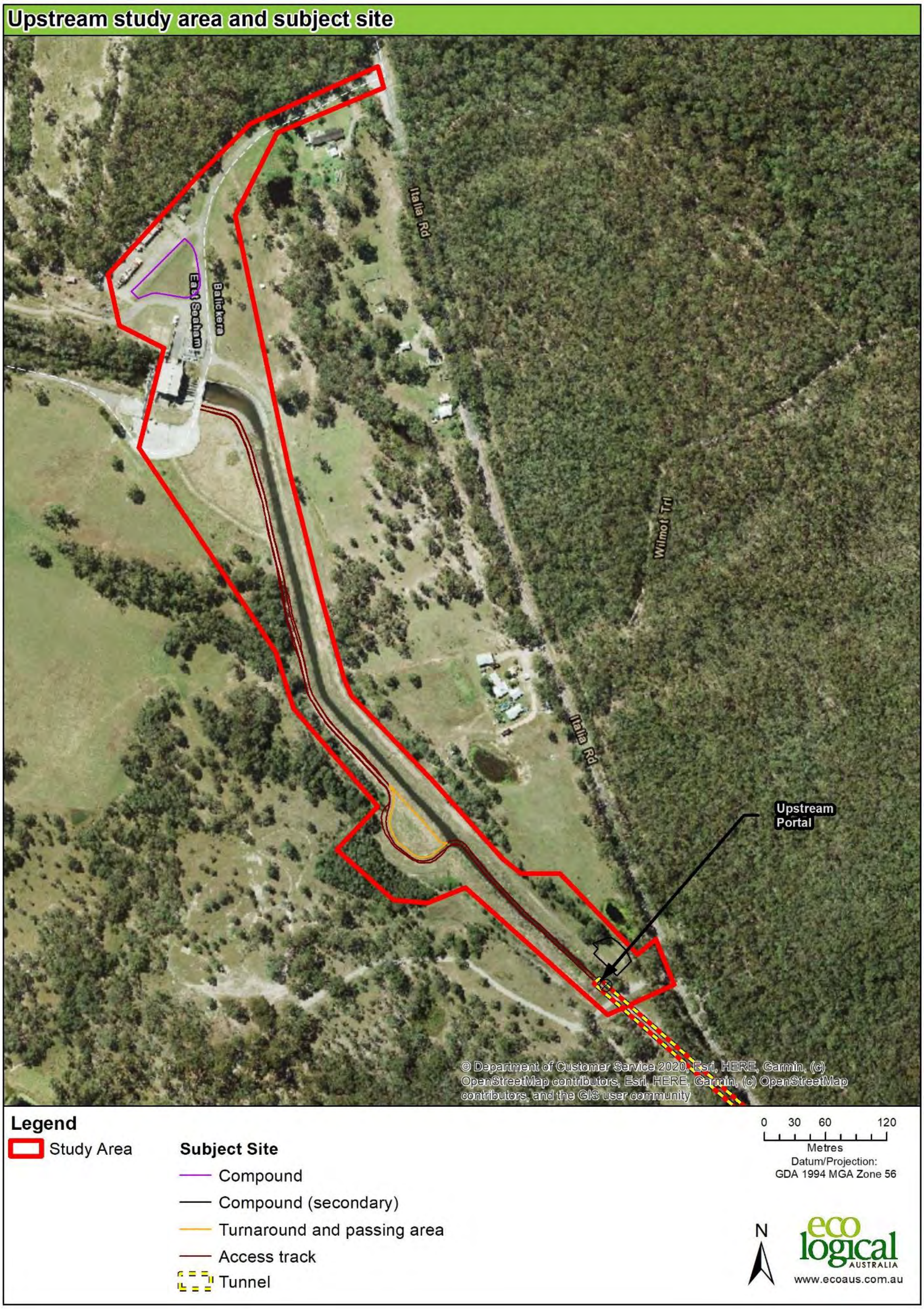



**Figure 2-2: Study area upstream and subject site**

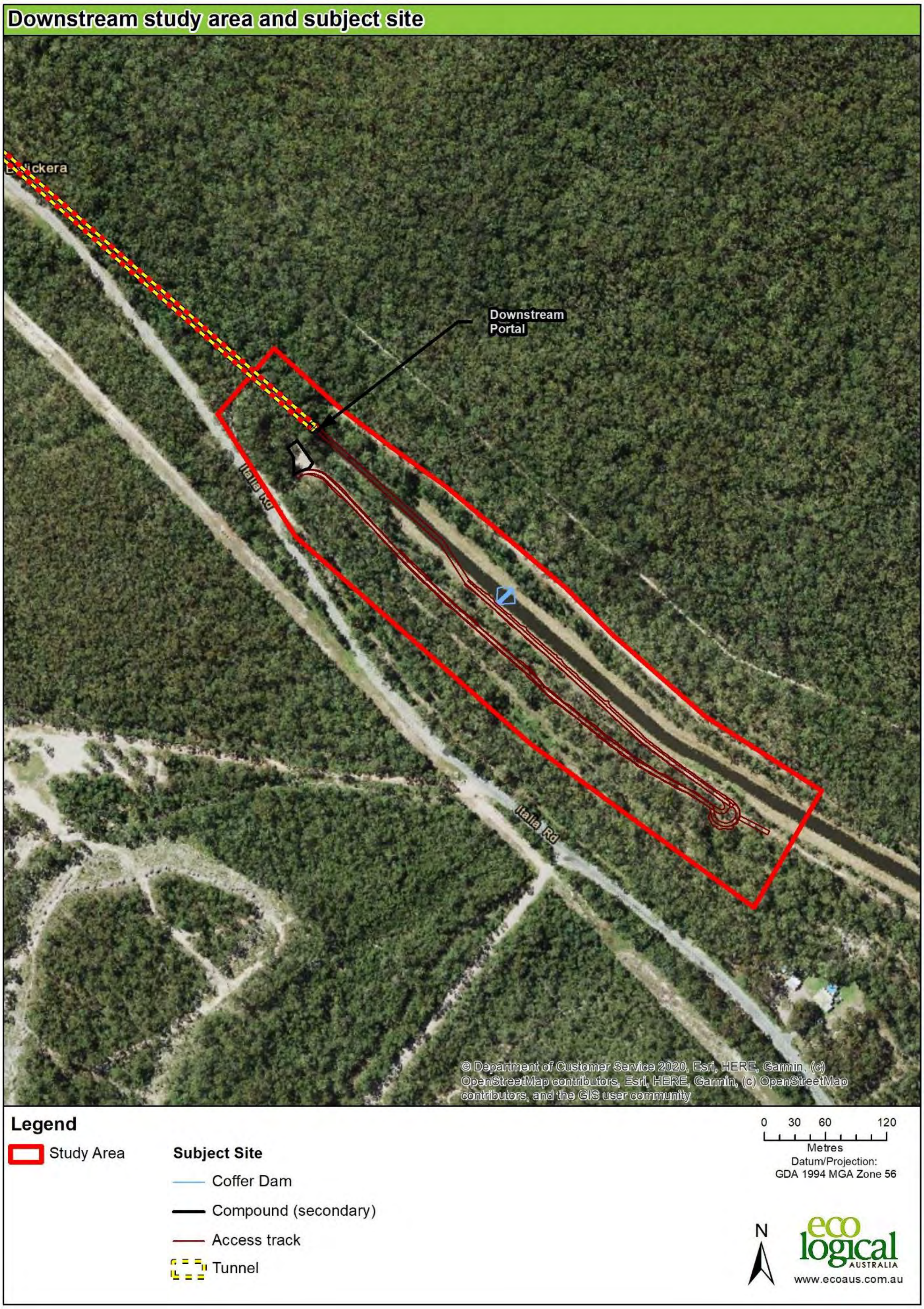



**Figure 2-3: Study area downstream and subject site**

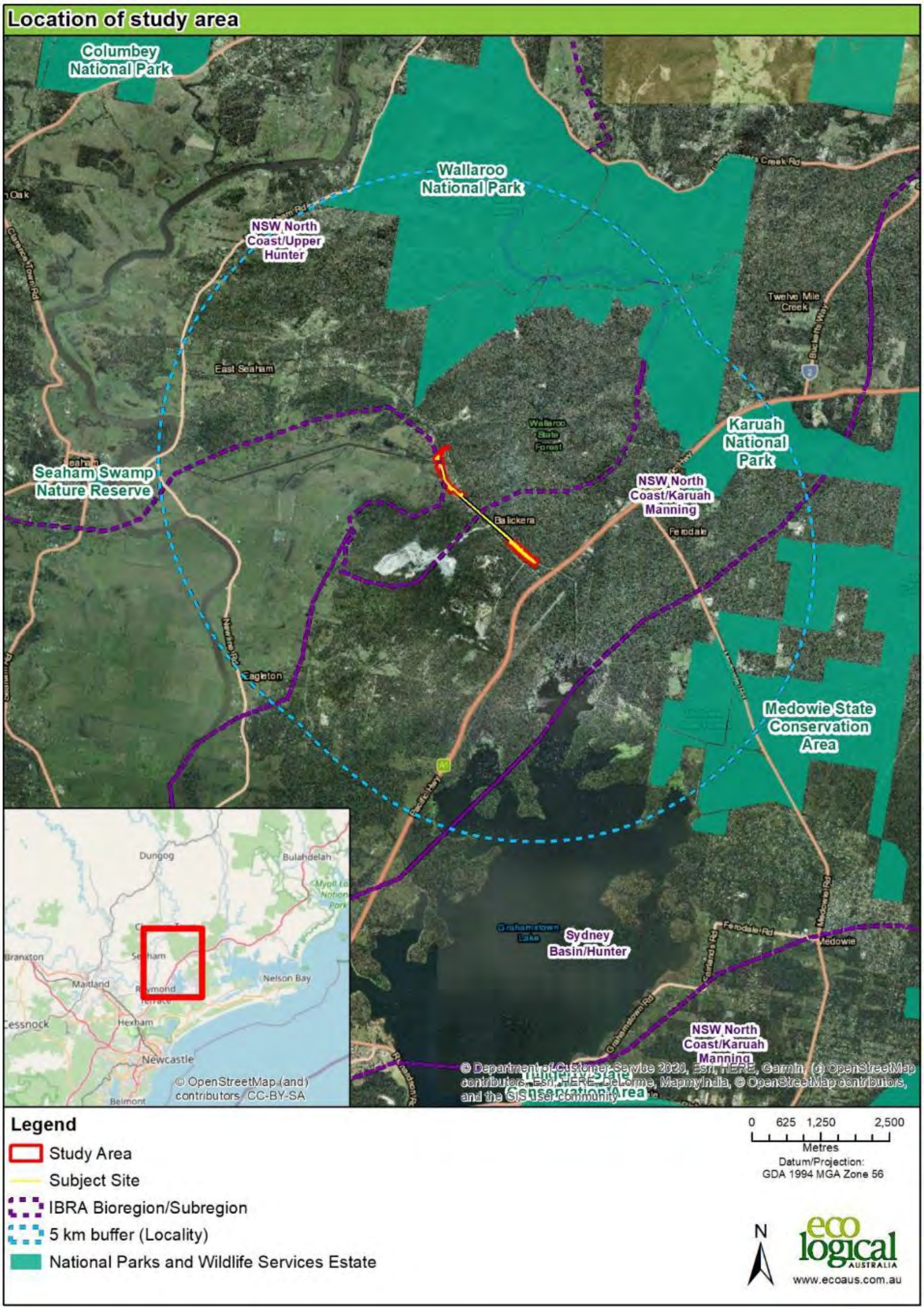



**Figure 2-4: Study area location and locality**


**Plate 1: Downstream portal during low water level (January 2020)**

**Plate 2: Downstream portal during high water level, with portal fully submerged (May 2021)**

**Plate 3: Upstream portal and surrounds during low water level (January 2020)**

**Plate 4: Upstream portal and surrounds during a pumping event showing high water level (March 2020)**

Plate 5: Balickera Pumping Station and Canal (facing west)

Plate 6: Existing access looking towards downstream portal and proposed coffer dam location (facing north west)

**Plate 7: Existing fenced access tracks adjacent to canal in upstream portion of study area (facing south east)**

**Plate 8: Maintained parkland in Balickera Park – site for proposed main compound (facing north)**

### 2.2.2 Locality and region

The locality is the area within a 5 km radius of the subject site (Figure 2-4). The locality is predominantly forested, with land to the north and east containing Wallaroo National Park and Wallaroo State Forest. The Pacific Highway passes though forests 300 m south east of the study area. Forested areas on private land occur to the south and west, and within this area, a large rock quarry and a motor racing track are present. To the north west of the study area is predominantly cleared, agricultural land on the floodplain. Balickera Canal extends from the west to the south east into Grahamstown Dam approximately 2.5 km south east of the study area. Karuah National Park and Medowie State Conservation Area are also present in the east of the locality.

The bioregion of relevance to the locality is identified as the NSW North Coast Bioregion. The majority of the study area, including the entire Balickera Tunnel, occurs within the NSW North Coast Bioregion, with a small part of the study area in the north west located within the Sydney Basin Bioregion (Figure 2-4).

### 2.2.3 Plant Community Types

The mapping and classification of the Plant Community Types (PCTs) in the study area was based on aerial imagery, traverses on foot, collection of Data Points (data on structure, dominant species in each stratum, field observed PCT and photograph) and vegetation quadrats (Vegetation Integrity Plots using the Biodiversity Assessment Method (BAM)). PCT type was assigned based on general location, vegetation structure and dominant species. Four PCTs were mapped in the study area and summarised in Table 2-1 and shown in Figure 2-5. Cleared areas are also present including maintained parkland, existing roads, access tracks and infrastructure.

Two PCTs identified within the study area represent Threatened Ecological Communities (TEC). These are listed under both the BC Act and the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The TECs have not been identified within the subject site.

**Table 2-1: Plant Community Types within the study area and subject site**

| PCT | TEC Status (BC Act and EPBC Act) | Area within study area | Area within subject site |
|---|---|---|---|
| 1588: Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast | Not listed | 3.48 ha | 0.05 ha |
| 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast | Not listed | 3.14 ha | 0 |
| 1598: Forest Red Gum grassy open forest on floodplains of the lower Hunter | *River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria* – EPBC Act Critically Endangered<br>*River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* – BC Act Endangered | 0.76 ha | 0 |

| PCT | TEC Status (BC Act and EPBC Act) | Area within study area | Area within subject site |
|---|---|---|---|
| 1729: Swamp Oak swamp forest on coastal lowlands of the Central Coast and Lower North Coast | *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* – EPBC Act Endangered<br>*Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions* – BC Act Endangered | 0.63 ha | 0 |
| Cleared / Non-native vegetation / Water (canal) / Tunnel | N/A | 9.70 ha | 2.27 ha |
| **Total** | | | **2.32 ha** |

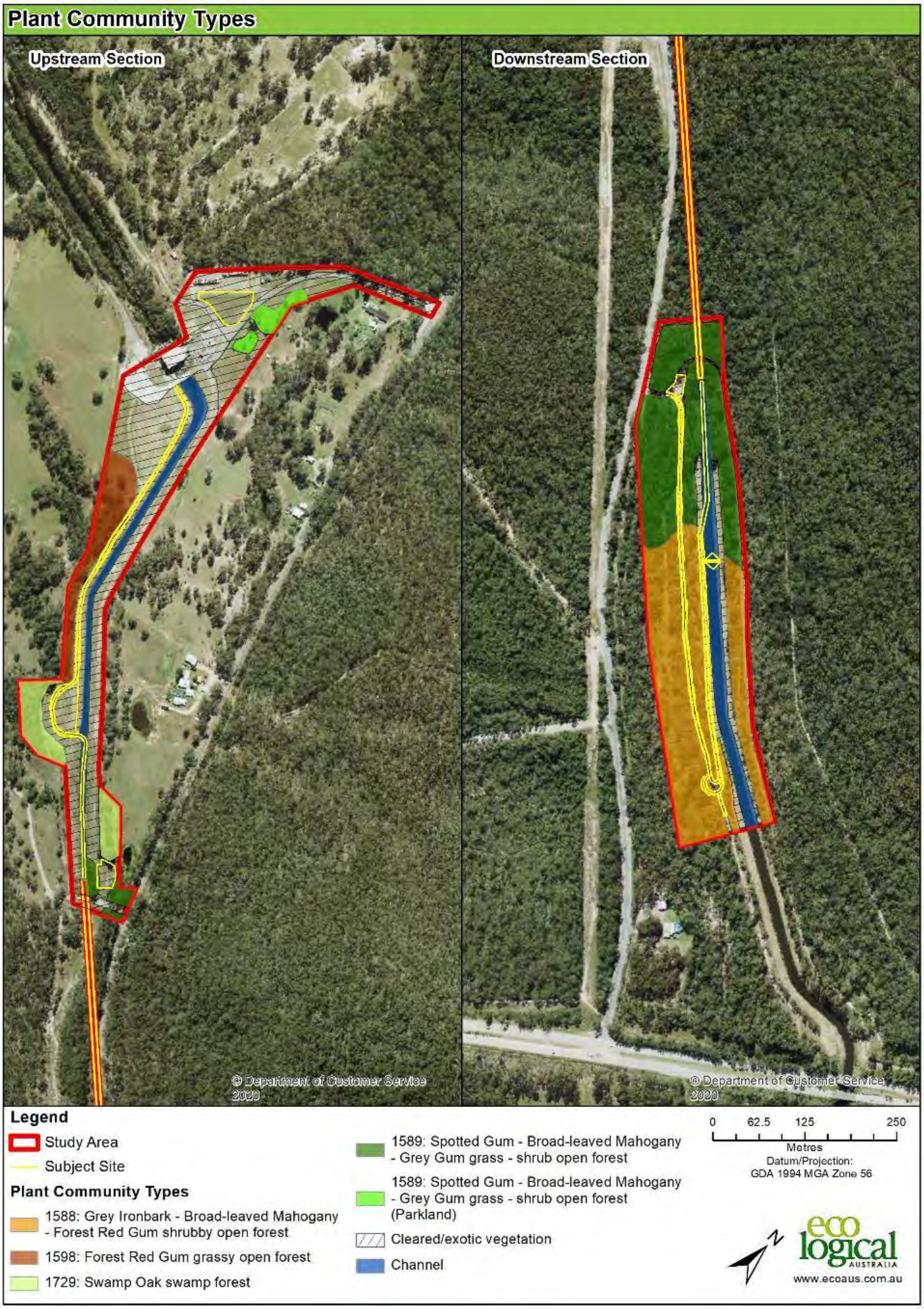



**Figure 2-5: Plant Community Types in the study area**

### 2.2.4 Previous land uses and events

The Balickera Tunnel was constructed in 1962 and involved significant disturbance and excavation of the canal and portal areas in the proximity of the tunnel. Historic aerial imagery from 1976 (Plate 9 and Plate 10) show evidence of disturbance from the Balickera Tunnel construction in the study area. The imagery also illustrates the extent of vegetation clearance to facilitate construction of the Balickera Tunnel, therefore the majority of vegetation within the study area has regenerated since this disturbance.

**Plate 9: Downstream portal in 1976 showing previous disturbance from canal construction**

**Plate 10: Upstream portal in 1976 showing previous disturbance from canal construction**

### 2.2.5 Fire history

Available data from the 'NSW National Parks and Wildlife Service fire history mapping' indicates the Lone Pine fire, in the 2016-17 fire season, burnt extensive areas of forest habitat in Wallaroo State Forest. This included the eastern edge of the study area, in the vicinity of the downstream portal.

### 2.2.6 Local planning provisions and land zoning

The subject site is located on land zoned under the Port Stephens LEP (2013) as SP1 – Special Activities.

The objectives of SP1: Special Activities zoning are:

- To provide for special land uses that are not provided for in other zones
- To provide for sites with special natural characteristics that are not provided for in other zones
- To facilitate development that is in keeping with the special characteristics of the site or its existing or intended special use, and that minimises any adverse impacts on surrounding land
- To ensure the protection of water catchment areas to safeguard the quality and quantity of groundwater and surface water
- To facilitate the provision of infrastructure provided by Hunter Water Corporation.

The Balickera Tunnel also passes under land zoned as RU2 – Rural Landscape and RU3 – Forestry.

### 2.2.7 Topography

The topography of the study area is generally flat with a low hill over the tunnel location. Steep banks are present at each tunnel portal as a result of the original tunnel construction. The upstream portal area represents the upper limit of the floodplain area.

The study area and locality are predominantly located on the Newcastle Coastal Ramp landscape (NSW Landscape, DPIE 2016) which is characterised by undulating lowlands and low to steep hills on complex patterns of faulted and gently folded Carboniferous conglomerate, lithic sandstone, feldspathic sandstone and mudstone. The general elevation is 50 to 275 m with local relief of 40 to 150 m.

A small portion of the study area in the far west, in the vicinity of the Balickera Pumping Station, is located on the Lower Hunter Channels and Floodplains landscape. This landscape consists of channel, floodplain, and estuarine swamps on Quaternary alluvial estuarine sediments of the Hunter River estuary tract, general elevation 0 m to 30 m, with local relief of <10 m. This landscape is present in the western part of the locality where predominantly cleared agricultural floodplain land is associated with the Williams River.

### 2.2.8 Land tenure

The study area is located on land owned by Hunter Water Corporation. No changes to land tenure are proposed as part of this proposal.

## 2.3 Statutory framework and approvals required

### 2.3.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

*The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) lists nine Matters of National Environmental Significance (MNES) that must be addressed when assessing the environmental impacts of a Proposal. Actions that may significantly affect MNES require assessment and/or approval from the Commonwealth Department of Agriculture, Water and the Environment (DAWE) under Part 6 of the EPBC Act.

An action will require the approval of the Federal Minister for the Environment (in addition to any State or Local Government approval or determination) if that action will have, or is likely to have, a significant impact on an MNES. Threatened species and communities listed under the EPBC Act are MNES.

This SIS has included assessment of threatened species and communities listed as MNES under the EPBC Act (Appendix I). No significant impact to MNES is expected to occur as a result of the proposal, as such an EPBC Referral is not recommended.

### 2.3.2 NSW Environmental Planning and Assessment Act 1979

The Balickera Tunnel Remediation works have been assessed in a Review of Environmental Factors (REF) under Division 5.1 of the NSW *Environmental Planning and Assessment Act* 1979 (EP&A Act). Hunter Water is the determining authority for the REF and this SIS. The SIS must have concurrence from the NSW Department of Planning, Industry and Environment (DPIE) prior to Hunter Water determining the REF.

### 2.3.3 NSW Biodiversity Conservation Act 2016

The BC Act seeks to conserve biological diversity at bioregional and State scales; to maintain the diversity and quality of ecosystems and enhance their capacity to adapt to change and provide for the needs of future generations; to assess the extinction risk of species and ecological communities and identify key threatening processes through an independent and rigorous scientific process; and to establish a framework to avoid, minimise and offset the impacts of proposed development and land use change on biodiversity.

Section 7.3 of the Act requires proponents of activities subject to Part 5, Division 5.1 of the EP&A Act to determine whether they will have a significant impact on threatened species. The test for significant impact is described in section 7.3 of the Act. If a significant impact is likely to occur, the proponent of the activity must prepare a Species Impact Statement (SIS) in accordance with section 7.20 or a Biodiversity Development Assessment Report (BDAR).

The proposed restoration works were considered likely to have a significant impact on the threatened species known to utilise the tunnel. In accordance with Section 7.8 (4) of the BC Act, Hunter Water has elected to prepare this SIS to assess the likely significant impact on threatened species.

# 3. Initial assessment

## 3.1 Initial assessment of subject species

Subject species are defined in the CERs as those threatened and significant species, populations and ecological communities which are known or considered likely to occur in the study area. Affected species are a subset of the identified subject species that are considered likely to be affected by the proposal.

Some subject species are not considered to be affected species. For example, a species may have initially been considered likely to occur within the study area based on database records, desktop mapping of habitat and knowledge of species habitat requirements. After collection of more detailed information about the actual habitat in the study area through the field survey, as well as the results of targeted surveys, that species may be considered to not occur within the study area, because the habitat type was not appropriate or because that species was not recorded after adequate surveys had been completed.

Alternatively, the study area may only provide relatively minimal resources for highly mobile species that may occur in the study area from time to time. Such a species is not considered to be an affected species if the habitat within the study area does not consist of important breeding, movement or foraging habitat.

The identification of subject and affected species within this SIS followed a four-stage approach and is described below.

## 3.2 Stage 1 Desktop assessment

A desktop assessment was undertaken to identify a list of species, populations and communities that have been recorded or that have been predicted within the locality, based on a review of databases, vegetation and habitat mapping and previous reports in and around the study area.

All the species, populations and communities from the desktop assessment were combined to produce a list of threatened species, populations and communities previously recorded or predicted in the locality.

This resulted in a list of 28 flora species, 95 fauna species and 18 ecological communities listed under the BC and EPBC Acts as potentially present in the study area, which is provided in the tables in Appendix B.

### 3.2.1 Desktop review

The identification of subject species was undertaken with consideration to the habitat types present within the study area, recent and historical records of threatened species or populations in the locality and the known distribution of threatened species.

The following databases were reviewed for recent (less than 10 years) and historic records and predictions of species, populations and communities when identifying the list of subject species:

- NSW BioNet (Atlas of NSW Wildlife), (www.bionet.nsw.gov.au), (DPIE, 2021)

- Atlas of Living Australia, (https://www.ala.org.au/), (ALA, 2021)
- Australian Museum, (http://ozcam.org.au), (AM, 2021)
- Birdlife Australia – Birdata (https://birdata.birdlife.org.au/), (BA, 2021)
- Royal Botanic Gardens, (http://plantnet.rbgsyd.nsw.gov.au), (RBG, 2021)
- EPBC Act Protected Matters Search Tool, (www.environment.gov.au/epbc/protected-matters-search-tool), (DAWE, 2021)
- Eremaea Birdlines, (www.eremaea.com), (EB, 2021)
- BatMap - Australasian Bat Society, (https://www.ausbats.org.au/batmap.html), (ABS 2021).

In addition, the CERs provided a list of species, populations and communities that have either been recorded in the general area (10 km radius), are within the species known geographic limits or their broad habitat preference may be within the study area.

### 3.2.2 Previous studies

#### *3.2.2.1 Fauna Impact Statement for the proposed Stage 2 augmentation of Grahamstown Dam - Ecotone (1995)*

Field surveys were completed by Ecotone to inform a Fauna Impact Statement for the Stage 2 augmentation of Grahamstown Dam in 1994. This included harp trapping for microbats. The results show seventy (70) of 96 bat captures in November 1994 were the cave and tunnel roosting Little Bent-winged Bat. Thirty-one (31) males, 30 non-breeding females and nine pregnant female Little Bent-winged Bats were captured. These findings led Ecotone to investigate the Balickera Tunnel as a potential roost area for Little Bent-winged Bat. Large numbers of bats were subsequently observed exiting the tunnel on dusk and several bat species, including Large Bent-winged Bat were detected via ultrasonic recording. A search for roost sites in the tunnel was unsuccessful, with few bats observed and most flying around during the inspection and preventing roost observations.

On 13 January 1995, a pipe inspection team from Hunter Water used inspection cameras with flexible cables to explore the holes in the concrete section which forms the first 200 m of the upstream end of the tunnel. Cavities large enough to house large groups of bats were found behind some of the holes. Several small groups of *Myotis macropus* (Southern Myotis) and a small group of Little Bent-winged Bats were observed using the concrete lined sections. An adult male, lactating female and a juvenile male Southern Myotis were captured at this time, confirming that Balickera Tunnel is a breeding site for Southern Myotis.

Prior to the Grahamstown Dam augmentation, pumping of water caused the downstream portal of the tunnel to be reduced to only 40 cm above water level when all pumps were operating. Observations by Ecotone suggest that pumping events such as this may have caused most of the bat colony to temporarily vacate the roost site. Stage 2 augmentation of Grahamstown Dam changed water levels in the tunnel, such that the lower entrance and 140 m of the tunnel are partially or fully submerged when Grahamstown Dam reaches or is near capacity.

#### *3.2.2.2 Monitoring of bat colonies roosting in Balickera Tunnel - Ecotone (2000)*

A monitoring program for the three bat species listed as Vulnerable under the NSW *Threatened Species Conservation Act* 1995 (now the BC Act) Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis, was requested by the determining authority of the Environmental Impact Statement (EIS) for Stage 2 of the Grahamstown Dam Augmentation Project. Ecotone conducted several inspections of the tunnel to identify roost locations, as well as trapping and banding of bats to determine seasonal usage and population estimates. These surveys identified two main Little Bent-winged Bat roosts on the rock substrate either side of the second concrete section (~230 and 415 m from the western entrance of the tunnel). The Southern Myotis, along with small numbers of both Little and Large Bent-winged Bats, were found roosting in vertical holes in concrete sections of the tunnel, primarily at the western end. No breeding Southern Myotis were observed at the lower eastern end of the tunnel.

Strong seasonal usage of the tunnel by Little Bent-wing-bats was observed during studies by Ecotone. Pregnant females were observed in November and early December with few females captured by mid-December. Females appear to leave the tunnel to give birth (migrating to a maternity cave, the location of which is unknown, nearest known maternity cave is 290 km to the north) and return to the tunnel in late February to early March. Few juvenile Bent-winged Bats were captured, and it is suggested that juveniles may arrive at the tunnel later in the year. The Southern Myotis occurs in the tunnel year-round and breeds in the tunnel between late October and February. Through most of the year the predominant species in residence is the Little Bent-winged Bat; however, capture data from a single winter capture session, indicates that in winter greater numbers of Large Bent-winged Bats may be present.

Population estimates based on limited mark-recapture data returned a population size of 8,674 Little Bent-winged Bats and 676 Large Bent-winged Bats. This estimate is for a period when females were absent from the colony. Ecotone estimated up to 11,000 Little Bent-winged Bats and 1,000 Large Bent-winged Bats may be present when females return in late February to early March based on extrapolation of banding data and capture ratios. The Southern Myotis was recorded in moderate numbers (60-80) and was observed breeding within concrete holes at the western end of the tunnel.

Sixteen alternative roost sites were investigated within 150 km of Balickera. While several roost sites were observed for Eastern Horseshoe Bats, Large Bent-winged Bats and Little Bent-winged Bats, none were considered suitable for breeding by Bent-winged Bats and did not approach the numbers of bats observed at Balickera. The only known maternity roost for Little Bent-winged Bats is at Willi Willi, 200 km to the north and this location may be where the females from Balickera Tunnel migrate to over summer. There may also be an undiscovered maternity roost for this species closer to Balickera Tunnel. The Balickera Tunnel was considered by Ecotone to be the most southern Little Bent-winged Bat roost site of its size then known.

#### *3.2.2.3 Balickera Tunnel Restoration Project - geotechnical and hydraulic advice and risk assessment - Pells Consulting (2015)*

The geotechnical and hydraulic advice and risk assessment concluded that concrete lined sections of the tunnel did not warrant concern at the time the report was prepared. However, rock bolts in the tunnel were well past their functional design life. Two options for remedial works were proposed; replacement of the existing rock bolt support by 2m long, full column resin encapsulated glass reinforced plastic or to spray a minimum 120mm thickness of dense, stainless-steel-fibre-reinforced shotcrete (SFRS) over the lengths of natural rock identified as being of medium and high risk of collapse.

The main roost area described by Ecotone (2000) is located approximately 270 m from the upstream portal of the tunnel, however Ecotone noted some discrepancy with tunnel measurements and throughout the remainder of this report is noted as being at 240 m from the upstream portal. The location of the roost site was categorised as high risk by Pells Consulting and thus will be subject to remediation works.

#### *3.2.2.4 Balickera Tunnel Bat Survey - Fauna Monitoring Report - Biosis (2017)*

Field surveys were conducted by Biosis during December 2016 and January 2017 in an attempt to determine the species, numbers and sex ratio of bats using the Balickera Tunnel. Harp trapping and ultrasonic recording (using Anabat detectors) were conducted over three nights adjacent to the tunnel portals. A thermal imaging camera (FLIR E60) was also used to record bats exiting the tunnel.

Anabat and harp trapping data indicated that the Little Bent-winged Bat is the most abundant species roosting in the Balickera Tunnel. *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) were also recorded on the ultrasonic detectors with a reasonable number of calls; however, none were caught in harp traps. All 29 bats that were captured in harp traps were male Little Bent-winged Bats.

Some ultrasonic recordings were made that could not be confidently identified to a single species because of overlap in the call profiles of some species. These were:

- *Chalinolobus gouldii* (Gould's Wattled Bat)/ *Mormopterus* sp. (Free-tailed Bats)
- *Nyctophilus* sp. (Long-eared Bats) / (Southern Myotis).

Technical issues hindered the use of the thermal imaging device and associated counting software and manual counts were undertaken from thermal video recordings. An estimate of 2,272 bats were estimated to be using the tunnel based upon the thermal imagery. The number of bats using the tunnel was considered likely to increase following the expected seasonal return of female Little Bent-winged Bats later in the year.

Despite previous studies recording Southern Myotis and Large Bent-winged bat, these species were not positively recorded during this study.

#### *3.2.2.5 Threatened microbat survey of Chichester Dam pipeline tunnel, Brookfield – Biosis (2018)*

The Brookfield pipeline tunnel is located approximately 20 km from the subject site at Balickera. Field investigations combining ultrasonic recordings and two walk-throughs of the tunnel were completed by Biosis between 23 February and 5 March 2018. Observations made during field investigations were that approximately 400 to 500 individual bats were roosting in the tunnel. The combined results of ultrasonic recording data and observations made during tunnel walkthroughs resulted in estimates of 200 - 250 Large Bent-winged Bats, 160 - 200 Little Bent-winged Bats and 40 - 50 Eastern Horseshoe Bats roosting within the tunnel during the survey period. As the field survey was conducted at the end of summer it could not be conclusively determined whether the tunnel represented a maternity roost or an over-winter roost site for any of the three species recorded at Brookfield pipeline tunnel.

#### *3.2.2.6 Balickera Tunnel Inspection, Ecology and Tunnel Condition Report – GHD (2018)*

GHD contracted Abyss Solutions to undertake video recordings of the internal surface of the tunnel using a remotely operated floating Tunnel Inspection Platform (TIP). The TIP survey during September 2018 recorded approximately 12 small clusters (10 – 50 individuals) and four large clusters (250-600 individuals) of bats, along with more than 50 occurrences of single bats being observed. While species cannot be identified from the video footage, the clustering of bats is a typical roosting behaviour of *Miniopterus* spp. (Bent-winged Bats). GHD estimated that the numbers of bats observed via TIP video footage in September exceeded 1,700 bats. However, this was considered likely to be an underestimate. Bat activity and roosting locations captured via the TIP footage were similar to those observed by Ecotone (2000) with bat activity concentrated between 250 to 750 m from the western end of the tunnel and associated with natural rock areas.

Ultrasonic recordings were undertaken outside the upstream and downstream portals on November 30, 2017 and again on 16 April 2018. An emergence survey was also conducted on the evening of 17 April 2018 trialling the use of an infra-red (IR) video system. At least four microbat species were considered likely to be using the tunnel during these emergence surveys including the same three threatened species documented in previous reports (Southern Myotis, Little Bent-winged Bat and Large Bent-winged Bat). The image quality and speed of bats exiting the tunnel prevented any count or estimate of bat numbers from the IR video footage.

## 3.3 Stage 2 Assessment of likelihood of occurrence

A likelihood of occurrence assessment for all species, populations and communities that have been recorded or are predicted to occur within the locality was then undertaken to identify a list of species that had potential to occur or that were likely to occur within the study area.

In order to produce a list of subject species (either known to occur or likely to occur in the study area) the results of the desktop assessment were analysed with consideration of the following factors:

- The type of vegetation communities present in the study area
- The habitat types and features within the study area
- The presence, quantity, quality and degree of fragmentation or likely habitat for individual threatened species
- The known distributions and geographic limits of species, populations and communities
- The known and predicted use of habitat for all potential species.

Based on the assessment shown in Appendix B, the following species, populations and communities are considered to be subject species (i.e. known or considered likely to occur in the study area based on the desktop assessment):

**Flora**

- *Angophora inopina* (Charmhaven Apple)
- *Asperula asthenes* (Trailing Woodruff)
- *Callistemon linearifolius* (Netted Bottlebrush)
- *Eucalyptus glaucina* (Slaty Red Gum)
- *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea)
- *Maundia triglochinoides* (Small Water-ribbons)
- *Persicaria elatior* (Tall Knotweed)
- *Pterostylis chaetophora* (A Greenhood Orchid)
- *Rhodamnia rubescens* (Scrub Turpentine)
- *Rhodomyrtus psidioides* (Native Guava)
- *Tetratheca juncea* (Black-eyed Susan).

**Amphibians**

- Green and Golden Bell Frog (*Litoria aurea*).

**Birds**

- Regent Honeyeater (*Anthochaera phrygia*)
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*)
- Speckled Warbler (*Chthonicola sagittata*)
- Spotted Harrier (*Circus assimilis*)
- Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- Little Lorikeet (*Glossopsitta pusilla*)
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*)
- Swift Parrot (*Lathamus discolor*)
- Square-tailed Kite (*Lophoictinia isura*)
- Powerful Owl (*Ninox strenua*)
- Scarlet Robin (*Petroica boodang*)
- Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)
- Masked Owl (*Tyto novaehollandiae*).

**Mammals**

- Spotted-tailed Quoll (*Dasyurus maculatus*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Little Bent-winged Bat
- Large Bent-winged Bat
- Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)
- Southern Myotis
- Squirrel Glider (*Petaurus norfolcensis*)
- Brush-tailed Phascogale (*Phascogale tapoatafa*)
- Koala (*Phascolarctos cinereus*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

**Communities**

- Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions.

## 3.4 Stage 3 Targeted surveys for subject species

At stage 3 of the assessment of subject species, a field survey strategy was drafted for subject species. Surveys included collection of vegetation data and information about habitats within the study area and responded to the survey requirements of the CERs.

Targeted surveys for threatened flora and fauna species were undertaken at a level at which it was reasonably expected that the species would be detected and at the correct time of year to maximise the likelihood of detection, using the correct survey technique as described within the relevant guideline.

## 3.5 Stage 4 Identification of affected species

Following results of the targeted surveys a list of affected species was identified (Appendix B). Species, populations or communities that are known to occupy the study area and that would be directly impacted by the proposal have been classified as affected species. Species, populations and communities that occupy the study area but that will not be directly impacted by the proposal are not considered to be affected species. Section 4 provides the methodology for the surveys within the study area designed to determine the presence of subject species within the study area.

Section 5 provides the results of surveys and subsequently identifies the affected species.

# 4. Survey methods

## 4.1 Rationale

The flora and fauna survey methodology used in this SIS have been directed by Section 4 of the CERs for the Proposed Balickera Tunnel Stability Works Program and have been undertaken according to the following guidelines:

- OEH, 2018. *'Species credit' threatened bats and their habitats. NSW survey guide for the Biodiversity Assessment Method.* State of New South Wales and Office of Environment and Heritage, Sydney, NSW
- DEC, 2004. *Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft)*, New South Wales Department of Environment and Conservation, Hurstville, NSW
- DECC, 2009. *Threatened species survey and assessment guidelines: field survey methods for fauna. Amphibians*. Department of Environment and Climate Change, Hurstville, NSW
- DPIE 2020a *NSW Guide to Surveying Threatened Plants and their habitats*. Department of Planning Industry and Environment, Hurstville, NSW.

Based on the preliminary list of subject species identified in Section 3 of this SIS, the following surveys were undertaken for the relevant subject species:

- Vegetation surveys to determine vegetation communities
- Targeted flora surveys during the correct flowering period
- Microbat surveys
- Amphibian surveys
- Arboreal and terrestrial mammal surveys
- Diurnal bird surveys.

## 4.2 Survey methods

### 4.2.1 Vegetation survey

An initial site visit and aerial photographic interpretation (API) was used to map vegetation in the study area. This was later refined following several site visits and collection of vegetation Rapid Data Points and floristic plot data. Three BAM vegetation integrity survey plots were completed on 2 January 2021 in order to characterise the vegetation present in the study area and assign a Plant Community Type (PCT). BAM plots involve recording all plant species within a 20 x 20 m area and assigning a cover percentage and abundance estimate. Data on functional attributes including stem size classes, number of large trees, number of trees with hollows, canopy regeneration and length of fallen logs is collected from within a 20 x 50 m plot. Five 1 x 1 m subplots were used to assess leaf litter cover.

### 4.2.2 Identification of Plant Community Types (PCTs)

PCTs identification was determined by incorporating field data with available databases and mapping and by incorporating the following factors:

- Occurrence of the PCT within the relevant IBRA subregion

- Vegetation formation
- Landscape position
- Dominant species.

The above data was compared against the PCT descriptions within the VIS Classification database. PCTs were selected based on a 'best fit' approach, with consideration given to the past disturbances within the study area.

### 4.2.3 Targeted threatened flora

Targeted surveys for flora subject species identified in Section 3.2 were undertaken via the transect method in accordance with DPIE (2020). This included a systematic approach that maximises the likelihood of detecting threatened plant species, including a consideration of seasonal and temporal constraints.

Transects were undertaken within areas of potential habitat within the study area, focusing on the subject site and adjacent areas. Transects spaced approximately 5 m apart were walked and tracks recorded using a handheld GPS. Subject species that were targeted, the flowering/fruiting periods, survey dates and confirmation with guidelines are provided in Table 4-1. A map showing the transects is provided in Figure 4-1.

**Table 4-1: Survey effort for flora subject species**

| Species name | Flowering/Survey period | Survey dates | Conforms to DPIE (2020) |
|---|---|---|---|
| *Angophora inopina* (Charmhaven Apple) | All year | 13 October 2020 | Yes |
| *Asperula asthenes* (Trailing Woodruff) | October to December | 13 October 2020 | Yes |
| *Callistemon linearifolius* (Netted Bottlebrush) | October to January | 13 October 2020 | Yes |
| *Eucalyptus glaucina* (Slaty Red Gum) | All year | 13 October 2020 | Yes |
| *Grevillea parviflora subsp. parviflora* (Small-flower Grevillea) | August to November | 13 October 2020 | Yes |
| *Maundia triglochinoides* | November to March | 29 January 2020 | Yes |
| *Persicaria elatior* (Tall Knotweed) | December to May | 29 January 2020 | Yes |
| *Pterostylis chaetophora* | September to November | 13 October 2020 | Yes |
| *Rhodamnia rubescens* (Scrub Turpentine) | All year | 13 October 2020 | Yes |
| *Rhodomyrtus psidioides* (Native Guava) | All year | 13 October 2020 | Yes |
| *Tetratheca juncea* (Black-eyed Susan) | September and October | 13 October 2020 | Yes |

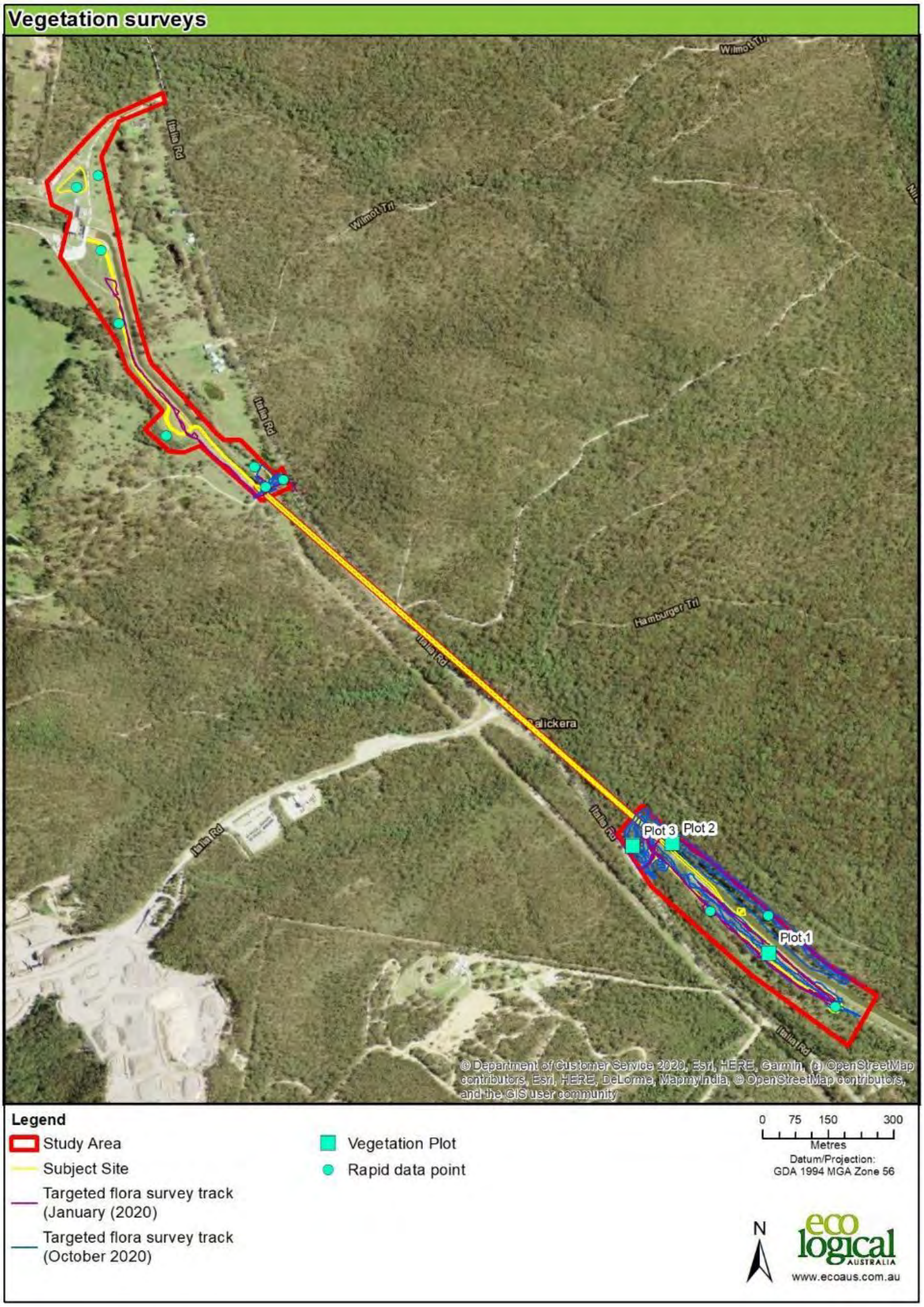



**Figure 4-1: Flora survey effort**

### 4.2.4 Fauna habitat assessment

A general fauna habitat assessment was undertaken in the subject site. This included searching for and recording the following features with a GPS, if they were present:

- Hollow-bearing trees (HBT)
- Bush rock / rocky outcrops
- Watercourses
- Wetland areas
- Standing / flowing water
- Permanent soaks and seepages
- Leaf litter
- Flowering tree species
- Winter flowering eucalypts
- Allocasuarina species
- Flowering shrubs
- Natural burrows
- Logs
- Nests and roosts
- Den trees
- Latrine or den sites
- Distinctive scats
- Bat subterranean roosts including caves, culverts, tunnels etc.

The study area was also mapped according to broad habitat types including forest, cleared/disturbed land and watercourses.

### 4.2.5 Microbat surveys

As previous studies found the threatened Southern Myotis, Large Bent-winged Bats and Little Bent-winged Bats roosting in Balickera Tunnel, the aim of the current bat survey was to answer several questions to inform this SIS. These included:

- Which species of microbat are currently roosting in Balickera Tunnel?
- How many individuals of each microbat species roost within Balickera Tunnel?
- Where in the tunnel are microbats roosting and what are the characteristics of the roosts?
- Are there seasonal differences in bat numbers or sex ratios?
- Is Balickera Tunnel being used as a maternity roost for the affected threatened microbat species?
- Do any of the microbat species inhabiting Balickera tunnel use it as a hibernation or staging roost?
- What elements of the population of each species of microbat (adults, juveniles, males, females) inhabit Balickera Tunnel?
- What alternative habitat for each species of microbat inhabiting Balickera Tunnel is available within the surrounding area, which is taken to be within 50km for the purposes of this assessment. This distance was selected because it approximates the nightly flight range known

for Large Bent-winged Bats, the species with the greatest nightly flight range of the three roosting within Balickera Tunnel.

A combination of survey methods were used in an attempt to answer these questions, as described in the following sections.

#### *4.2.5.1 Harp trapping*

Harp trapping was conducted to capture bats leaving Balickera Tunnel in order to determine which bat species were roosting within the tunnel, and to obtain information on the sex, life stage and breeding status of each bat captured. Three harp traps were set up on the existing stop gate directly outside the downstream tunnel entrance (Plate 11). Between three and four harp traps were set amongst trees above the upstream tunnel entrance (Plate 12). Harp trapping was conducted on the nights of 10 March 2020 (autumn), 9 June 2020 (winter), 7 September 2020 (spring) and 27 January 2021 (summer) to investigate seasonal changes in microbat populations utilising the tunnel. Harp trapping was not conducted directly in front of the upstream portal due to a lack of safe access to the canal for survey personnel. Harp trapping was not conducted at the downstream portal in January 2021 because the canal was at peak levels and the portal was completely flooded. When the downstream portal is experiencing a 1 in 100 year flood, the internal area of the tunnel is flood affected to a maximum of 530 m from the downstream portal, leaving the remainder of the tunnel open and accessible to microbats from the upstream portal.

**Plate 11: Harp traps set to catch microbats leaving the downstream portal**

**Plate 12: Harp traps set adjacent to the upstream portal**

### *4.2.5.2 Thermal Imaging*

Thermal video recording surveys were completed to obtain accurate counts of bats emerging from the Balickera Tunnel and to examine seasonal differences in bat numbers.

A thermal imaging video camera (FLIR A615 / FLIR A655SC / FLIR A65) was used to record video footage of bats emerging from the tunnel portals on two consecutive nights in each season (a total of eight nights). The thermal cameras were located to obtain a field of view which captured the entire tunnel portal and allowed for clear discrimination of when bats were entering or exiting the portal. At the upstream portal the thermal camera was suspended on a rigid pole directly in line with the tunnel entrance, facing directly downwards and over the midpoint of the canal. At the downstream portal the thermal camera was supported on a rigid pole attached to the viewing platform above the southern rock wall, so that the lens was angled at roughly 45 degrees to the plane of the tunnel entrance and 70 degrees from the horizontal (Plate 13). A camera was used at each tunnel entrance concurrently to ensure the full emergence was recorded on each survey night.

The thermal video recording set-up at each end of the tunnel consisted of a thermal camera connected to a laptop computer. Thermal video was recorded directly to the computer hard drive via a user interface program developed by IMC Thermal Control. Thermal video was recorded at a frame rate of between 30 and 60 frames per second, depending on the camera model used, with minimum thermal detector resolution of 640 x 480 pixels and an operating temperature range of -15$^{0}$C to 50$^{0}$C. Thermal cameras were set up at least 30 minutes before dusk and recording was controlled by an ELA ecologist operating the laptop with minimal/red light to avoid disturbance to emerging bats. Recording commenced when the first bat was observed exiting and ceased after one hour, when microbat activity around the tunnel entrances had reduced following the peak emergence period.

Approximate counts of the thermal video footage were completed manually on site during each thermal camera survey by estimating the number of bats observed over a 1 minute period every 5 minutes from the start of the recording. Detailed counting of bats from the recorded footage was undertaken following completion of the surveys at a playback speed of between 1x and 1/8 speed, depending on the intensity of the emergence in each frame. A tally was obtained for each minute of recorded footage, and included the number of bat exits and bat entries during the one hour survey. A screenshot of the thermal video footage is shown in Plate 14.

Bats were visually noted to exit and re-enter the tunnel multiple times during the emergence. The emergence count (population estimate) of microbats present during each one hour thermal camera survey was therefore calculated as the number of exits minus the total number of entries.

**Plate 13: Thermal video recording at the downstream portal**

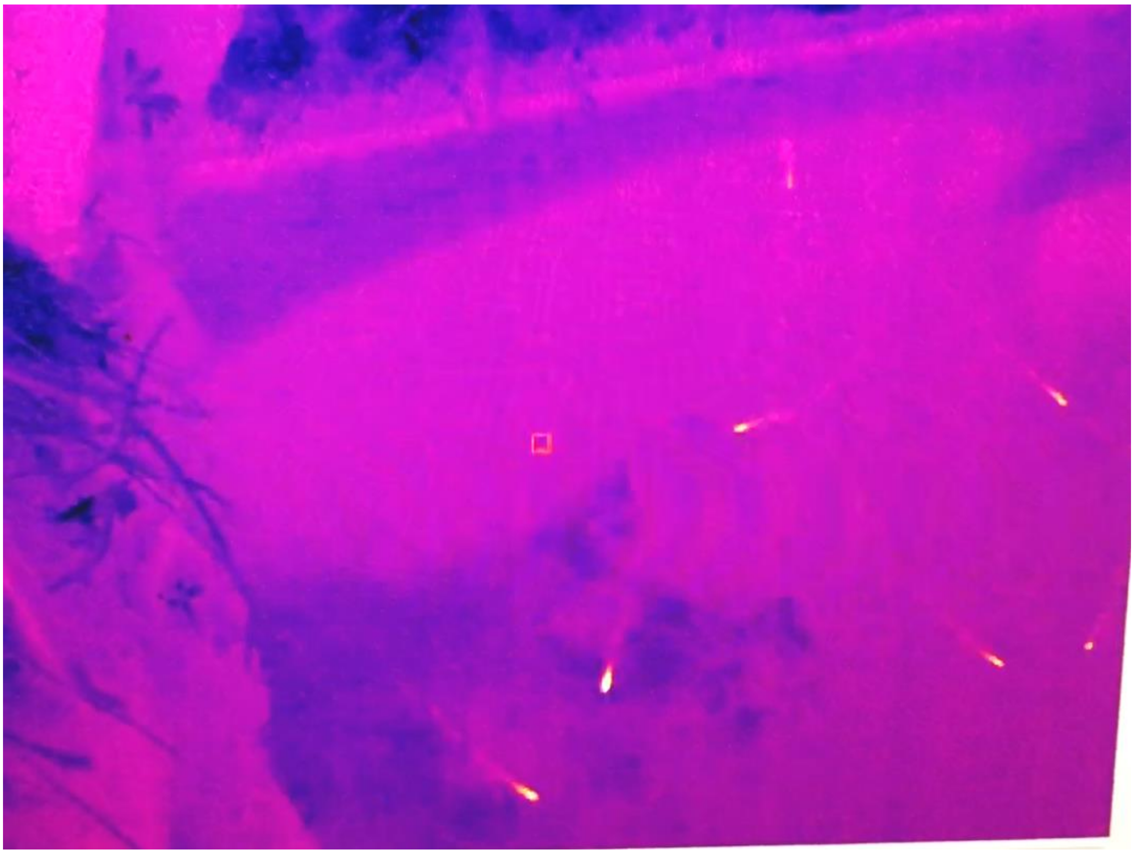


**Plate 14: Thermal imagery still taken from video footage of seven bats (yellow) exiting the downstream portal**

#### *4.2.5.3 Ultrasonic recording*

Ultrasonic recording devices (Wildlife Acoustics SongMeters SM2+BAT) were set up at either end of the tunnel to record microbat calls to assist with species identification and compile a record of bat activity at each tunnel portal during each season. Calls were recorded for a minimum of four nights in each season, with surveys undertaken during March 2020 (autumn), June 2020 (winter), September 2020 (spring) and January 2021 (summer). Each detector was set to record ultrasonic microbat calls passively from 30 minutes prior to sunset until 30 minutes after sunrise for the duration of the survey period each season.

The detectors were positioned to obtain maximum recordings of bats emerging from the tunnel portal and flying immediately in front of the portal entrances. At the upstream portal the detector microphone was attached to a metal beam suspended approx. 6 m above the canal and approximately 6 m from the tunnel entrance. At the downstream portal the detector was placed on the stop gate structure at the same height as the top of the tunnel portal approximately 4 m from the tunnel portal (Plate 15).

Data analysis was conducted on at least four nights of ultrasonic data collected from each detector each season for a total of 32 nights of ultrasonic data, meeting the threatened bat survey requirements under the BAM. Files were recorded as WAV sound files. These WAV files were viewed using the software program Anabat Insight (Version 1.9.7-0-g6302e49) (Titley Scientific) in either zero crossing (ZC) format and / or full spectrum formats. Prior to analysing the data, both the ZC and WAV files were subjected to a Decision Tree Analysis (DTA). The DTA is an automated process that applies noise filters and species-specific filters to the data. In this way files that cannot be attributed to microbat echolocation calls (e.g. noises made by insects, vegetation, wind, train and vehicle movement) are removed from the analysis.

Files are also sorted by characteristic frequency (one of the key identifiable features of microbat calls) to make the analysis more efficient and to separate files into frequency ranges for further analysis. The filtered data was then reviewed manually in both WAV and ZC formats using Anabat Insight (Titley Electronic: Version 1.9.0-4-g15fdd88) to confirm digitally allocated species identifications and to assign or adjust (where necessary) any incorrect species labels applied during the DTA.

Call identifications were made by Alicia Scanlon and Rod Armistead from ELA using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from Sydney Basin, NSW (which is available at http://www.forest.nsw.gov.au/research/bats/default.asp). Species identification was guided by considering the probability of occurrence of a bat species based upon the general distribution information that is provided in Churchill (2008); Pennay *et al.* (2011), Van Dyck and Strahan (2008), Van Dyck et al. (2013) and on BatMap (https://www.ausbats.org.au/batmap.html) and the Atlas of Living Australia web page (https://www.ala.org.au/). To ensure reliable and accurate results the following protocols (adapted from Lloyd *et al.* 2006) were applied:

- Search phase calls were used when analysing the data because they contain more diagnostic features, rather than cruise phase calls or feeding buzzes (McKenzie *et* al. 2002)
- Recorded calls containing less than three pulses were not analysed as they are too short to confidently determine the identity of the species making the call (Law *et al.* 1999). These short sequences were either removed manually or were labelled as unidentifiable
- Calls made by bats that cannot be used for identification purposes such as social calls, short and low-quality calls, cruise and approach phase calls were removed from the analysis of species
- Sequences not attributed to microbat echolocation calls (e.g. insect buzzes, wind, train and vehicle movement) were dismissed from the analysis.

Collation of the results for each portal in each survey period was undertaken by generating species count reports in Anabat Insight. The species count report produces a summary of the number of calls recorded for each species on each night of survey. More detailed reports were also generated which summarised the number of calls of each species recorded during every minute of the survey period on each night of survey, and during every hour of the survey period on each night of survey. The detailed reports were used to correlate species with the number of bats recorded during the one hour thermal camera emergence survey data and to examine the number and proportion of calls of each species recorded during the emergence period.


**Plate 15: Ultrasonic recorder (green box) set near downstream portal of Balickera Tunnel**

#### *4.2.5.4 Tunnel inspection platform*

Abyss Solutions were engaged to conduct a remote above water inspection of Balickera Tunnel on 12 June 2020 to obtain video footage of the internal tunnel crown to determine the roosting locations of microbats in the tunnel. The Tunnel inspection platform (TIP) consisted of a needle-shaped floating platform with infrared illumination and a set of three cameras with adjustable orientation (Plate 16). The TIP was operated by applying tension to two lines attached to the TIP, from the tunnel ends. The lines were floated through the tunnel prior to the inspection using controlled water flow from the Balickera pumping station. Imagery of the tunnel crown for the full length of the tunnel was recorded on the three cameras and merged into a single video file for review and analysis. The Abyss Solutions Balickera Tunnel Inspection Report is included as Appendix K.


**Plate 16: Tunnel Inspection Platform prepared for tunnel inspection**

#### *4.2.5.5 Regional assessment of alternative bat roosts*

Bats displaced from the Balickera Tunnel will require alternative roost habitat during the proposal. ELA conducted a search to locate alternative roosting habitat for the three subterranean roosting species (Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis).

A search for alternative roosting habitat within a 50 km radius that may be used by the affected subterranean roosting species (Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis) such as bridges, tunnels, derelict mines or cave structures was conducted by ELA using a combination of literature review, GIS analysis and physical inspections of structures and ultrasonic recording.

An initial desktop assessment was conducted using GIS to identify potential sites within a 50km radius of the study area. This distance was selected because it approximates the nightly flight range of Large Bent-winged Bats which have been reported to travel 65 km in a night (Churchill 2008). Large Bent-winged Bats are the species with the greatest nightly flight range of the species roosting within Balickera Tunnel. Nightly flight ranges for Little Bent-winged Bats are most commonly up to 33 km (Dwyer 1968), but have been recorded up to 59.5 km (Dwyer 1968) and Southern Myotis is known to travel up to 12 km (Alicia Scanlon pers. comm.). The assessment included identifying known roosts from the literature and BioNet records, bridge crossings over third order streams or higher, areas of steep slope as areas potentially containing cliff/cave habitat, and known mines and tunnels.

From this analysis a group of known and potential roost sites were selected for investigation based on their location, type of potential habitat and accessibility. Sites were investigated with visual inspection and if potential roost habitat was identified ultrasonic recording was undertaken to measure the level of bat activity and aid with species identification (Table 4-2; Figure 4-2).

**Table 4-2: Regional microbat survey locations**

| Site name | Date | Survey methods |
|---|---|---|
| Bushrangers Cave | 7/10/2020 | Visual inspection |
| Richmond Vale Rail Tunnel 1 | 7/10/2020 | Visual inspection and ultrasonic recording |
| Richmond Vale Rail Tunnel 2 | 7/10/2020 | Visual inspection and ultrasonic recording |
| Richmond Vale Rail Tunnel 3 | 7/10/2020 | Visual inspection and ultrasonic recording |
| Brookfield Tunnel | 10/9/2021 | Visual inspection and ultrasonic recording |
| Dungog WTP Tunnel | 10/9/2020 | Visual inspection and ultrasonic recording |
| Pacific Highway Bridges over Balickera Canal | 26/1/2021 | Visual inspection and ultrasonic recording |
| Seaham Bridge | 10/9/2020 | Visual inspection |
| Grahamstown Drain Overpass | 9/9/2020 | Visual inspection |
| Grahamstown Spillway | 9/9/2020 | Visual inspection |
| Grahamstown Culvert | 9/9/2020 | Visual inspection |
| 9 Mile Creek Bridge | 9/9/2020 | Visual inspection |
| M1 Bridge Pambalong | 7/9/2020 | Visual inspection |
| M1 Tunnel Pambalong | 7/9/2020 | Visual inspection, ultrasonic recording and stag watch |

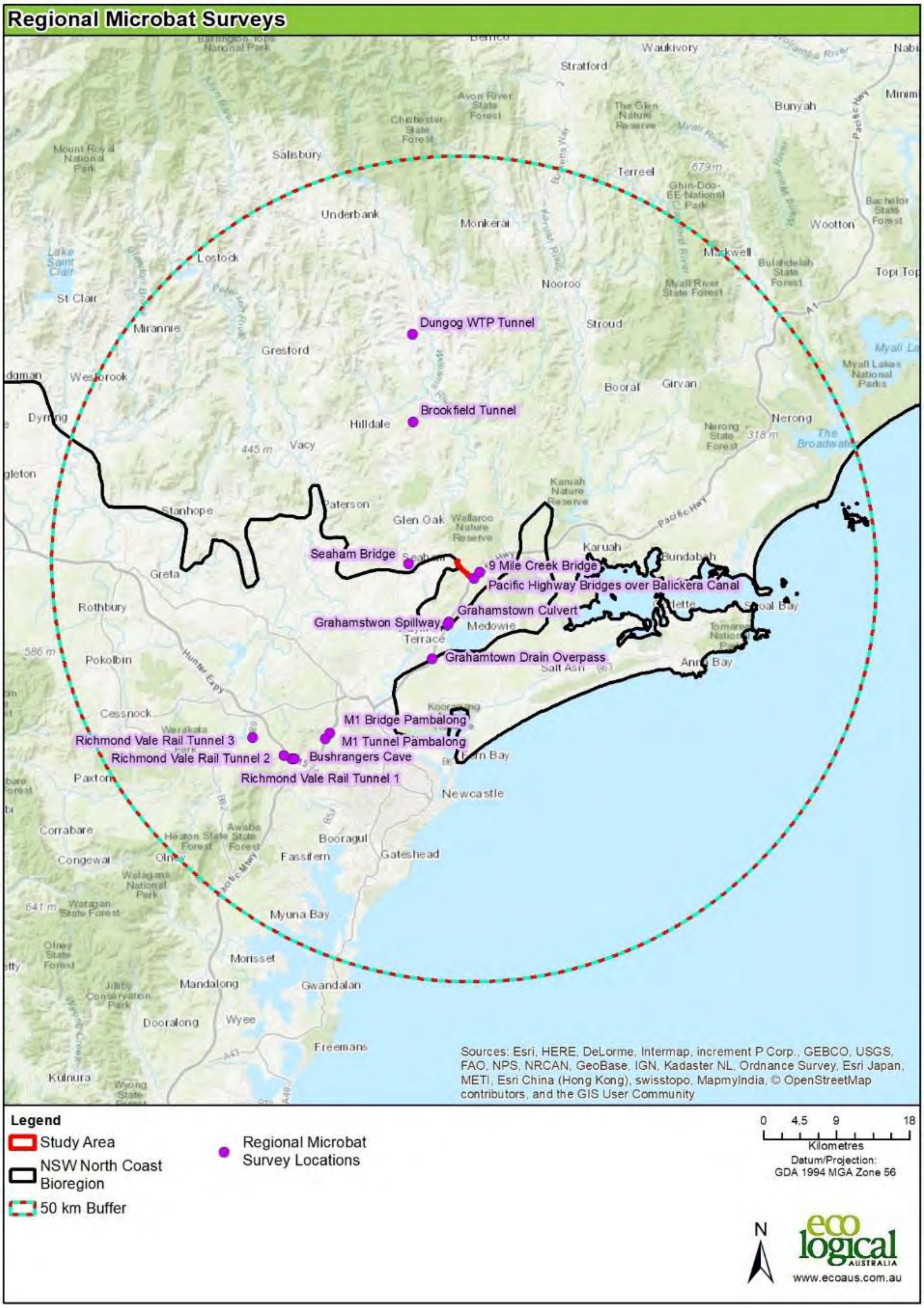



**Figure 4-2: Regional microbat survey locations**

### 4.2.6 Arboreal and terrestrial mammals

Surveys were undertaken for the following threatened mammal species:

- Spotted-tailed Quoll
- Squirrel Glider
- Brush-tailed Phascogale
- Koala
- Grey-headed Flying-fox.

Techniques used included (DEC, 2004):

- Spotlight surveys on foot
- Remote cameras
- Searches for scats and signs.

Spotlight surveys were conducted on the 29 January, 9 March, 12 June, 9 September 2020, and 25 January 2021. Short spotlighting searches were also undertaken in forest habitats in the vicinity of each portal on multiple nights during seasonal bat (trapping and thermal) surveys (Figure 4-3, Table 4-3).

Eight remote cameras were deployed in land immediately surrounding the north and south tunnel entrances between 29 January and 13 March 2020. Three cameras were set to target Spotted-tailed Quoll and placed low on a tree or log and baited with tuna oil and sardines with flour. Four cameras were set to target Squirrel Glider and Brush-tailed Phascogale and were faced towards the trunks of trees baited with universal bait (peanut butter, oats and honey). Bait trees were also sprayed with a honey and water mix as an additional attractant. The final camera was placed facing towards a small ephemeral waterhole on an unnamed drainage line near the downstream portal.

Scats and signs of Koala or Spotted-tailed Quoll were searched for on an opportunistic basis while conducting fieldwork on site. This included systematic litter search within 1 m radius of suitable Koala feed tree trunks and observation of markings on the tree.

### 4.2.7 Amphibian surveys

Surveys were undertaken for the following *Litoria aurea* (Green and Golden Bell Frog), although habitat within the study area was considered to be marginal due to the general lack of aquatic vegetation and frequent disturbance from pumping within the Balickera Canal. Techniques used included spotlighting and active searches on foot, active listening and call playback (DECC 2009).

Nocturnal searches for adult frogs involved walking around the potential habitat actively looking for exposed or active frogs and eyeshine and listening for calls. Surveys concentrated on the areas of potential amphibian habitat in the study area including the Balickera Canal, an unnamed ephemeral creek and surrounding forest habitat adjacent to the downstream portal and a vegetated farm dam adjacent to the study area near the upstream portal.

Spotlight surveys with call playback for amphibians were conducted on the night of 29 January 2020, and spotlighting surveys were conducted on 9 March 2020 and 25 January 2021 (Figure 4-3; Table 4-3). Conditions for surveys were considered suitable for the target species. Air temperature during the surveys were >18 °C and rainfall (>25mm) had been recorded in the area on 26 January 2020 and 6 March 2020 in the lead up to surveys.

### 4.2.8 Diurnal bird surveys

Diurnal bird surveys were completed in the study area using the area search method (20 minute / 1ha), during which all species of bird observed or heard calling were recorded (DEC 2004). A total of eight area search surveys were completed across the study area (Figure 4-3, Table 4-3). Survey locations were at both ends of the tunnel. Incidental observations of birds were also recorded throughout other surveys within the study area. A focus was given by determining the presence of the subject species (identified in Section 3.3) within the study area.

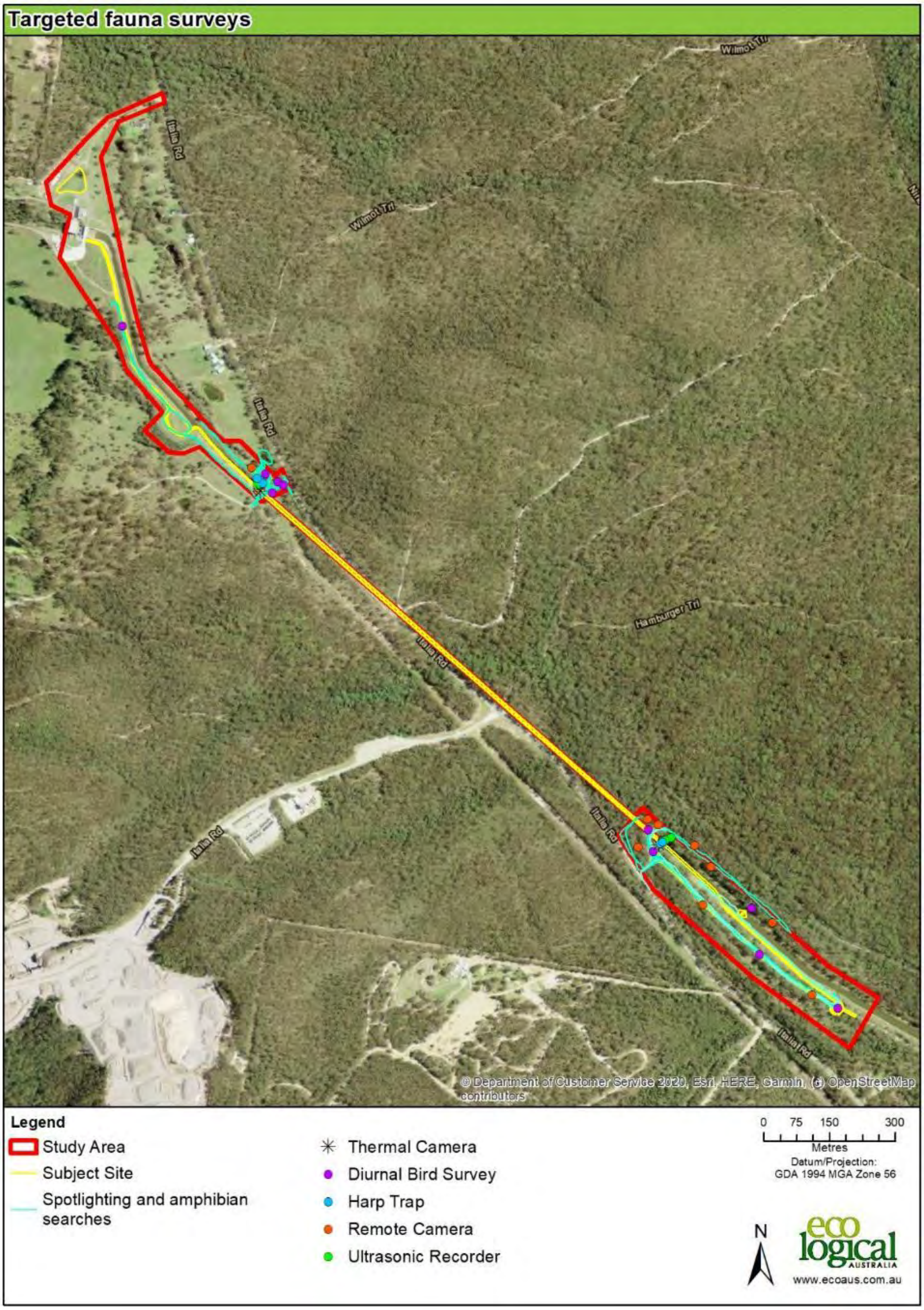



**Figure 4-3: Fauna survey locations**

## 4.3 Summary of survey effort

A summary of all fauna survey effort is shown in Table 4-3. Surveys were designed to be compliant with guidelines specified in the CERs (or newer guidelines where available) and surveys were undertaken by experienced surveyors (Table 4-4). Surveys were compared to the appropriate recommended surveys effort for that survey technique including DEC (2004) and DPIE (2020) for vegetation and habitat description and targeted flora and fauna searches and DECC (2009) for amphibian searches.

**Table 4-3: Survey effort summary**

| Subject species | Survey method | Location and times | Dates | Effort | Recommended effort | Compliance |
|---|---|---|---|---|---|---|
| **Threatened flora** | Parallel transects | Aquatic areas<br>Forest areas | 29 January 2020<br>13 October 2020 | 2 person hours<br>3 person hours | 5 m parallel transects in suitable habitat (DPIE 2020a) | Yes |
| **Microbats** | Harp trapping | Both portals<br>From 30 minutes before sunset to three hours after sunset. | 10 March 2020 (Autumn)<br>9 June 2020 (Winter)<br>7 September 2020 (Spring)<br>27 January 2021 (Summer) | 5 traps<br>6 traps<br>6 traps<br>4 traps (upstream portal only, downstream flooded) | Two trap nights over two consecutive nights (with one trap placed outside the flyways for one night) (DECC, 2004).<br>Southern Myotis: 16 trap nights over a minimum of four nights (OEH 2018)<br>Little Bent-wined Bat and Large Bent-winged Bat: 8 trap nights over a minimum of four nights (OEH 2018) | Yes<br>(trapping focussed on capturing emerging bats so consecutive nights of trapping were not undertaken for ethical reasons) |
| | Ultrasonic recording | Both portals<br>All night (30 mins before sunset to 30 mins after sunrise) | 9-13 March 2020 (Autumn)<br>9-13 June 2020 (Winter)<br>7-11 September 2020 (Spring)<br>25-29 January 2021 (Summer) | 8 nights<br>8 nights<br>8 nights<br>8 nights<br>Total (32 nights) | Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights (DECC, 2004).<br>Southern Myotis: 16 detector nights over a minimum of four nights (OEH 2018) | Yes |
| | Thermal imaging | Both portals<br>From first bat emergence for 1 hour | 11 and 12 March 2020 (Autumn) | Recorded emergence on 8 nights across four seasons | No minimum guideline | Yes |

| Subject species | Survey method | Location and times | Dates | Effort | Recommended effort | Compliance |
|---|---|---|---|---|---|---|
| | | | 11 and 12 June 2020 (Winter)<br>10 and 11 September 2020 (Spring)<br>25 and 26 January 2021 (Summer) | Total of 14 hours of recording | | |
| | Tunnel Inspection | Internal tunnel area | 12 June 2020 | Full internal IR video footage of tunnel | 1 search per structure (OEH 2018) | Yes |
| **Microbats** | Regional Microbat assessment | 14 sites | 7-10 September 2020<br>7-11 October 2020<br>26-29 January 2021 | Visual inspection of 14 sites<br>Ultrasonic recording at six sites | No minimum guideline | Yes |
| **Arboreal mammals** | Remote cameras | 4 sites for 44 nights | From 29 January and 13 March 2020 | 4 sites x 44 nights = 176 trap nights | No minimum guideline | Yes |
| | Spotlighting on foot | Forest habitat | 29 January, 9 March, 12 June, 9 September 2020, and 25 January 2021 | 7 person hours over 5 separate nights | 2 x 1 hour spotlighting on two separate nights (DECC, 2004). | Yes |
| **Terrestrial mammals** | Remote cameras | 3 sites for 44 nights | From 29 January and 13 March 2020 | 3 sites x 44 nights = 132 trap nights | No minimum guideline | Yes |
| | Spotlighting on foot | Forest habitat | 29 January, 9 March, 12 June, 9 September 2020, and 25 January 2021 | 8 person hours over 5 separate nights | 2 x 1 hour spotlighting on two separate nights (DECC, 2004). | Yes |
| **Megachiropteran bats** | Spotlighting on foot | Forest habitat | 29 January, 9 March, 12 June, 9 September 2020, and 25 January 2021 | 8 person hours over 5 separate nights | For targeted survey near likely food resources:<br>2 x 1 hour spotlighting on two separate nights (DECC, 2004). | Yes |

| Subject species | Survey method | Location and times | Dates | Effort | Recommended effort | Compliance |
|---|---|---|---|---|---|---|
| **Amphibians** | Nocturnal searches | Dam and Canal | 29 January 2020, 9 March 2020, 25 January 2021 | 6 person hours over three separate nights | Minimum of one hour on three separate occasions during the species' activity period (OEH, 2009) | Yes |
| | Static or point call surveys | Dam and Canal during nocturnal searches | 29 January 2020, 9 March 2020, 25 January 2021 | 6 person hours over three separate nights | Can be conducted during nocturnal searches (OEH, 2009) | Yes |
| | Call playback | Dam and Canal during nocturnal searches | 29 January 2020 | Two ecologists at two sites on one night | No minimum guideline | Yes |
| **Diurnal birds** | Area search | Forest habitat and Canal<br>Early morning or late afternoon | 29 January, 12 March, 9 and 12 June, 13 October 2020, 25, 26 and 27 January 2021 | 8 x 20-minute surveys, plus incidental observation over multiple seasons | No minimum guideline | Yes |

## 4.4 Weather conditions

Weather conditions during surveys were considered appropriate to detect subject species. Survey timing was scheduled to coincide with suitable weather conditions and included multiple seasons to maximise detection of species.

Weather conditions during the study period were typical of the region and are presented in Chart 1. Observations for daily minimum and maximum temperatures and rainfall were taken from the nearby station Williamtown RAAF (Weather Station ID061078) (BOM, 2021).

No abnormal weather events (such as heat waves) that may preclude detectability of species were experienced. There were numerous nights where heavy rainfall occurred during the survey period. However, trapping or thermal camera video recording was aborted if heavy rainfall was predicted and moved to an alternative night during the survey week each season. Ultrasonic recording was affected by rainfall events, but this was mitigated by the collection of ultrasonic data over a minimum of four nights during each season.

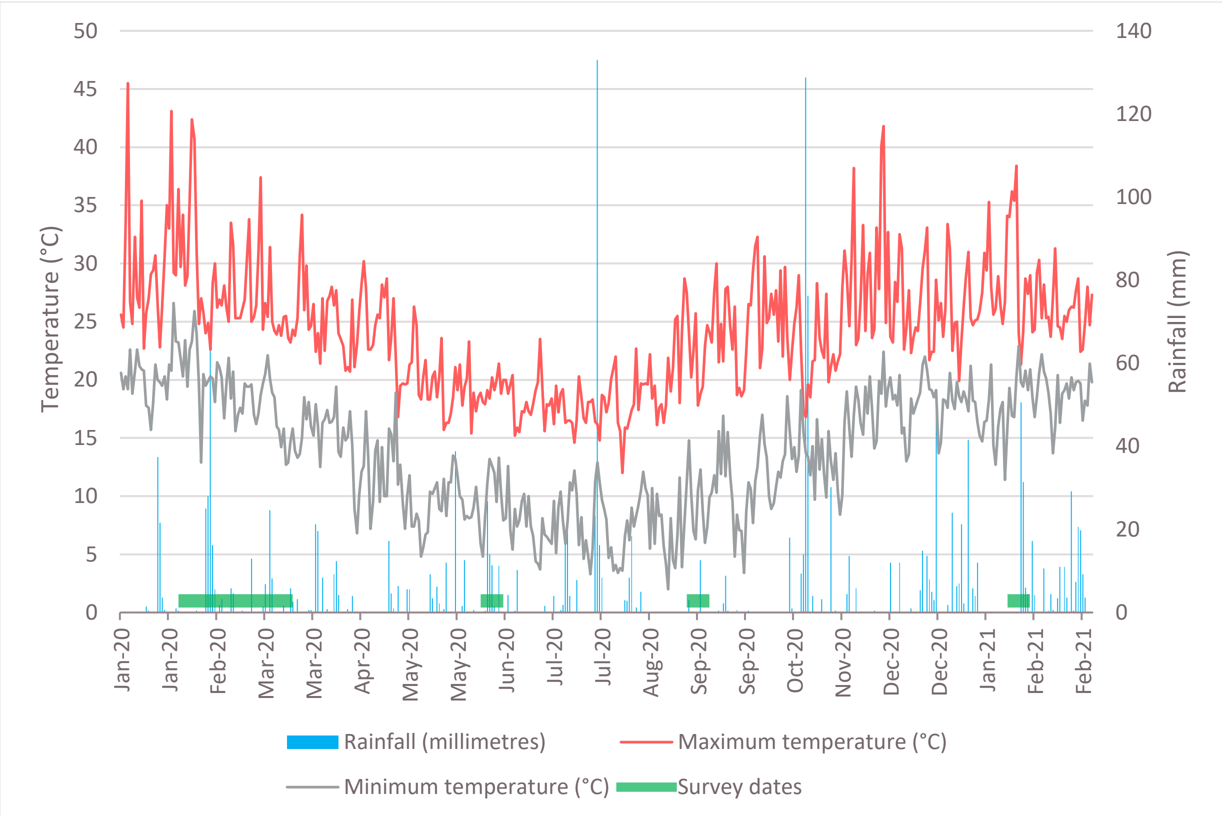



**Chart 1: Weather conditions during the study period**

The water level within Balickera Canal is dictated by the water level within the Grahamstown Dam. Consequently, the water depth within the tunnel and the area available to bats upon exit / entrance varied during the study. As a result of the prevailing drought in the lead up to the study, the dam water levels were very low (52.9% in February 2020) and the canal upstream of the tunnel was reduced to a series of puddles. Over the course of the study higher rainfalls lead to Grahamstown Dam filling, and by January 2021 the dam level was over 95%. During the summer bat survey in January 2021 the water level was so high that the downstream portal was fully submerged. The water level has remained high since this time, and the downstream portal and an estimated 150 m of the downstream end of the tunnel remains submerged at the time of writing (May 2021). Even when the downstream portal is flooded, the majority of the microbat roosting habitat within the tunnel remains accessible and inhabited by microbats as it is located towards the upstream portal.

## 4.5 Experience and qualifications

The field survey was undertaken by trained and experienced ELA ecologists as described in Table 4-4.

**Table 4-4: Survey and planning team**

| Name | Responsibility | Qualifications | Years of relevant experience |
|---|---|---|---|
| Sophie Powrie | Project Director, QA, report review | Bachelor of Applied Science (Environmental Biology) | 19 |
| Tom Schmidt | Project Manager, BAM Accredited Assessor field survey, reporting | Bachelor of Environmental Science (Hons)<br>BAM Accredited Assessor (BAAS19034) | 9 |
| Alicia Scanlon | Microbat Specialist, bat survey lead, data analysis, reporting lead | Bachelor of Science (Ecology and Biogeography) | 19 |
| Dr Frank Lemckert | Field survey, technical review | Bachelor of Science (Terrestrial Ecology and Marine Management)<br>Master of Science<br>PhD (Ecology) | 29 |
| Daniel McKenzie | Field survey, reporting | Bachelor of Environmental Science and Management (Hons) | 10 |
| Dr Rodney Armistead | Field survey, data analysis | Bachelor of Advanced Science (Hons)<br>PhD (Conservation Biology) | 18 |
| Deidre Ryder | Field survey | Bachelor of Environmental Science Management | 5 |
| Rachel Brown | Field survey | Bachelor of Environmental Science (Ecological Conservation) | 2 |

## 4.6 Licencing

ELA holds current Scientific Licence (SL100243) under the BC Act to conduct general flora and fauna surveys.

ELA holds an Animal Research Authority (ARA) issued by the NSW Department of Primary Industries (DPI) to conduct general wildlife surveys associated with consultancies, projects and contract research.

# 5. Results

## 5.1 Vegetation communities

Vegetation surveys identified four PCTs within the study area. Details of these vegetation communities, and their defining features are detailed in Table 5-1 to Table 5-4. Cleared areas of exotic / non-native vegetation were also recorded (Table 5-5). PCT mapping within the study area is shown on Figure 5-1.

No impacts to native vegetation within the upstream area was expected due to existing tracks and fencing between vegetation. Therefore, plot based floristic surveys were undertaken in the downstream portion of the study area and vegetation within the upstream portion of the study area was characterised through collection of rapid data points.

A summary of the area of each PCT within the study area and subject site is presented in Table 5-6.

**Table 5-1: PCT 1588: Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest**

| **1588: Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast** | |
|---|---|
| Vegetation formation: | Dry Sclerophyll Forests (Shrub/grass sub-formation) |
| Vegetation class: | Hunter-Macleay Dry Sclerophyll Forests |
| Vegetation structure | Open forest |
| Conservation status: | Not listed |
|  | This community occurs in the downstream portal section of the study area predominantly in areas of mature regeneration along the Balickera Canal where *Eucalyptus tereticornis* dominates a grassy open forest. Sparse shrubs include *Breynia oblongifolia, Dodonaea triquetra, Exocarpus cupressiformis* and the ground layer included grasses such as *Entolasia stricta* and *Echinopogon sp*. as well as a variety of forbs. Exotic grasses such as *Melinis repens* have high cover in some areas, particularly in areas with previous disturbance and near existing tracks. |
| Landscape position | Low hills |
| Characteristic trees | *Eucalyptus tereticornis* |
| Characteristic midstorey | *Breynia oblongifolia, Dodonaea triquetra, Exocarpos cupressiformis, Persoonia linearis, Alphitonia excelsa* |
| Characteristic groundcovers | *Entolasia stricta, Echinopogon sp., Dichondra repens, Glycine microphylla, Cheilanthes sieberi, Cynodon dactylon,* |
| Exotic species | *Melinis repens, Lantana camara, Ehrharta erecta, Eragrostis curvula* |

| **1588: Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast** | |
|---|---|
| Condition | Moderate-Good condition. Mature regeneration in vicinity of Balickera Canal. |
| Variation and disturbance | Ground cover varies with disturbance regime. High exotic grass cover near tracks. |
| Soil type | Brown Soloths and bleached loams/Lithosols |
| % remaining in NSW | 44% |
| Threats | Weed invasion |
| No. sites sampled | Plot 1 |
| PCT selection justification | The vegetation most resembles a dry sclerophyll forest, is in the Karuah Manning subregion and does not occur on a floodplain area. The plot data recorded characteristic species from all strata. *Eucalyptus tereticornis* is the dominant canopy species. Mid storey species including *Breynia oblongifolia*, *Dodonaea triquetra* and *Pandorea pandorana* are present. Diagnostic species from the ground layer are present including *Entolasia marginata* and *Lobelia purpurascens*. |

**Table 5-2: PCT 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest**

| **1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast** | |
|---|---|
| Vegetation formation: | Dry Sclerophyll Forests (Shrub/grass sub-formation) |
| Vegetation class: | Hunter-Macleay Dry Sclerophyll Forests |
| Vegetation structure | Open forest |
| Conservation status: | Not listed |
|  | This community occurs in the downstream and upstream sections of the study area and includes regeneration areas around the canal and adjacent forest. This community has a diverse eucalypt canopy. A sparse shrub layer is present including *Acacia longifolia subsp. longifolia, Ozothamnus diosmifolius, Callistemon salignus, Glochidion ferdinandi var. ferdinandi*. The ground layer is dominated by grasses *Entolasia marginata, Imperata cylindrica, Microlaena stipoides, Oplismenus aemulus, Panicum simile.* Exotic cover was generally low, although *Lantana camara* is present. |
| Landscape position | Low ranges of the lower Hunter Valley and Central Coast at lower elevations. |
| Characteristic trees | *Eucalyptus acmenoides, Eucalyptus siderophloia, Eucalyptus umbra, Eucalyptus punctata Corymbia maculata,* |
| Characteristic midstorey | *Acacia longifolia subsp. longifolia, Ozothamnus diosmifolius, Callistemon salignus, Glochidion ferdinandi var. ferdinandi* |

| 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast | |
|---|---|
| Characteristic groundcovers | *Entolasia marginata, Imperata cylindrica, Microlaena stipoides, Oplismenus aemulus, Panicum simile, Aristida vagans, Lobelia purpurascens, Dianella caerulea var. caerulea,* |
| Exotic species | *Lantana camara, Hypochaeris radicata* |
| Condition | Moderate-Good condition. Mature regeneration in vicinity of Balickera Canal. |
| Variation and disturbance | Disturbance associated with historical construction of Balickera Canal and Tunnel, and possibly forestry.<br>A highly modified 'parkland' zone of this community occurs within Balickera Park in the north of the study area where some scattered trees are present within maintained/mown parkland. |
| Soil type | Brown Soloths and bleached loams/Lithosols |
| % remaining in NSW | 29% |
| Threats | Weed invasion |
| No. sites sampled | Plot 2 and 3 |
| PCT selection justification | The vegetation most resembles a dry sclerophyll forest, is in the Karuah Manning subregion and does not occur on a floodplain area. Characteristic canopy species present include *Eucalyptus umbra*, *Eucalyptus punctata* and *Corymbia maculata*. The plot data recorded characteristic species from all strata. The canopy includes a variety of eucalypt species. |

**Table 5-3: PCT 1598: Forest Red Gum grassy open forest on floodplains of the lower Hunter**

| 1598: Forest Red Gum grassy open forest on floodplains of the lower Hunter | |
|---|---|
| Vegetation formation: | Forested Wetlands |
| Vegetation class: | Coastal Floodplain Wetlands |
| Vegetation structure | Open forest |
| Conservation status: | *River Flat Eucalypt Forest on Coastal Floodplains* (Endangered BC Act; Critically Endangered EPBC Act) |
|  | This community occurs in the upstream section of the study area on floodplain area west of the canal. |

| 1598: Forest Red Gum grassy open forest on floodplains of the lower Hunter | |
|---|---|
| Landscape position | Coastal floodplain |
| Characteristic trees | *Eucalyptus tereticornis, Eucalyptus molucanna* |
| Characteristic midstorey | *Casuarina glauca, Breynia oblongifolia* |
| Characteristic groundcovers | *Microlaena stipoides, Cynodon dactylon* |
| Exotic species | *Lantana camara* |
| Condition | Moderate. Mature regeneration of previously cleared farmland. |
| Variation and disturbance | Minimal variation. |
| Soil type | Silty loam |
| % remaining in NSW | Not available |
| Threats | Weed invasion |
| No. sites sampled | One rapid data point |
| PCT selection justification | The vegetation resembles an open forest and occurs on a floodplain. The canopy is dominated by *Eucalyptus tereticornis*, and with a grassy ground layer. |

**Table 5-4: 1729: Swamp Oak swamp forest on coastal lowlands of the Central Coast and Lower North Coast**

| 1729: Swamp Oak swamp forest on coastal lowlands of the Central Coast and Lower North Coast | |
|---|---|
| Vegetation formation: | Forested Wetlands |
| Vegetation class: | Coastal Swamp Forest |
| Vegetation structure | Open forest |
| Conservation status: | *Swamp Oak Floodplain Forest* (Endangered BC Act and EPBC Act) |
|  | This community occurs in two patches in the upstream section of the study area on floodplain / lowland areas either side of the canal.<br>*Casuarina glauca* forms a dense tree layer in these areas which have regenerated in areas of formerly cleared farmland. The groundcover is sparse and contains a mixture of native and exotic species including *Microlaena stipoides, Cynodon dactylon, Lantana camara* and *Ehrharta erecta.* |
| Landscape position | Coastal Lowland / Floodplain |
| Characteristic trees | *Casuarina glauca* |
| Characteristic midstorey | *Parsonsia straminea* |

| 1729: Swamp Oak swamp forest on coastal lowlands of the Central Coast and Lower North Coast | |
|---|---|
| Characteristic groundcovers | *Microlaena stipoides, Cynodon dactylon* |
| Exotic species | *Lantana camara, Ehrharta erecta, Bidens pilosa, Conyza bonariensis* |
| Condition | Low to Moderate condition. Regeneration in vicinity of Balickera Canal and former farmland. |
| Variation and disturbance | Occurs as regeneration with in disturbed lower lying areas. |
| Soil type | Silty loam |
| % remaining in NSW | Not Available |
| Threats | Weed invasion |
| No. sites sampled | Two rapid data points |
| PCT selection justification | The vegetation is dominated by *Casuarina glauca* and occurs on coastal lowlands. |

**Table 5-5: Exotic / non-native vegetation**

| Exotic / non-native vegetation | |
|---|---|
| Vegetation formation: | No applicable vegetation formation |
| Vegetation class: | No applicable vegetation class |
| Vegetation structure | Grassland / lawns / cleared land |
| Conservation status: | Not listed |
|  | The vegetation zone is present where historic clearing and ongoing maintenance has occurred. In the upstream portion of the study area parkland, existing access tracks and canal edges are dominated by exotic grassy vegetation including *Pennisetum clandestinum, Paspalum dilatatum, Cynodon dactylon Melinis repens, Chloris gayana*, and *Plantago lanceolata*.<br>In the downstream portion of the study area exotic grasses such as *Melinis repens* and *Chloris gayana* dominate the edges of existing access tracks and the canal banks. |
| Landscape position | Various |
| Characteristic trees | Not present |
| Characteristic midstorey | Not present |
| Characteristic groundcovers | *Melinis repens, Chloris gayana, Paspalum dilatatum, Pennisetum clandestinum, Cynodon dactylon, Plantago lanceolata* |
| Exotic species | Exotic dominated grassland |
| Condition | Poor / Non-native |

| Exotic / non-native vegetation | |
|---|---|
| Variation and disturbance | Includes maintained parkland, existing access tracks and modified canal edges. |

**Table 5-6: Vegetation communities within the study area**

| PCT | TEC Status | Area within study area | Area within subject site |
|---|---|---|---|
| 1588: Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast | Not listed | 3.48 ha | 0.05 ha |
| 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast | Not listed | 3.14 ha | 0 |
| 1598: Forest Red Gum grassy open forest on floodplains of the lower Hunter | *River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria* – EPBC Act Critically Endangered<br>*River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* – BC Act Endangered | 0.76 ha | 0 |
| 1729: Swamp Oak swamp forest on coastal lowlands of the Central Coast and Lower North Coast | *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* – EPBC Act Endangered<br>*Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* – BC Act Endangered | 0.63 ha | 0 |

### 5.1.1 Threatened ecological communities

Two of the PCTs identified within the northern portion of the study area comply with final determinations for listed TECs. The location of TECs within the study area is shown on Figure 5-2.

PCT 1598 in the study area corresponds to *River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* listed as Endangered under the BC Act and Critically Endangered under the EPBC Act.

PCT 1729 in the study area corresponds *Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* listed as Endangered under the BC Act and EPBC Act.

The two TECs occur in the upstream section of the study area. The TECs do not occur within the subject site and occur on the other side of 2 m tall cyclone fencing to the existing access tracks that will be used for the proposal. As such, no impacts to these TECs are expected to occur.

The occurrences of PCT 1588 and PCT 1589 in the study area were considered against the final determination for *Lower Hunter Spotted Gum – Ironbark Forest*, which is listed as an Endangered Ecological Community (EEC) under the BC Act. PCT 1588 in the study area is not considered to correspond to the EEC as the canopy is dominated by *Eucalyptus tereticornis* (Forest Red Gum) and the characteristic canopy species from the EEC, *Corymbia maculata* and *Eucalyptus fibrosa* (Red Ironbark) are not present. PCT 1589 in the study area is not considered to correspond to the EEC as the characteristic canopy species from the EEC, *Eucalyptus fibrosa*, is not present and the vegetation is not dominated by *Corymbia maculata*. This PCT in the study area contains high abundance and diversity of other Eucalypt species which is not typical of the listed community. The EEC is also typically associated with Permian sediments, which do not occur in the study area.

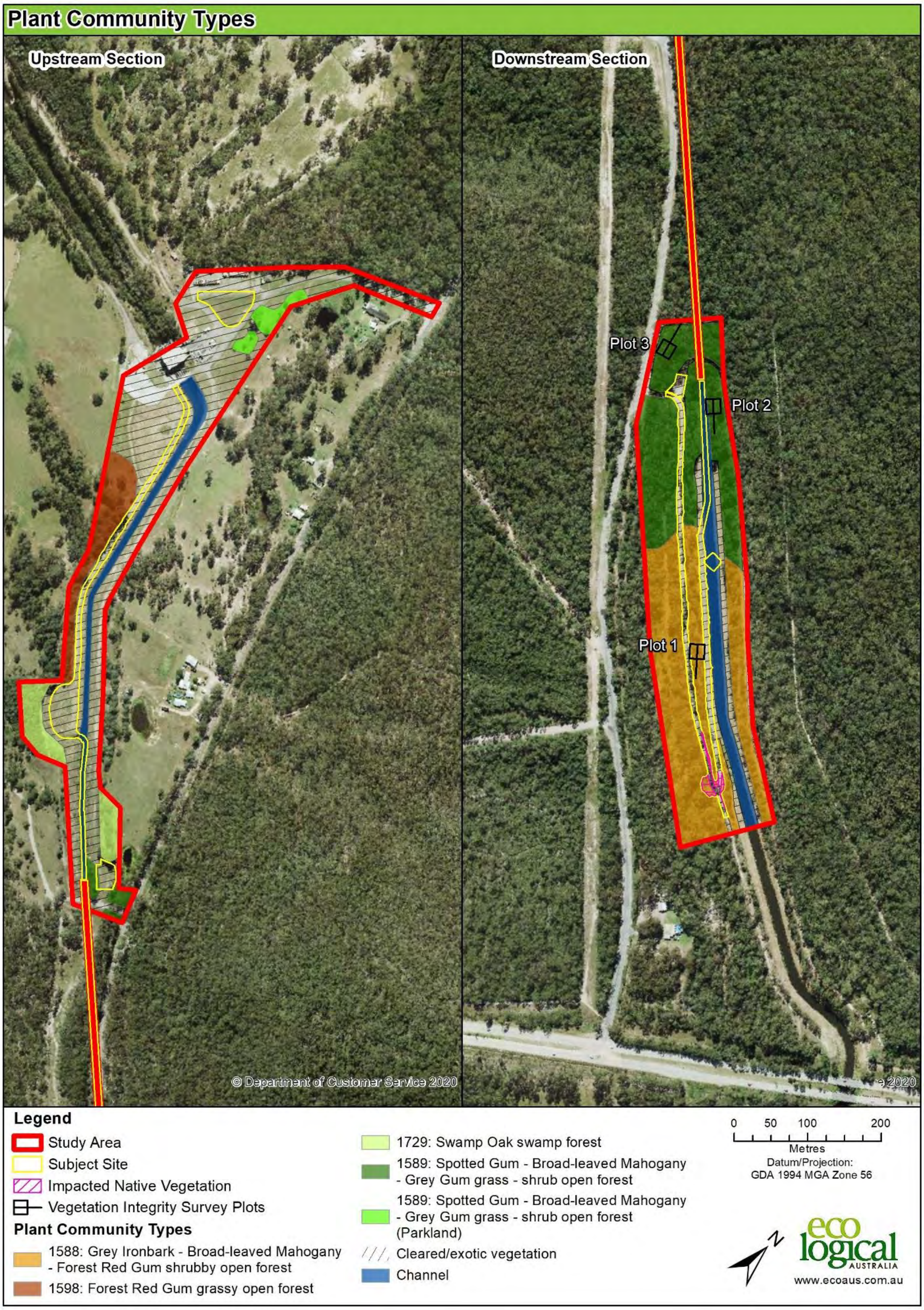



**Figure 5-1: Plant Community Types within the study area**

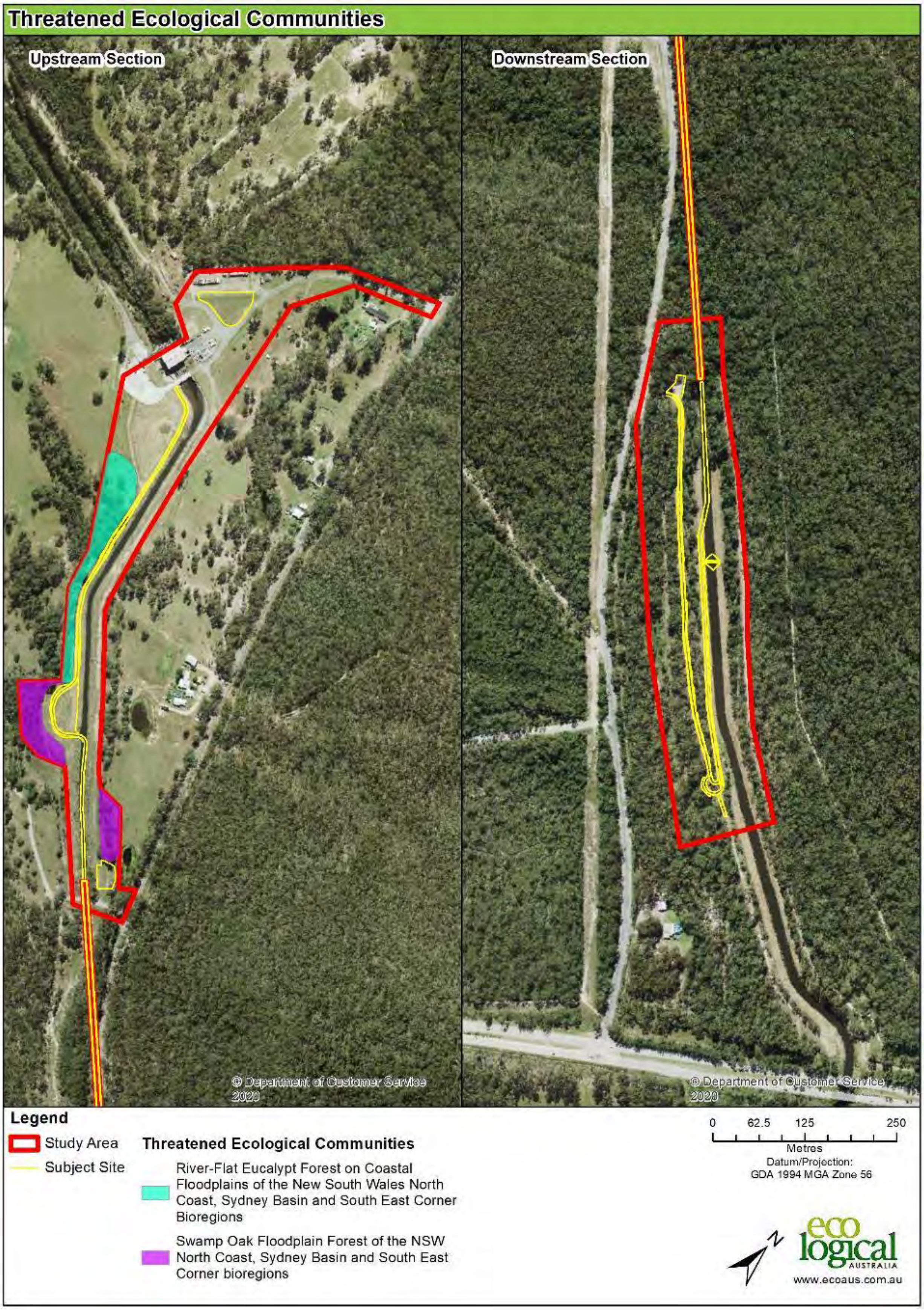



**Figure 5-2: Threatened Ecological Communities within the study area**

## 5.2 Habitat assessment

Fauna habitat in the downstream portion of the study area consists of regenerating open forest on the banks of the canal with connectivity to large areas of remnant forest within the adjacent Wallaroo State Forest and National Park to the north and east and forested private property to the south. Exotic grass areas dominate the immediate surrounds of the canal where existing access tracks are present.

The upstream portion of the study area is generally more disturbed with cleared and partially cleared grassland areas immediately surrounding the canal with some patches of regenerating forest present more broadly. Tree hollows and logs are generally absent from this area. One small open and vegetated dam is located adjacent to the study area approximately 100 m of the upstream portal. Short exotic grass areas dominate the immediate surrounds of the canal and Balickera Park, both of which are maintained by Hunter Water. Habitat features of the study area are summarised in Table 5-7 with habitat types shown in Figure 5-3.

**Table 5-7: Habitat features within the study area**

| Fauna habitat type | Site characteristics |
|---|---|
| Site topography | Generally flat to low hills. Edge of floodplain landscape in the northwest, low coastal hills in the centre and east. The tunnel passes through a central high point. |
| Soil landscapes | Ten Mile Road: undulating low hills on carboniferous sediments and acid volcanics in the Medowie Lowlands and Clarencetown Hills regions.<br>Medowie: gently undulating low hills on relict sediments in the Medowie Lowlands region.<br>Nungra: widespread gently inclined footslopes and drainage plains of the Medowie Lowlands and Karuah Mountains physiographic regions. |
| Habitat types | Dry Sclerophyll Forest, cleared areas, water canal. |
| Hollow-bearing trees | No hollow-bearing trees were recorded in the study area.<br>Hollows are likely to be present in adjacent forest. |
| Rocky outcrops | Canal construction has created some areas of steep rocky slopes near tunnel entrances. Some surface rocks associated with ephemeral stream near downstream portal. |
| Watercourses | Balickera Canal.<br>Drainage line near site entry off Italia Road. |
| Wetland areas | Balickera Canal. |
| Leaf litter | Leaf litter present within forest areas. |
| Flowering tree species | Eucalyptus species, *Corymbia maculata.* |
| Flowering shrubs | Sparse cover of diverse shrubs is generally present in forest areas. Species present include *Acacia longifolia* subsp. *longifolia*, *Callistemon salignus, Ozothamnus diosmifolius, Daviesia ulicifolia, Lissanthe strigose* and *Melaleuca ericifolia.* |
| Bush rock and rocky outcrops | No bush rock recorded. |
| Natural burrows | None observed. |
| Logs | Some logs are present within forest areas. Generally few logs are present due to historical clearing. |
| Standing or flowing water | Balickera Canal. Ephemeral stream. |

| Fauna habitat type | Site characteristics |
|---|---|
| Nests and roosts | No nests were recorded.<br>Balickera Tunnel is a known roost for bats. No other roosts were recorded. |
| Den trees | No den trees recorded. |
| Distinctive scats | No distinctive scats recorded. |
| Latrine or den sites | No latrine or den sites recorded. |
| Allocasuarina sp. | No Allocasuarina species recorded. |
| Bat tree roosts | No bat tree roosts recorded. |
| Bat subterranean roosts | Yes. Balickera Tunnel. |
| Winter flowering eucalypts | *Corymbia maculata*. |
| Permanent soaks and seepages | None. |
| Disturbance history | Canal construction in 1960s. |
| Koala habitat | Forests within the study area are potential Koala habitat. |


**Figure 5-3: Fauna habitats**

## 5.3 Targeted threatened flora surveys

Surveys were conducted at suitable times of the year to determine the occurrence of each target species within the study area. A reference site for *Pterostylis chaetophora* in the locality was checked on the same day as targeted survey in October 2020, which confirmed flowering, and the species was subsequently recorded in the study area confirming the suitability of the survey timing for this species.

Targeted flora surveys within the study area recorded one threatened species, *Pterosytlis chaetophora*, listed as Vulnerable under the BC Act (Plate 17, Figure 5-4). *Pterostylis chaetophora* was not recorded within the subject site. Four individuals were recorded in two separate patches close to an existing access track on the north-eastern side of the Balickera Canal in the downstream section of the study area. The species has also been previously recorded in the upstream portion of the study area, near the subject site and upstream portal, although it was not recorded at this location during targeted surveys in October 2020. This area of potential habitat will be demarcated and fenced as a no-go-zone during construction to ensure no impacts to this habitat area occur.

Following targeted surveys in the appropriate season no threatened flora species are expected to occur within the subject site or be impacted by the proposal.

**Plate 17: *Pterostylis chaetophora* recorded within the study area during targeted surveys. Not recorded within subject site.**

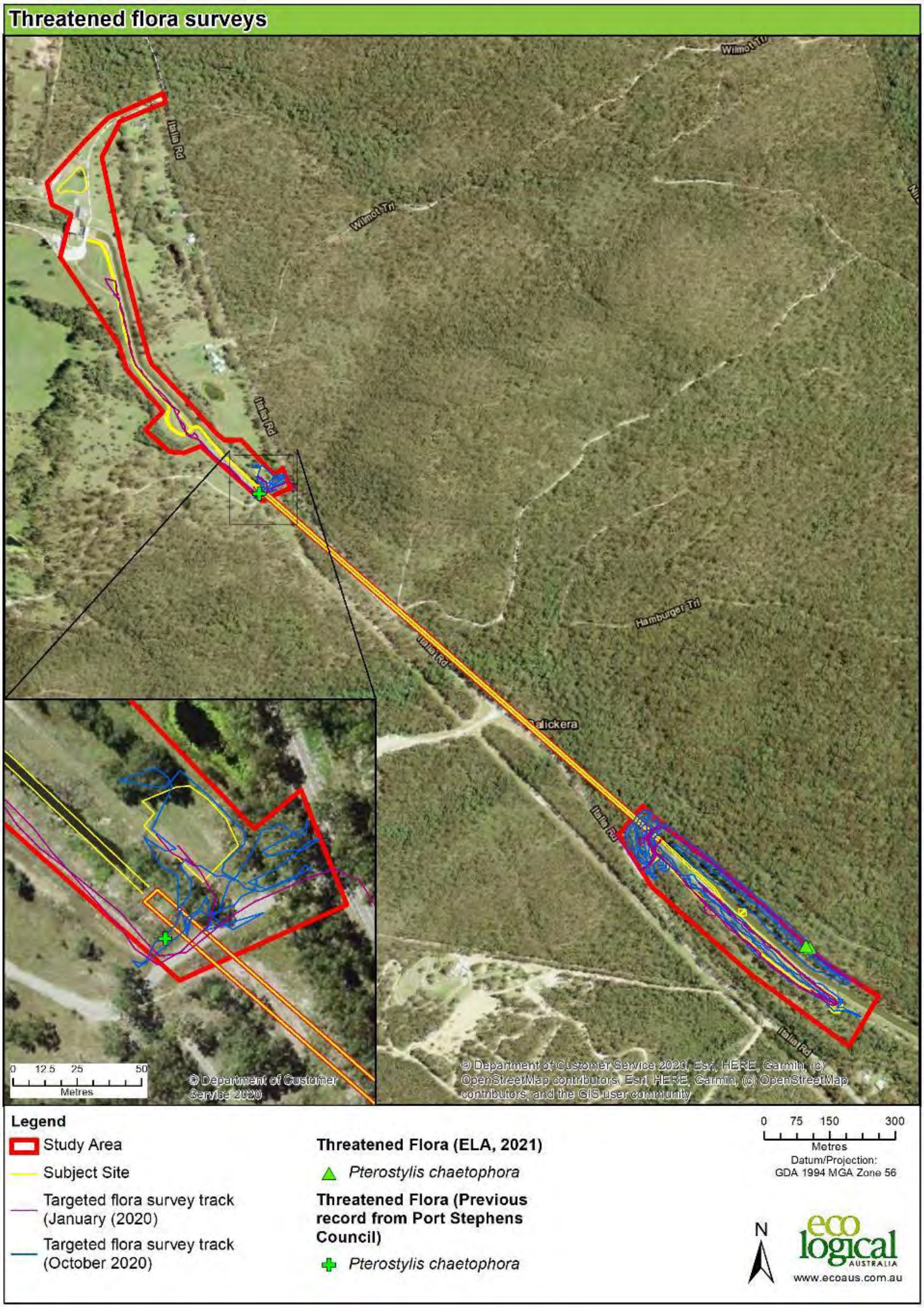



**Figure 5-4: Threatened flora species recorded**

## 5.4 Targeted threatened fauna surveys

### 5.4.1 Microbat surveys

#### *5.4.1.1 Harp Trapping*

Harp trapping outside of Balickera Tunnel resulted in 295 captures of two species of bats over four seasonal trapping surveys conducted at both portals, with the exception of the downstream portal in January 2021 when it was fully submerged (Table 5-8). Of all animals captured, 99% were Little Bent-winged Bats, with Southern Myotis making up the remaining 1%.

Several seasonal differences were observed within the Little Bent-winged Bat colony occupying the tunnel. The trapping data suggests that adult male to female sex ratios change with season (Chart 2). Males outnumbered females during the first autumn survey by 2.4:1. Male to female sex ratios then appeared to even out during winter and spring with slightly more females captured and a sex ratio of 1:1.1 during both surveys. During the final summer survey, a total of 19 adult male Little Bent-winged Bats were captured, but no females were captured. These results are consistent with the pattern of movement between summer maternity roosts and winter roosts reported in the scientific literature for the Little Bent-winged Bat (Dwyer 1968, Mills 2021).

Ten potential sub-adult Little Bent-wing Bats were identified during the initial autumn survey period. Four females during this survey also showed signs of having historically reared young with enlarged or worn nipples. No pregnant females, or female Little Bent-wing Bats that showed recent signs of lactation were captured during the study. Pregnant female Little and Large Bent-winged Bats generally depart winter roost sites between September and December each year and begin to return from February onwards (Ecotone 2000, Dwyer 1968, Mills 2021)

If average body mass is taken as an indicator of physical condition, the condition of both female and male bats peaked during surveys in early autumn. Both male and females dropped body mass during winter and early spring surveys with the males captured in summer appearing to have put on body mass following the winter and spring period.

Three Southern Myotis individuals were captured during the spring survey period in early September 2020 at the downstream portal and consisted of two adult females and one adult male.

There were no bats banded or radio tagged during this study.

**Table 5-8: Numbers of bats captured at Balickera Tunnel during the study**

| Survey season | Species | Male | Female | Sex not recorded | Bats not measured (due to large number of captures) | Total captures |
|---|---|---|---|---|---|---|
| Autumn (March 2020) | Little Bent-winged Bat | 41 | 16 | 1 | 0 | **58** |
| Winter (June 2020) | Little Bent-winged Bat | 54 | 60 | 0 | 17 | **131** |
| Spring (September 2020) | Little Bent-winged Bat | 40 | 43 | 1 | 0 | **84** |
| | Southern Myotis | 1 | 2 | 0 | 0 | **3** |

| Survey season | Species | Male | Female | Sex not recorded | Bats not measured (due to large number of captures) | Total captures |
|---|---|---|---|---|---|---|
| Summer (January 2021) | Little Bent-winged Bat | 19 | 0 | 0 | 0 | **19** |
| **Total** | | | | | | **295** |

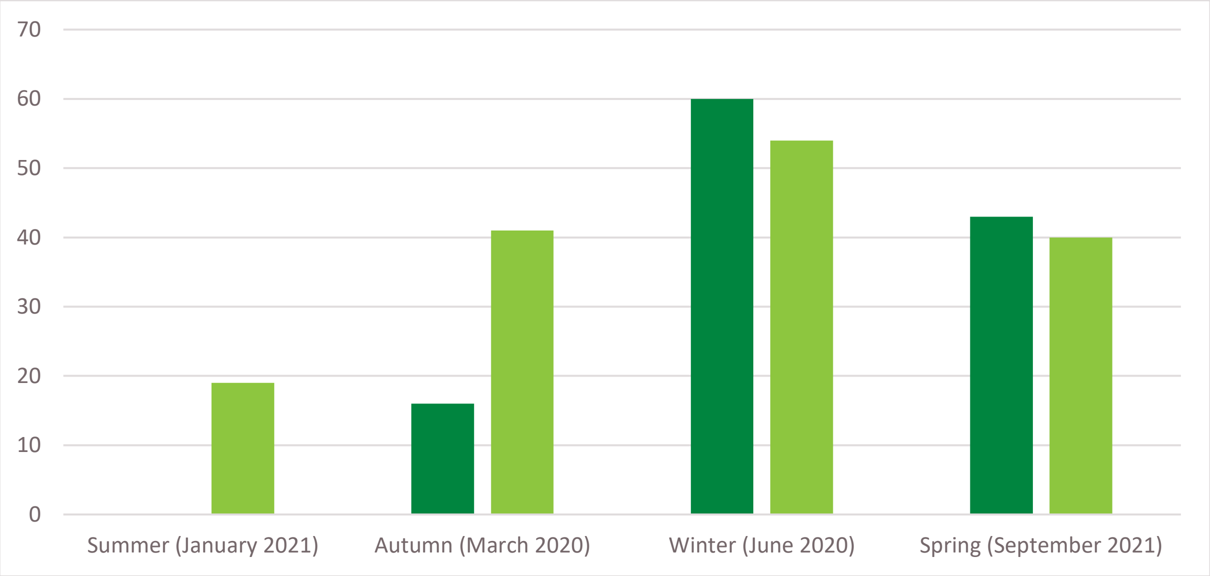



**Chart 2: Number of male (light green) and female (dark green) Little Bent-winged Bats captured per survey season**

#### *5.4.1.2 Thermal imaging*

Thermal imaging successfully recorded emergence of bats from both portals concurrently and allowed accurate counts of bats exiting and re-entering the tunnel during the emergence. Thermal imaging was completed on eight nights over four seasons and survey dates and times are shown in Table 5-9. The emergence of bats generally began 5-10 minutes earlier at the downstream portal. This is likely due to the east facing, shadowed aspect of this portal resulting in darker conditions earlier in the evening than at the upstream portal which faces west and is more open.

During the summer survey in January 2021 under La Nina climatic conditions, rains raised the water level causing the downstream portal to be blocked and therefore thermal imaging of the emergence was completed at the upstream portal only. A camera error causing a low frame rate on one night of the spring survey (10 September 2020) caused footage from the upstream portal to be of insufficient quality to obtain accurate bat counts. Good quality footage enabling a full count was recorded the following night.

Initial review of the thermal imaging video identified that bats commonly exited and re-entered the portal in quick succession during the emergence period. As such, simply counting bat exits from the portal would result in inaccurate emergence counts. For example, an individual bat may exit, re-enter and then exit again within a few seconds. If exits only were counted, this single bat would be recorded as two in the total count. To account for bats exiting and re-entering multiple times during the emergence, separate counts of exits and entries were recorded for each minute of the emergence. The actual emergence count was then calculated as the number of exits minus the number of entries, as described in Section 4.2.

Thermal imaging count results for each survey are presented in Table 5-10. A graphed example of the minute by minute emergence counts is shown in Chart 3. To obtain population estimates for each season the upstream and downstream actual emergence count results from each survey night were added to give the nightly estimate. The higher of the two counts was then used as the tunnel total population estimate for the season, where two counts were available (Table 5-10; Chart 4).

A distinct pattern of seasonal variation in total tunnel bat population was recorded. The bat population in the tunnel peaked in winter and spring at around 5500 – 6000 bats and decreased in summer and autumn to between 2000 – 3000 bats (Chart 4). This result indicates a clear seasonal pattern of tunnel use by Little Bent-winged Bats and supports the results of previous studies at the site.

The majority of female Little Bent-winged Bats leave the tunnel in early summer to travel to a maternity roost to raise their young. The nearest and only known Little Bent-winged Bat maternity roost site in NSW is at Willi Will Caves near Kempsey, however there may be a closer unknown site (Ecotone 2000). Previous monthly trapping studies (Ecotone, 2000) also recorded strong seasonal usage of the tunnel by Little Bent-winged Bats, with pregnant females observed in November and early December but very few females captured by mid-December. Ecotone (2000) found that females started returning to the tunnel in late February to early March.

The population estimates obtained from thermal imaging counts during this study also are equivalent to the most recent population estimates but are significantly lower than estimates from 2000. A mid-January thermal imaging count by Biosis in 2017 estimated the tunnel bat population at 2,272 bats. These estimates are significantly less than those provided by mark-recapture data gathered by Ecotone in 2000. Ecotone estimated there to be 8,674 Little Bent-winged Bats and 676 Large Bent-winged Bats present during the summer period. Over winter there is potentially up to 11,000 Little Bent-winged Bats and 1000 Large Bent-winged Bats.

**Table 5-9: Thermal imaging survey dates and times**

| Survey | Date | Downstream Portal Time | Upstream Portal Time |
|---|---|---|---|
| Autumn 1 | 11-Mar-2020 | 19:20-20:20pm | 19:25-20:25pm |
| Autumn 2 | 12-Mar-2020 | 19:20-20:20pm | 19:30-20:30pm |
| Winter 1 | 11-Jun-2020 | 17:09-18:09pm | 17:00-18:00pm |
| Winter 2 | 12-Jun-2020 | 17:00-18:00pm | 17:08-18:08pm |
| Spring 1 | 10-Sep-2020 | 17:55-18:55pm | 18:00-19:00pm |
| Spring 2 | 11-Sep-2020 | 18:00-19:00pm | 18:00-19:00pm |
| Summer 1 | 25-Jan-2021 | No survey (portal blocked) | 20:25-21:25pm |
| Summer 2 | 26-Jan-2021 | No survey (portal blocked) | 20:25-21:25pm |

**Table 5-10: Thermal imaging count results**

| Season | Date | Portal | Exits | Entries | Actual emergence | Tunnel Total |
|---|---|---|---|---|---|---|
| Autumn | 11-Mar-2020 | Downstream | 3897 | 2855 | 1042 | 2487 |
| Autumn | 11-Mar-2020 | Upstream | 3146 | 1701 | 1445 | |
| Autumn | 12-Mar-2020 | Downstream | 4303 | 2900 | 1403 | **2670** |
| Autumn | 12-Mar-2020 | Upstream | 4020 | 2753 | 1267 | |
| Winter | 11-Jun-2020 | Downstream | 6401 | 3783 | 2618 | **5807** |
| Winter | 11-Jun-2020 | Upstream | 4591 | 1402 | 3189 | |
| Winter | 12-Jun-2020 | Downstream | 5525 | 3425 | 2100 | 4715 |
| Winter | 12-Jun-202- | Upstream | 5380 | 2765 | 2615 | |
| Spring | 10-Sep-2020 | Downstream | 2821 | 1465 | 1356 | n/a |
| Spring | 10-Sep-2020 | Upstream | No count – video error, frame rate insufficient to count | | | |
| Spring | 11-Sep-2020 | Downstream | 3919 | 1655 | 2264 | **5579** |
| Spring | 11-Sep-2020 | Upstream | 5693 | 2378 | 3315 | |
| Summer | 25-Jan-2021 | Downstream | No count – tunnel blocked | | | 2015 |
| Summer | 25-Jan-2021 | Upstream | 4400 | 2385 | 2015 | |
| Summer | 26-Jan-2021 | Downstream | No count – tunnel blocked | | | **2370** |
| Summer | 26-Jan-2021 | Upstream | 4829 | 2459 | 2370 | |

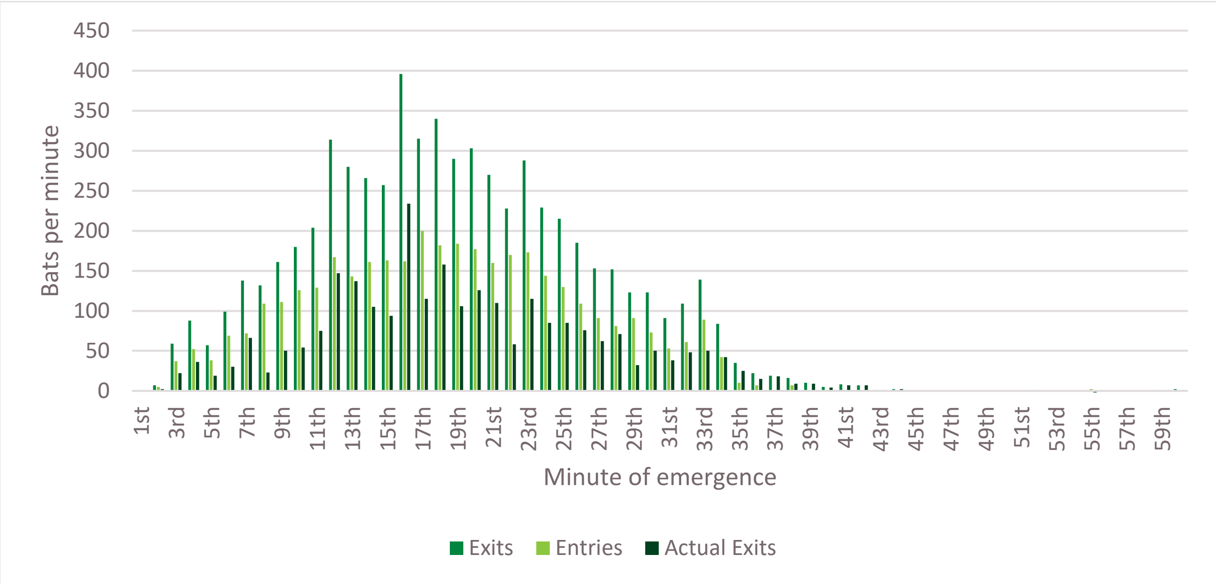



**Chart 3: Example of emergence count data (downstream portal 11 June 2020)**

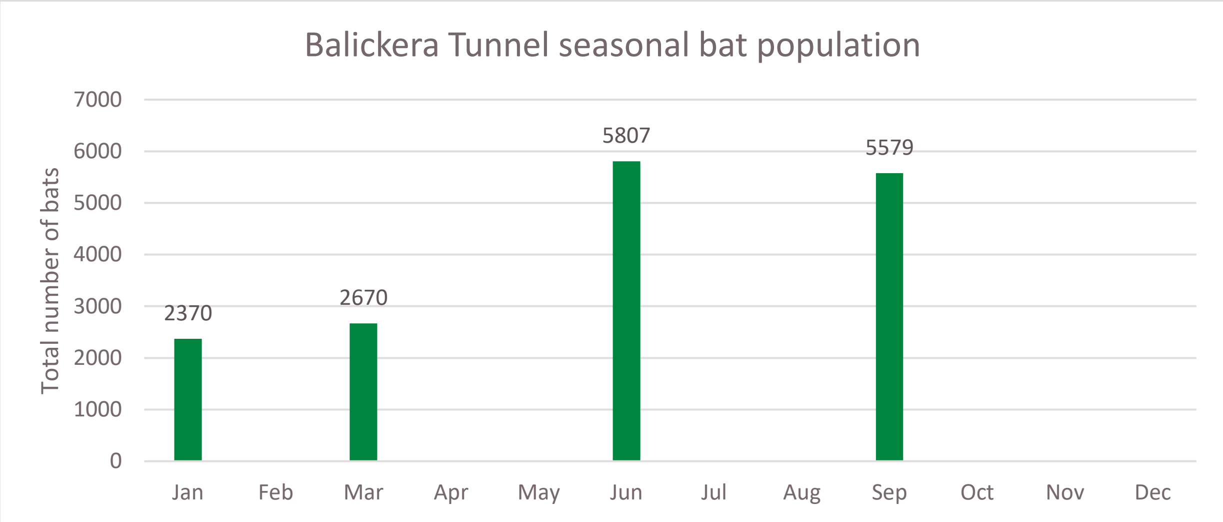



**Chart 4: Balickera Tunnel seasonal bat population counts based on thermal imaging of emergence**

#### *5.4.1.3 Ultrasonic recording*

There were a total of 80,128 files containing bat calls recorded during this study across a total of 36.25 survey nights (Table 5-11). There were two occasions when a complete survey night was not recorded because the SD card was full or the batteries powering the detector were depleted (Table 5-11). Of the 80,128 files, 76,924 (96%) were able to be analysed to species or species group, with the remaining 3,204 (4%) of calls being of low quality, social calls, or contained call sequences that were too short to identify confidently to species level. Detailed results listing the species recorded and the number of calls recorded each night per species for each survey event and each location (upstream or downstream portal) are provided in Appendix F.

The calls of at least ten, and up to 18 microbat species were identified within the combined survey data, including seven species listed as vulnerable under the BC Act (Table 5-12). Five of the seven vulnerable species were confidently identified as being present within the subject site:

- Eastern Coastal Free-tailed Bat
- Eastern False Pipistrelle
- Large Bent-winged Bat
- Little Bent-winged Bat
- Southern Myotis.

Two other threatened species, the Greater Broad-nosed Bat, and Eastern Cave Bat *(Vespadelus troughtoni*) could also be present within the subject site but could not be positively identified from the recorded calls. This Greater Broad-nosed Bat produces calls that overlap with several other species, including the threatened Eastern False Pipistrelle and non-threatened Eastern Broad-nose Bat (*Scotorepens orion*). There were some recorded calls that did not contain enough defining characteristics for a confident identification between Eastern False Pipistrelle, Eastern Broad-nosed Bat and Greater Broad-nosed Bat and those calls were assigned to a multi-species grouping. These three species are hollow roosting microbat species and would not roost within the tunnel in large numbers on a regular basis.

Similarly, Eastern Cave Bats produce calls that overlap with those of two other common species including Eastern Forest Bat *(Vespadelus pumilus)* and Little Forest Bat (*V. vulturnus*). Eastern Cave Bats are a threatened species known to roost in caves, boulder piles, mines and buildings (Churchill 2008). Whereas Eastern Forest Bats and Little Forest Bats are hollow roosting species. There was only one recorded location with an ultrasonic record of Eastern Cave Bat from within a 5 km radius of the Study area. There is no preferred sandstone outcrop habitat for Eastern Cave Bats within nightly flight range of Balickera Tunnel. No Eastern Cave Bats were captured during harp trapping at the tunnel. The calls of Eastern Forest Bat were recorded confidently at the tunnel in January 2021. Calls potentially attributed to Eastern Cave Bat were recorded in September and January. It is most likely that the recorded calls were made by Eastern Forest Bats or Little Forest Bats. Eastern Cave Bats are not likely to be present within the Study area.

**Table 5-11 Summary of ultrasonic recording results**

| Survey location and date | Total calls | Calls identified | # survey nights | Average # calls per night | % Little Bent-winged Bat | % Large Bent-winged Bat | % Southern Myotis |
|---|---|---|---|---|---|---|---|
| March 2020 upstream | 5807 | 5765 | 2 | 2904 | 82.0% | 2.5% | 13.1% |
| March 2020 downstream | 5109 | 4839 | 3.125 | 1634 | 82.0% | 2.5% | 13.1% |
| June 2020 upstream | 18402 | 18346 | 5 | 3680 | 87.6% | 4.5% | 7.7% |
| June 2020 downstream | 14465 | 13976 | 8 | 1808 | 82.1% | 3.6% | 4.5% |
| Sept 2020 upstream | 13178 | 13163 | 4.125 | 3195 | 95.0% | 0.8% | 3.7% |
| Sept 2020 downstream | 10367 | 9299 | 4.125 | 2513 | 72.8% | 0.9% | 21.9% |
| Jan 2021 upstream | 11041 | 10218 | 4 | 2760 | 65.8% | 1.2% | 31.6% |
| Jan 2021 downstream | 1759 | 1318 | 5 | 352 | 54.8% | 3.0% | 4.6% |
| Totals | 80128 | 76924 | 36.25* | 2356 | 77.8% | 2.4% | 12.5% |
| Totals upstream | 48428 | 47492 | 16 | 3139.5 | 82.6% | 2.3% | 14.0% |
| Totals downstream | 31700 | 29432 | 20.25 | 1584.25 | 72.9% | 2.5% | 11.0% |
| Totals without Jan 2021 downstream | 78369 | 75606 | 31.25 | 2642 | 81.0% | 2.3% | 13.7% |

* There were two occasions when a complete survey night was not recorded because the SD card was full or the batteries powering the detector were exhausted.

There were four subterranean (caves, tunnels, derelict mines, stormwater drains, culverts and bridges) roosting microbat species recorded during this study. All four species use Balickera Tunnel as roosting habitat to varying degrees. The four subterranean roosting species were:

- Large Bent-winged Bat
- Little Bent-winged Bat
- Eastern Horseshoe Bat (*Rhinolophus megaphyllus*)
- Southern Myotis.

Species diversity varied between survey events and between the up and downstream portal (Table 5-12). A greater number of species were detected in calls recorded at Balickera Tunnel during spring and summer surveys than during winter and autumn surveys. This result is consistent with the broadly accepted activity patterns of microbats, that being greater activity from a broader range of species during the spring and summer months when food resources are plentiful and birth / raising of young is occurring. This statement relates to general microbat activity and does not hold true for ultrasonic recording at roost sites because activity levels at roost sites are directly related to the periods of time species are resident at the roost.

There was also usually a greater number of species recorded at the downstream portal compared to the upstream portal (Table 5-12). This result may be related to the greater degree of forested vegetation surrounding the downstream portal providing increased foraging habitat for a range of microbat species. Whereas the species diversity and activity at the upstream portal was largely driven by subterranean species roosting in the tunnel.

Based upon the personal experience of the author and several other ultrasonic call analysis experts (Greg Ford Balance Environmental pers. comm.; Amy Rowles Corymbia Ecology pers. comm.), expected levels of activity for ultrasonic surveys conducted on the east coast and tablelands of New South Wales, for the purposes of presence / absence, range between 0 and 300 calls per night. Activity levels of microbats (calls per night) at Balickera Tunnel were very high. When all data was combined, the average number of calls recorded per night was 2,642 ranging between 1,634 calls per night recorded at the downstream portal in March 2020 to 3,680 calls per night recorded at the upstream portal in June 2020 (Table 5-11). Results for the downstream portal in January 2021 were discarded because the tunnel entrance was submerged, and no bats could emerge from it. The average number of calls recorded per night in January 2021 at the downstream portal was 352 calls, much lower than the combined average and lower than at any other time during the ultrasonic surveys, as would be expected given no bats were able to emerge from the downstream portal. In comparison, the average number of calls per night recorded at the upstream portal during January 2021 was 2760, well within the range of results recorded during all other survey events. The heightened activity levels recorded during this survey are consistent with Balickera Tunnel being a roost site for large numbers of bats.

Calls produced by the Little Bent-winged Bat were recorded during every survey event and accounted for 77.8% of all recorded calls positively identified (Table 5-11 and Table 5-12). The percentage of calls attributed to Little Bent-winged Bats was greater during autumn (82% upstream, 82% downstream), winter (88% upstream, 82% downstream) and spring (95% upstream and 73% downstream) than during summer (66% upstream and 55% downstream) (Table 5-11 and Chart 5). Calls produced by the Large Bent-winged Bat were also recorded during every survey event but in much lower numbers, accounting for only 2.4% of all recorded calls positively identified (Table 5-11 and Table 5-12). Calls produced by Southern Myotis were recorded during every survey event and accounted for 12.5% of all recorded calls positively identified (Table 5-11 and Table 5-12).

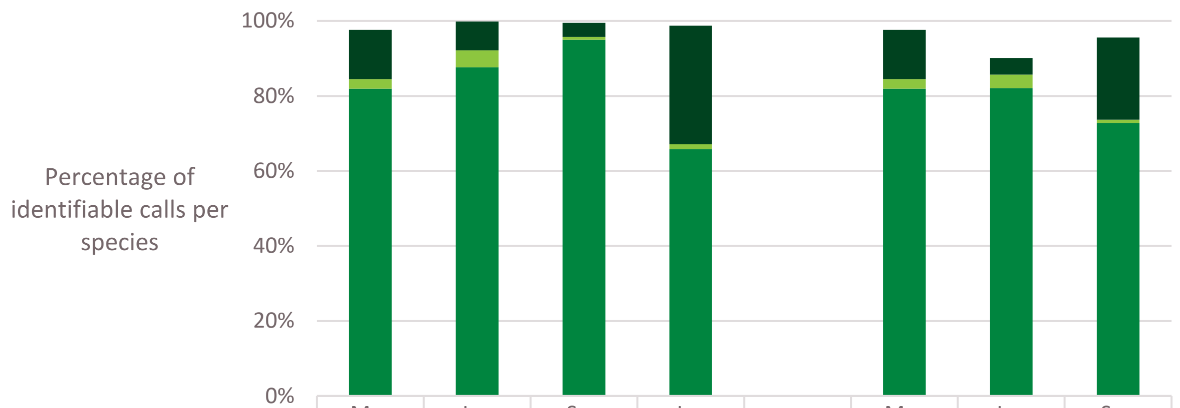
Ultrasonic activity throughout the night and during the emergence period did not correlate with the number of bats estimated using the tunnel based on the thermal imaging counts. There was no correlation or clear pattern in the variance of the number of calls recorded per night to allow it to be used to discern whether the number of bats in the tunnel changes from night to night. It is not possible to identify individual bats using current call analysis technology which means that in a sample of 10 calls, ultrasonic analysis is unable to determine whether those 10 calls were made by a single bat passing the detector 10 times or ten different bats each passing the detector once. Therefore, it is unlikely that the number of calls recorded per night consistently correlates with the number of bats recorded as present using visual techniques for counts.

**Table 5-12: Species and species groups recorded during ultrasonic surveys at Balickera Tunnel between March 2020 and January 2021.**

| Scientific Name | Common Name | Mar-20 | | Jun-20 | | Sep-20 | | Jan-21 | | Roosting in tunnel |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Up stream | Down stream | Up stream | Down stream | Up stream | Down stream | Up stream | Down stream | |
| *Austronomus australis* | White-striped Free-tailed Bat | N | Y | N | N | Y | N | Y | Y | N |
| *Chalinolobus gouldii* | Gould's Wattled Bat | N | Y | N | N | N | Y | Y | Y | N |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | N | Y | Y | Y | Y | Y | Y | Y | N |
| *Chalinolobus morio* | Chocolate Wattled Bat | Y | Y | Y | Y | Y | Y | Y | Y | N |
| *Chalinolobus morio / Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | N | N | N | Y | Y | Y | Y | Y | N |
| *Falsistrellus tasmaniensis** | Eastern False Pipistrelle | N | N | N | N | N | N | N | Y | N |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Greater Broad-nosed Bat / Eastern Broad-nosed Bat | N | Y | N | N | N | Y | Y | Y | N |
| *Micronomus norfolkensis** | Eastern Coastal Free-tailed Bat | N | N | N | Y | N | Y | N | N | N |
| *Micronomus norfolkensis* / Ozimops ridei* | Eastern Coastal Free-tailed Bat / Ride's Free-tailed Bat | N | N | N | N | N | Y | N | N | N |
| ***Miniopterus australis**** | **Little Bent-winged Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Miniopterus australis* / Vespadelus pumilus* | Little Bent-winged Bat / Eastern Forest Bat | N | N | N | N | Y | N | N | N | N |
| ***Miniopterus orianae oceanensis**** | **Large Bent-winged Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |

| Scientific Name | Common Name | Mar-20 | | Jun-20 | | Sep-20 | | Jan-21 | | Roosting in tunnel |
|---|---|---|---|---|---|---|---|---|---|---|
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Large Bent-winged Bat / Southern Forest Bat | N | Y | Y | N | Y | Y | N | Y | N |
| ***Myotis macropus**** | **Southern Myotis** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | Y | Y | Y | Y | Y | Y | Y | Y | N |
| *Ozimops ridei* | Ride's Free-tailed Bat | N | N | Y | **N** | Y | Y | Y | Y | N |
| ***Rhinolophus megaphyllus*** | **Eastern Horseshoe Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Vespadelus pumilus* | Eastern Forest Bat | N | N | N | N | N | N | N | Y | |
| *Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | N | N | N | N | Y | N | Y | Y | N |

* Threatened species under BC Act




| | Mar 2020 | Jun 2020 | Sep 2020 | Jan 2021 | | Mar 2020 | Jun 2020 | Sep 2020 |
|---|---|---|---|---|---|---|---|---|
| % Southern Myotis | 13% | 8% | 4% | 32% | | 13% | 4% | 22% |
| % Large Bent-winged Bat | 3% | 5% | 1% | 1% | | 3% | 4% | 1% |
| % Little Bent-winged Bat | 82% | 88% | 95% | 66% | | 82% | 82% | 73% |
| | Upstream Portal | | | | | Downstream Portal | | |

**Chart 5: Proportion of all nightly identifiable calls attributed to each species at either end of the tunnel**

Using detected bat calling as a means of comparing activity between species and times provides a challenge as the extent to which calls are recorded is highly dependent on a range of factors. Whilst the number of bats present is clearly one of those factors, other factors play important roles in determining what is recorded.

As described above, microbat activity is generally greater during spring, summer and autumn than over winter because of the increased activity and availability of insect prey at these times and the presence of juveniles adding to the population in autumn. The same site sampled in different seasons can have markedly different levels of microbat activity recorded. The specific activities of bats at the detector sites also influences what is recorded. When bats are emerging / entering roosts there will be higher levels of activity related to use of the roost site. When recording calls over a waterbody, particularly one in an environment where there are few water sources for bats there will generally be greater levels of activity than the surrounding landscape as all bats need to drink regularly. Bats foraging in an area will spend more time there and call more often than if they are simply passing through briefly.

The microclimatic and environmental conditions experienced at the time the call is being recorded can affect the transmission of sound waves through the air. Humid conditions can make sound transmission difficult and reduce the distances sound will travel. Weather and climatic conditions affect the quality and quantity of recorded data as well as the availability of insect prey and therefore the suitability of each site at a given time to provide for the foraging needs of microbats at a given site.

Background noise or that produced by electrical infrastructure (wind, water, insects, high powered transmission lines) can drown out other sounds and have a masking effect if it is produced at similar frequencies to those being produced by the bats. These types of signals are not always consistently produced at a given site and can therefore lead to different levels of activity at a site at different times.

Calls produced by different bat species differ in fundamental ways related to the foraging mode / activity of each species. Calls of different species and the different types of calls produced by each species (cruise, search, social, approach, attack) are not equally recorded by ultrasonic detectors. Some of the more open adapted species such as the Free-tailed Bats (*Austronomus, Micronomus Ozimops* spp.) that forage above the canopy or over open spaces are known to produce loud calls that can be detected at greater distances from the detector than soft calling species such as the Long-eared Bats (Nyctophilus spp.).

Whether a bat emerges to forage from a roost on a nightly basis and the time of that emergence is dependent upon local conditions and the level of hunger / thirst experienced by the bat which itself is heavily dependent upon hydration levels and foraging success over previous nights. Given all of this is not unexpected that clear trends in ultrasonic activity were not apparent in the data.

The ultrasonic call data does provide some relative information useful as supporting data including the following observations. There were a greater number of ultrasonic calls recorded per night at the upstream portal of the tunnel than the downstream portal of the tunnel (Table 5-11). This result was evident even when the January 2021 data was excluded from the analysis because the downstream portal was submerged and unable to be used by bats at that time forcing bats to use the upstream portal. This aligns with the knowledge that the majority of the roost sites within the tunnel are much closer to the upstream portal and indicates that bats preferentially exit / enter the tunnel from the upstream portal.

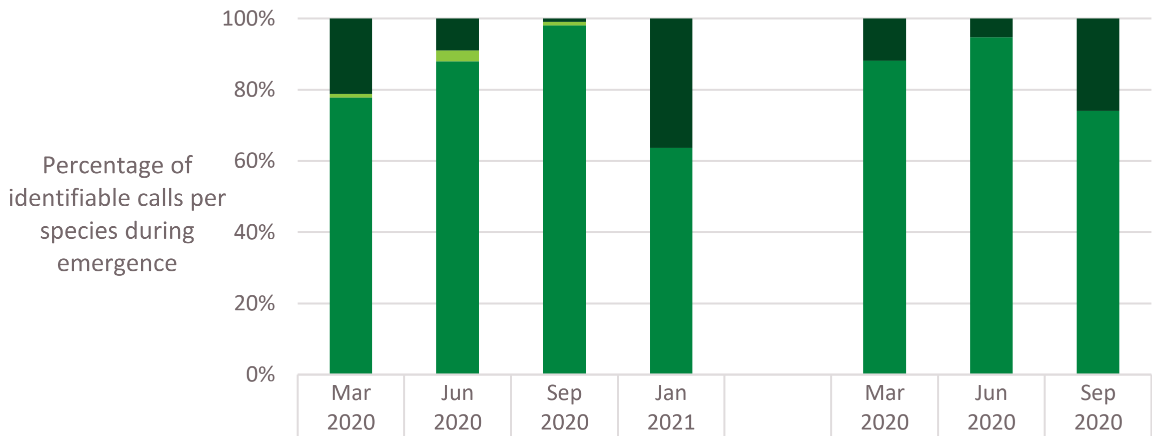
A more consistent approach to assess calling data is to look at emergence data from the tunnel, which has less bat species for consideration and the activity (leaving the roost) is less impacted by other factors. When only the hour during which the thermal camera recorded emergence was analysed the patterns described above remained consistent, with the exception that no Large Bent-winged Bats were recorded emerging from the downstream portal (Table 5-13 and Chart 6). The average number of calls recorded during emergence was greater at the upstream portal than the downstream portal during each season and overall (Table 5-13 and Chart 6). There were minor fluctuations in the proportion of calls attributed to each species during emergence when compared with the nightly averages (Chart 6).

**Table 5-13. Summary of average number of calls recorded and proportion attributed to each species during thermal imaging counts (emergence)**

| Location | Survey date | Average number of calls during emergence | % Little Bent-winged Bat | % Large Bent-winged Bat | % Southern Myotis |
|---|---|---|---|---|---|
| Upstream | Mar 2020 | 291 | 77% | 1% | 21% |
| Upstream | Jun 2020 | 222 | 88% | 3% | 9% |
| Upstream | Sep 2020 | 198 | 98% | 1% | 1% |
| Upstream | Jan 2021 | 192 | 63% | 0% | 36% |
| | | | | | |
| Downstream | Mar 2020 | 145 | 82% | 0% | 11% |
| Downstream | Jun 2020 | 149 | 89% | 0% | 5% |
| Downstream | Sep 2020 | 119 | 74% | 0% | 26% |
| Downstream | Jan 2021 | | | | |

The key message from these results is that Large Bent-winged Bats do not appear to be emerging from the downstream portal. The low number of calls recorded during the emergence period in comparison to nightly average calls also suggests that Large Bent-winged Bats may be emerging later in the evening than Little Bent-winged Bats and Southern Myotis. It may also indicate that some of the Large Bent-winged Bat activity recorded could be from Large Bent-winged Bats arriving from other roosts, rather than emerging from the tunnel.

The other important fact to note is that the average number of calls recorded during emergence was less than 20% of the total number of bats estimated to have been roosting in the tunnel at the time the calls were recorded. When the total number of passes (exits + re-entries) was compared with the average number of bats recorded during thermal counts this figure reduces to about 10%. There could be two reasons for this. The ultrasonic detectors may not be picking up all calls of bats as they exit / re-enter the roost, and not all bats are calling as they approach the tunnel portal. It is known that not all bats use echolocation when in the immediate vicinity of the roost, and it is assumed to be based upon familiarity with the space. However, with so many bats exiting and potentially re-entering the tunnel it is suggested that echolocation would be crucial for avoiding collisions with conspecifics at large roost sites such as this. Both factors are likely to be playing a role in the low number of calls recorded in comparison to the number of bats passing through the portals at the time of recording.




| | Mar 2020 | Jun 2020 | Sep 2020 | Jan 2021 | | Mar 2020 | Jun 2020 | Sep 2020 |
|---|---|---|---|---|---|---|---|---|
| % Southern Myotis | 21% | 9% | 1% | 36% | | 11% | 5% | 26% |
| % Large Bent-winged Bat | 1% | 3% | 1% | 0% | | 0% | 0% | 0% |
| % Little Bent-winged Bat | 77% | 88% | 98% | 63% | | 82% | 89% | 74% |
| | Upstream Portal | | | | | Downstream Portal | | |

**Chart 6: Proportion of identifiable calls attributed to each species during emergence; the period when thermal video recording was also undertaken to obtain counts of the number of bats roosting within the tunnel. *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) has been excluded due to the very infrequent detections recorded.**

The spread of bat activity throughout the night for the cave roosting species; Little Bent-winged Bats, Large Bent-winged Bats, Southern Myotis and Eastern Horseshoe Bats shows a fairly consistent level of activity at both the upstream and downstream ends of the tunnel (Chart 6). Interestingly, the number of calls recorded per hour is lowest during the first hour(s) of the evening and last hour(s) of the evening. This is contrary to what might be expected at a large roost site where it might be assumed that the first hour(s) of the night would be the busiest. That fewer calls were recorded during the first hour of the night may also reflect the twin issues of a potential limit of the technology to record calls of multiple bats during periods of intense activity or that bats are not calling as frequently as they otherwise might during emergence because of a familiarity with the roost entrance / exit. This suggestion aligns with data presented above for the comparison of the number of calls recorded during the period that thermal video recording was undertaken. Detectors are capable of recording multiple call sequences at a given point in time as evidenced during analysis when the call signatures of up to four species are recorded in the one file. However, this is detectable by the call analyst because of the differences in call signatures. What is not clear is whether multiple bats calling at the same frequency would be discernible in a file.

These results show clearly that there is a constant stream of activity at the tunnel and suggests that there are ample foraging opportunities for the colony within a short flight distance from the tunnel, allowing bats to come and go, interspersing periods of foraging with periods of rest throughout the night. It also indicates the importance of the surrounding forested areas including Wallaroo National Park, Wallaroo State Forest, Medowie State Conservation Area, Grahamstown Dam and for Balickera Canal as foraging and commuting habitat for bats roosting in the tunnel.

#### *5.4.1.4 Tunnel inspection platform*

Abyss Solutions conducted a remote above water inspection of Balickera Tunnel on 12 June 2020 and recorded infra-red video footage of the internal tunnel crown for the full length of the tunnel. The Abyss Solutions Balickera Tunnel Inspection Report is included as Appendix K.

The inspection recorded two clustered bat sightings and 30 isolated sightings in both natural rock and concrete lined sections of the tunnel. A summary of the observations recorded is provided in Table 5-14. The majority of bats were recorded towards the upstream end of the tunnel, as per previous tunnel inspections. Bat roost locations within the tunnel are mapped in Figure 5-5 and Figure 5-6.

The main roost was recorded at 995 m from the downstream portal (Plate 18). Other smaller clusters were also recorded in the vicinity of the main roost (Plate 19), as well as scattered individuals/small groups further away from the roost (Plate 20). These occurrences were all in natural rock sections of the tunnel, particularly in the first natural rock section from the upstream portal which extends from approximately 175m – 295m (Pells, 2015).

The main roost appears to be consistently in the same location based on comparison with previous tunnel inspections (Plate 22), although the recorded distance (chainage) varied between 915 m, 930 m, 995 m from downstream. It is likely there is some variation in the chainage between tunnel inspections as the chainage is estimated based on the timing of pulling the inspection platform through the tunnel. Based on comparison of available imagery, tunnel plans and previous studies, the main roost is estimated to be at 240 m from the western portal and has remained in the same location since the tunnel was discovered as a roost site in 1995.

Individual or small groups of bats were also recorded using 21 vertical hole structures, and / or the cavities behind them within concrete lined sections of the tunnel (Plate 21; Table 5-14). The majority of these roost sites were also located in the upstream end of the tunnel, including within the first concrete lined section joined to the upstream portal. This roosting behaviour is considered to mostly represent Southern Myotis, which has previously been recorded breeding within these structures in this part of the tunnel (Ecotone 1995, 2000). However, some Little Bent-winged Bats and Large Bent-winged Bats have also been recorded roosting within these holes.

It should be noted that although the Abyss Solutions report provides counts of the number of roosting bats, the primary purpose of the tunnel inspection was to identify bat roosting locations. Based on ELA review of the imagery collected by Abyss Solutions, and results of other survey methods utilised in this study that are considered to provide more accurate bat counts, it is likely that the counts included within the Abyss Solutions report underestimated the actual number of bats due to a combination of image quality, small size of bats and clustering.

A summary of the findings of the microbat surveys in relation to the original study questions is provided in Table 5-15.

**Plate 18: Main roost recorded within Balickera Tunnel by tunnel inspection platform in June 2020 (995 m from downstream portal (Abyss 2020))**

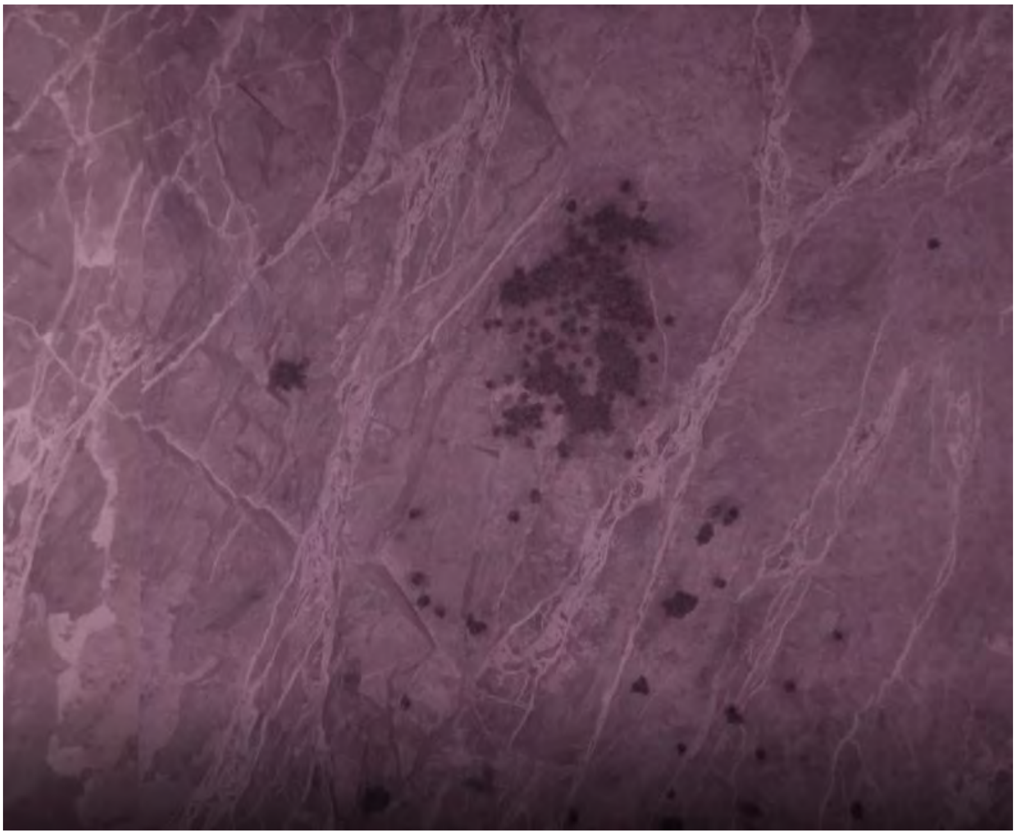


**Plate 19: Roost at 985 m (Abyss, 2020) (actually a few metres upstream of 259m dyke)**

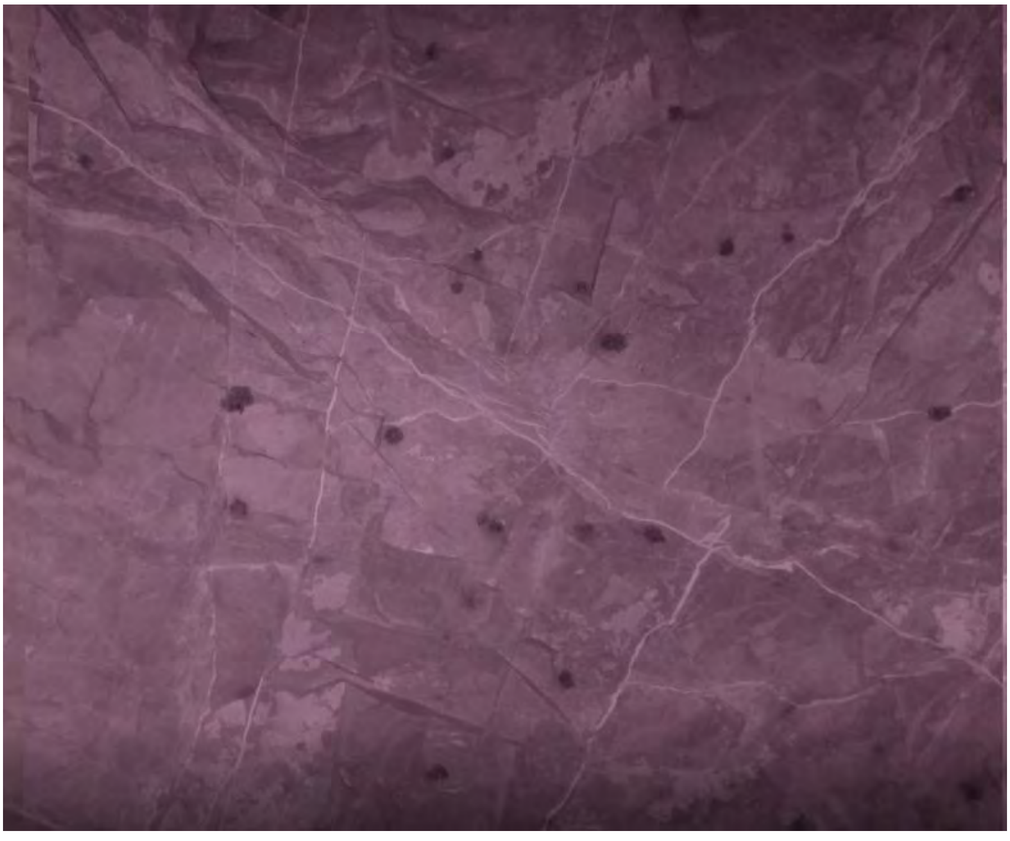


**Plate 20: Scattered bats roosting within main cluster area near main roost (approximate chainage 975 m from downstream (Abyss 2020))**

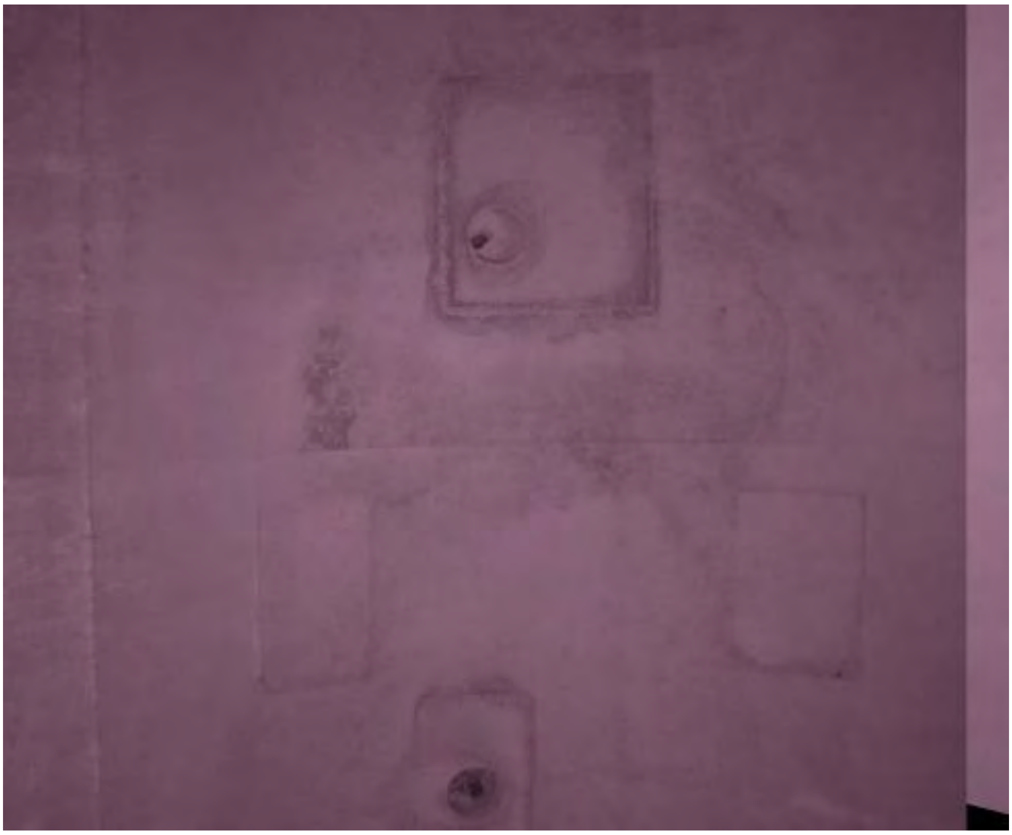


Plate 21: Isolated (or small group) bat occurrences in vertical cylindrical holes in concrete lined sections of Balickera Tunnel

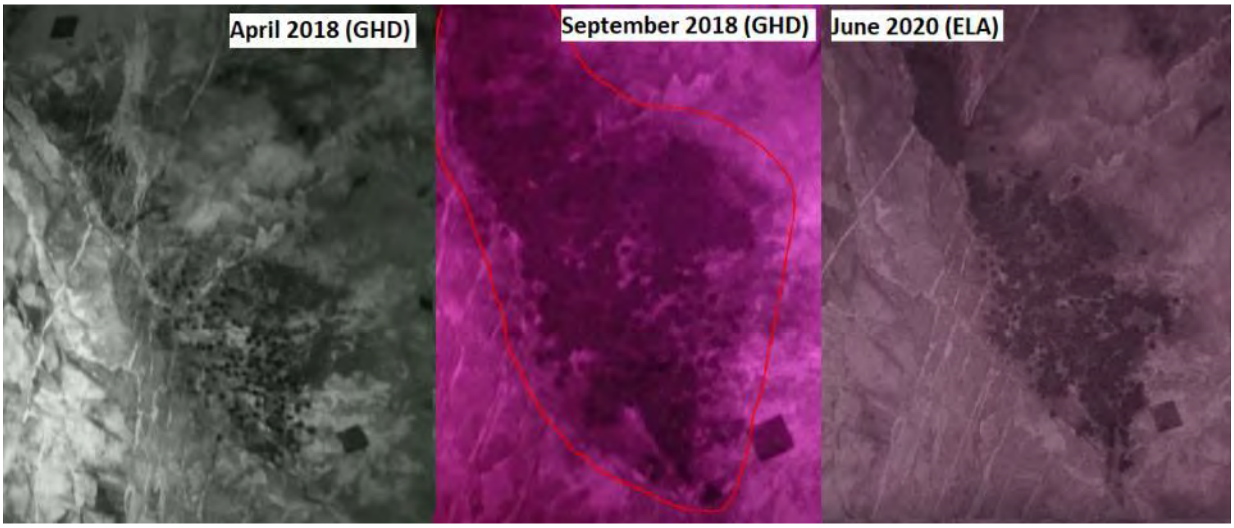



Plate 22: Comparison of the main Bent-winged Bat roost in Balickera Tunnel from three recent TIP surveys by Abyss Solutions

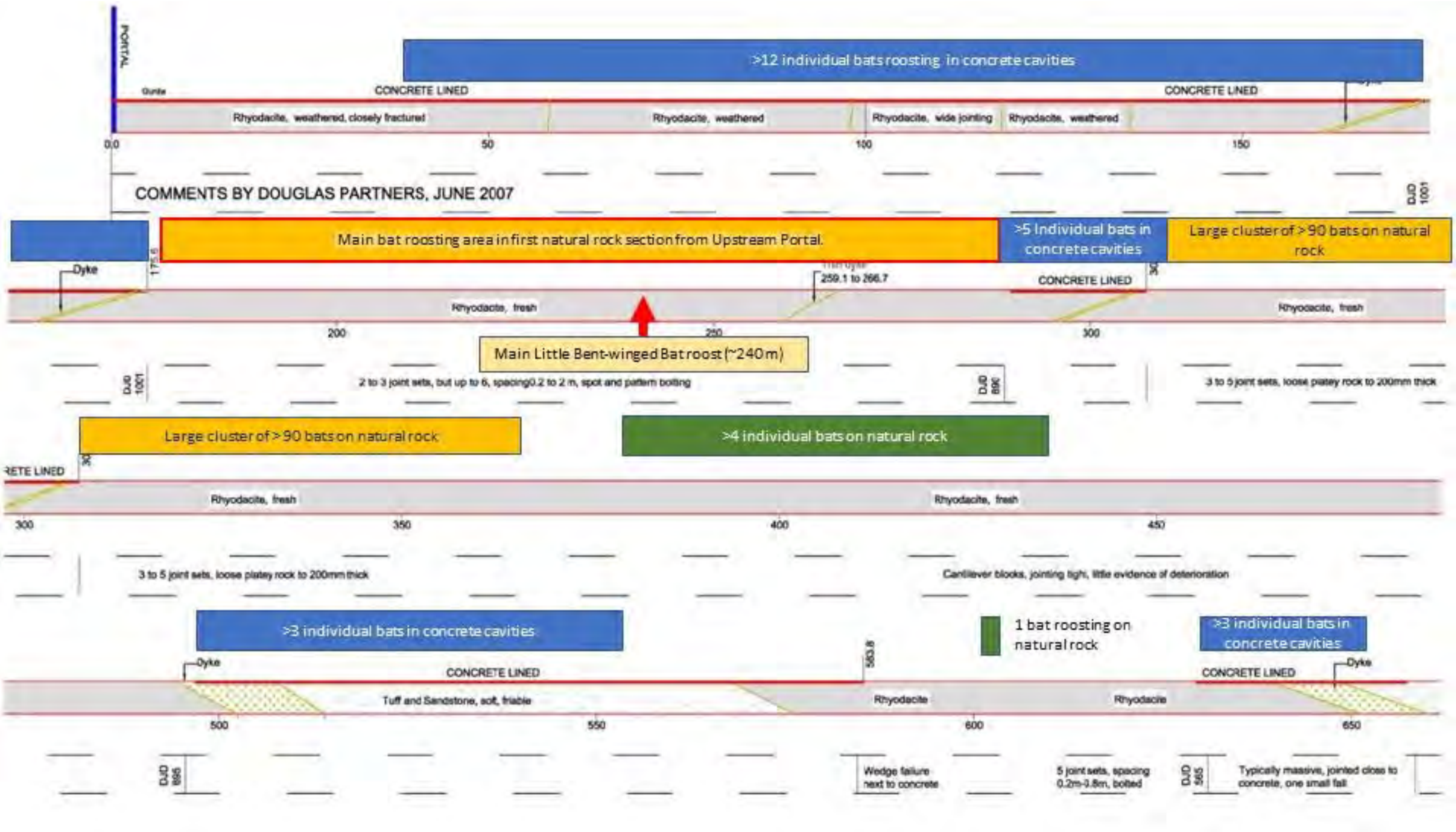



Figure 5-5: Bat roost locations within Balickera Tunnel – upstream half of tunnel (adapted from Pells Consulting, 2015)

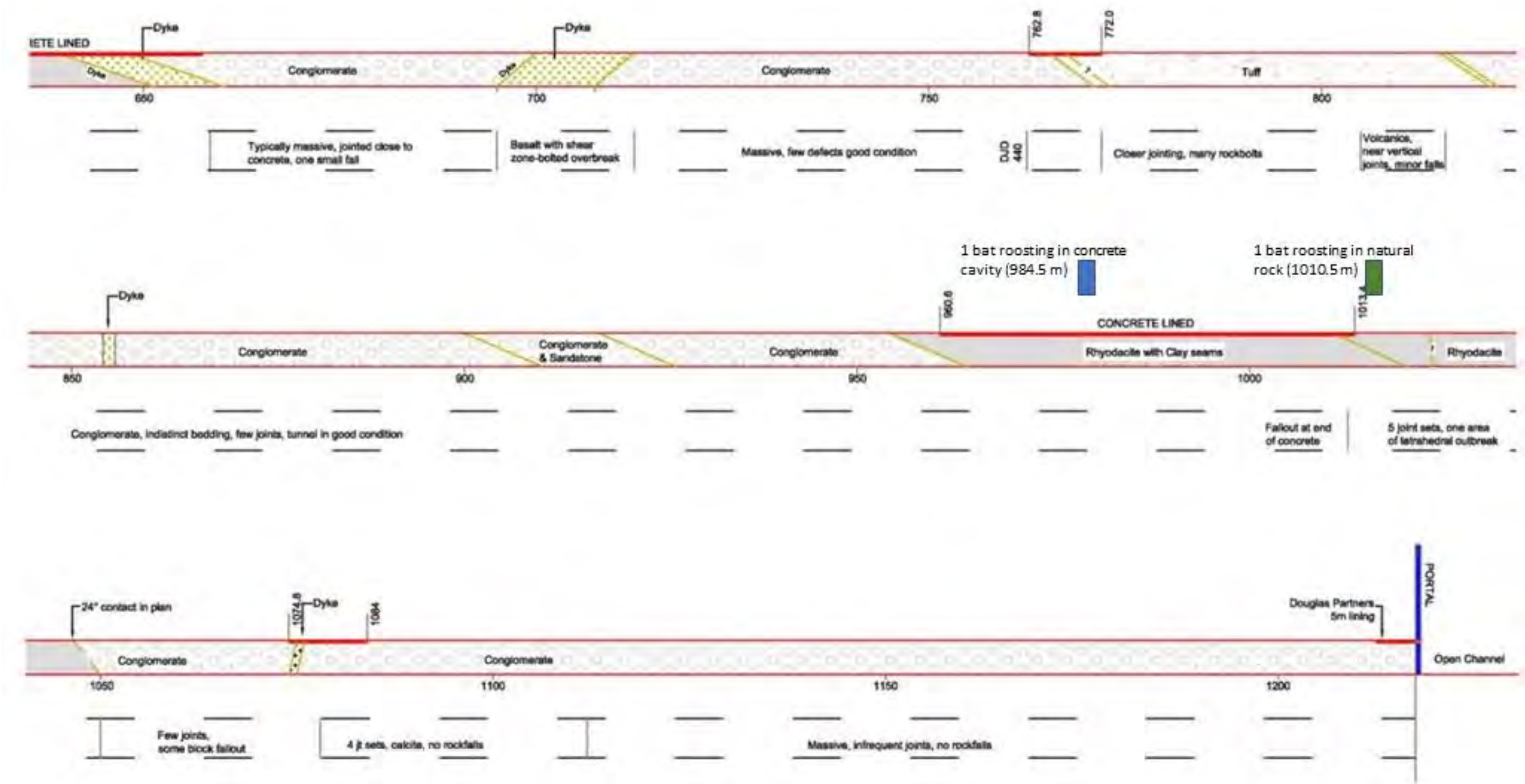



**Figure 5-6: Bat roost locations within Balickera Tunnel – downstream half of tunnel (adapted from Pells Consulting, 2015**

**Table 5-14: Tunnel inspection platform bat roosting observations**

| Chainage (m) from Downstream portal | Chainage (m) from Upstream portal | Category | Count of bats | Accumulated bat count | Notes |
|---|---|---|---|---|---|
| 207 | 1010 | isolated | 1 | 1 | isolated bat on natural rock crown |
| 233 | 984 | isolated | 1 | 2 | isolated bat in concrete cavity |
| 579 | 638 | isolated | 1 | 3 | isolated bat on natural rock crown |
| 588 | 629 | isolated | 1 | 4 | isolated bat in concrete cavity |
| 589 | 628 | isolated | 1 | 5 | isolated bat in concrete cavity |
| 616 | 601 | isolated | 1 | 6 | isolated bat on natural rock crown |
| 668 | 549 | isolated | 1 | 7 | isolated bat on natural rock crown |
| 690 | 527 | isolated | 1 | 8 | isolated bat in concrete cavity |
| 731 | 486 | isolated | 1 | 9 | isolated bat in concrete cavity |
| 780 | 437 | isolated | 1 | 10 | isolated bat on natural rock crown |
| 787 | 430 | isolated | 1 | 11 | isolated bat on natural rock crown |
| 792 | 425 | isolated | 1 | 12 | isolated bat on natural rock crown |
| 837 | 380 | isolated | 1 | 13 | isolated bat on natural rock crown |
| 847-927 | 370-290 | cluster | 90 | 103 | cluster of bats on natural rock crown (scattered individuals) |
| 937 | 280 | isolated | 2 | 105 | isolated bat in concrete cavity |
| 940 | 277 | isolated | 1 | 106 | isolated bat in concrete cavity |
| 946 | 271 | isolated | 1 | 107 | isolated bat in concrete cavity |
| 948 | 269 | isolated | 1 | 108 | isolated bat in concrete cavity |
| 954-1039 | 263-178 | cluster | 1571 | 1679 | cluster of bats on natural rock crown |
| 1062 | 155 | isolated | 1 | 1680 | isolated bat in concrete cavity |
| 1064 | 153 | isolated | 1 | 1681 | isolated bat in concrete cavity |
| 1080 | 137 | isolated | 1 | 1682 | isolated bat in concrete cavity |
| 1092 | 125 | isolated | 1 | 1683 | isolated bat in concrete cavity |
| 1093 | 124 | isolated | 1 | 1684 | isolated bat in concrete cavity |
| 1095 | 122 | isolated | 1 | 1685 | isolated bat in concrete cavity |
| 1114 | 103 | isolated | 1 | 1686 | isolated bat in concrete cavity |
| 1118 | 99 | isolated | 1 | 1687 | isolated bat in concrete cavity |
| 1145 | 72 | isolated | 1 | 1688 | isolated bat in concrete cavity |
| 1159 | 58 | isolated | 1 | 1689 | isolated bat in concrete cavity |
| 1164 | 53 | isolated | 1 | 1690 | isolated bat in concrete cavity |
| 1177 | 40 | isolated | 1 | 1691 | isolated bat in concrete cavity |

**Table 5-15: Summary of bat survey results in relation to original study questions**

| Original study questions | Survey methods used for investigation | Summary of results |
|---|---|---|
| Which species of microbat are currently roosting in Balickera Tunnel? | Harp trapping and ultrasonic call recording | Little Bent-winged Bat – year round resident, non-breeding.<br>Large Bent-winged Bat – year round resident, non-breeding.<br>Southern Myotis – year round resident, breeding over summer in October / November and January / February.<br>Eastern Horseshoe Bat – year round resident, possible breeding site. |
| How many individuals of each microbat species roost Balickera Tunnel? | Thermal imaging and ultrasonic recording | The bat population in the tunnel peaks in winter and spring at around 5500 – 6000 bats and decreases in summer and autumn to between 2000 – 3000 bats.<br>The majority of bats are Little Bent-winged Bats (77.8% of ultrasonic calls). Southern Myotis account for 12.5% of recorded calls and Large Bent-winged Bats just 2.4% of recorded calls.<br>Estimated population of Southern Myotis is 50 – 200 bats.<br>Estimated population of Large Bent-winged Bats is 300 – 500 bats.<br>Estimated population of Little Bent-winged Bats is 2000 – 5000 bats.<br>Estimated population of Eastern Horseshoe Bats is 10 – 50 bats. |
| Where in the tunnel are microbats roosting and what are the characteristics of the roosts? | Tunnel Inspection, previous studies | **Bent-winged Bats:** Main roost and majority of these species are within the first natural rock section from upstream portal, between chainage 178 and 263 m from the upstream portal. The main roost is estimated to be located at 240 m from the upstream portal, with smaller clusters and scattered individuals in the vicinity of this roost. The location of this roost matches that recorded during surveys undertaken by Ecotone in 2000 and in imagery taken in April and September 2018. Another large cluster of bats was recorded in a separate natural rock section between chainage 290 and 370 m from the upstream portal. Scattered individuals and pairs were recorded roosting on natural rock and in vertical cylindrical 20 cm diameter holes in the concrete lined sections between chainages 380 to 1010 m.<br>**Southern Myotis:** Predominantly roost in vertical cylindrical 20 cm diameter holes within concrete lined sections of the tunnel. The majority of these sites are within the upstream half of the tunnel and at least some of these are likely to be used for breeding. There are 106 vertical holes within the concrete lined sections of the tunnel and 39 of those have been recorded to contain roosting microbats (Ecotone 2000). Those observed to be used regularly are located between chainages 0 to 172 m (22 roosts) and 287 to 304 m (2 roosts). Southern Myotis were also recorded roosting in holes between, 493 to 580 m (6 roosts), 629 to 655 (4 roosts) and 957 to 1010 (5 roosts). |

| Original study questions | Survey methods used for investigation | Summary of results |
|---|---|---|
| Are there seasonal differences in bat numbers or sex ratios? | Harp trapping | **Bent-winged Bats:** The population of Little Bent-winged Bats halves over summer when females leave to give birth and raise young in a maternity cave elsewhere. There are very few females present between December and February. The population builds up gradually over autumn when males outnumber females and reaches peak occupancy throughout winter and early spring when sex ratios approach 1:1 for breeding / mating purposes.<br>**Southern Myotis:** The ultrasonic evidence suggests that Southern Myotis numbers build up over spring reaching a peak during summer. Trapping data was insufficient to provide detail on sex ratios. However, Myotis generally form colonies of related females attended by a dominant breeding male. It is expected that prior to giving birth in October / November, sex ratios would be skewed towards females. Once the young are born in October / November and January / February, sex ratios should approach 1:1 until autumn when the young (predominantly males) disperse from the maternal roost. Females are likely to outnumber males at a maternity roost for the majority of the year. |
| Is Balickera Tunnel being used as a maternity roost for the affected threatened microbat species? | Harp trapping, ultrasonic recording and previous studies | **Bent-winged Bats:** No. Females appear to vacate the tunnel during the summer breeding period.<br>**Southern Myotis:** Yes. Southern Myotis previously recorded breeding in tunnel, and was recorded through all seasons, including high levels of ultrasonic call activity during the breeding seasons. |
| Do any of the microbat species inhabiting Balickera tunnel use it as a hibernation or staging roost? | | **Bent-winged Bats:** Yes. The tunnel is used by both Bent-winged Bat species as an over-wintering / hibernation roost.<br>**Southern Myotis:** Yes. Southern Myotis are present year round and would undertake extended torpor bouts over winter. |
| What elements of the population of each species of microbat (adults, juveniles, males, females) inhabits Balickera Tunnel? | Harp trapping, previous studies | **Bent-winged Bats:** Adult males and females during autumn, winter and spring, mostly adult males during summer. No juveniles were recorded at Balickera Tunnel during surveys undertaken for this SIS. Three juvenile Large Bent-winged Bats were recorded during February 1998, 1999 and 2000 (Ecotone 2000). Sub-adults were recorded in autumn indicating that the young from the previous summer that are not yet sexually mature also roost within Balickera Tunnel.<br>**Southern Myotis:** Adult males and females captured during spring harp trapping. Pregnant and lactating females and juveniles observed in January and February 1999 (Ecotone 2000). |
| What alternative habitat for each species of microbat inhabiting Balickera Tunnel is available within the surrounding area? | Regional microbat assessment, desktop review, consultation | **Bent-winged Bats:** There are 8 potential alternative roosts within nightly flight range (33 km) for Little Bent-winged Bats being the Brookfield Tunnel, M1 Tunnel, Pilcher's Mountain Caves, Dungog WTP Tunnel, Blue Gum Hills Derelict Mine and the three Richmond Vale Rail Tunnels. It is unknown whether Brookfield Tunnel is suitable as a year round roost. The M1 Tunnel and the three Richmond Vale Rail Tunnels are unsuitable for large numbers of bats and at risk from development. Dungog WTP contains mostly Large Bent-winged |

| Original study questions | Survey methods used for investigation | Summary of results |
|---|---|---|
| | | Bats. There were no Little Bent-winged Bat calls and few Large Bent-winged Bat calls recorded at Blue Gum Hills Derelict Mine during in winter 2017 (L. Gonsalves pers. comm.). Pilchers Mountain Caves are likely to be suitable as a year round roost with capacity for several thousand bats. There are an additional 4 alternative Little Bent-winged Bats roosts known within a 50 km radius of Balickera Tunnel; Yacaaba Sea Caves, Sugarloaf SCA, Bulahdelah Mountain Alum Mine and Jesmond culvert. These roosts are capable of accommodating a maximum of 500 – 1000 additional bats between them with Yacaaba Sea Caves being suitable as a year round (non-breeding) roost site. There are twenty potential alternative roosts within nightly flight range (60km) for Large Bent-winged Bats. Many of these are suitable only for individuals or small numbers of bats. At least four are capable of accommodating 200 – 500 Large Bent-winged Bats and three would be suitable as roost sites year round.<br>**Southern Myotis**: At least three known alternative maternity roosts within nightly flight range (10 - 12 km) at the Pacific Highway Bridges over Twelve Mile Creek and Grahamstown Drain and Clarencetown Bridge over the Williams River. Grahamstown Drain is known to have capacity to accommodate an additional 50-100 Southern Myotis and Clarencetown Bridge could also accommodate a minimum of an additional 50 Southern Myotis (F. Lemckert pers. comm.). |

### 5.4.2 Regional microbat survey results

The desktop analysis, literature review and GIS mapping of existing records returned numerous potential roost sites for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis from within a 50 km radius of Balickera Tunnel. The 50 km radius was chosen as it approximates the nightly flight range of the Large Bent-winged Bat and the maximum distance travelled in a single night by the Little Bent-winged Bat (Dwyer 1966 and Dwyer 1968). Nightly flight ranges for Little Bent-winged Bats were more commonly recorded to be approximately 33 km (Dwyer 1968) and approximately 10 - 12 km for the Southern Myotis (ELA 2008). It is important to determine roosting options available to each species within their nightly flight range because any bats excluded from the tunnel will need to locate alternative roosts nearby within a single night.

The focus for the regional surveys was to visit the most likely locations of suitable alternative roosts to determine whether bats were currently using these sites and whether there was additional capacity to accommodate bats displaced from Balickera Tunnel. Searches for alternative roosts were conducted in September to minimise disturbance to roosting bats that would potentially occur over winter whilst also attempting to capture the tail end of peak occupancy for winter roosting Little and Large Bent-winged Bats. By September, Southern Myotis maternity roosts are establishing.

A total of 14 sites between 1 km and 33 km from Balickera Tunnel were visited and evaluated for their ability to provide roosting habitat for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis between September and October 2020, and in January 2021. The sites are shown on Figure 4-2. There were microbats present at five of the 14 sites during the inspection, four sites containing Little Bent-winged Bats, three sites containing Large Bent-winged Bats and at least two sites containing Southern Myotis (Table 5-16).

The regional surveys confirmed the presence (not necessarily roosting) of Little Bent-winged Bats at the Pacific Highway Bridge over Balickera Canal, Brookfield Tunnel, M1 Tunnel at Pambalong Nature Reserve, Dungog Water Treatment Plant (Dungog WTP) Tunnel, and all three Richmond Vale Rail Tunnels. Large Bent-winged Bats were confirmed at the Pacific Highway Bridge over Balickera Canal, Brookfield Tunnel, Dungog WTP Tunnel, and the Richmond Vale Rail Trail Tunnels. A new maternity colony of 70+ Southern Myotis was discovered at the Pacific Highway Bridge over Grahamstown Drain, 11 km from the Balickera Tunnel (Plate 24) in addition to a colony in the M1 Tunnel at Pambalong Nature Reserve. There were also potential ultrasonic records for Southern Myotis at the three Richmond Vale Rail Tunnels but the calls of Southern Myotis overlap with those of *Nyctophilus* spp. (Long-eared Bats) and without further investigation it is not possible to confirm presence of Southern Myotis within these tunnels.

Ultrasonic and visual surveys undertaken beneath the north and southbound lanes of the Pacific Highway Bridge over Balickera Canal confirmed that the canal is used as a commuting route for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis, as well as a foraging site for Southern Myotis. This result is not unexpected given the proximity of the bridge to Balickera Tunnel (<1 km from the downstream portal). The bridge however does not currently contain any roosting or breeding habitat. This site would be an ideal location for installation of bat boxes for Southern Myotis and could provide suitable alternative habitat within 1 km of the subject site (Plate 23).

**Plate 23: Underside of northbound lane of Pacific Highway Bridge over Balickera Canal**

**Plate 24: Highway Bridge over Grahamstown Drain, Southern Myotis maternity roost**

Brookfield Tunnel located 19 km from Balickera Tunnel is the nearest known roost site capable of accommodating up to 1000 additional bent-winged bats from those that would be displaced from Balickera Tunnel. The tunnel was constructed through a hill at Brookfield to carry the main water pipeline from Chichester Dam. It is portal shaped, partially concrete lined (first 4 m) and natural rock surface structure 2.3 m in height, 3.2 m wide with a length of approximately 110 m (Plate 25). It runs north – south and has an unimpeded entrance at each end. It contains the Chichester Dam water pipeline which is approximately 0.8 m wide diameter pipe at this location. Surrounding land use includes cleared farmland with remnant patches of woodland vegetation. Unwarrabin Creek is located approximately 600 m south of the tunnel.

Biosis (2018) reported the presence of 200 – 250 Large Bent-winged Bats, 160 – 200 Little Bent-winged Bats and 40 – 50 Eastern Horseshoe Bats during surveys in late summer 2018. During current visual and ultrasonic surveys undertaken in September 2020 by ELA, up to 1000 bats were recorded roosting within the tunnel with a greater number being Little Bent-winged Bats and a smaller number being Large Bent-winged Bats. There were significant guano deposits on the floor of the tunnel and on top of the water pipeline, as well as clearly stained areas on the roof of the tunnel indicating that large numbers of bats regularly roost within the tunnel. It is unknown whether this is suitable as a year round roost for either Bent-winged Bat species.

**Plate 25: Brookfield Tunnel approximately 19km from Balickera**

Dungog WTP Tunnel located approximately 29.5 km from Balickera Tunnel was identified by Ecotone in 2000 as a roost site for Large Bent-winged Bats with estimates of more than 600 individuals present as well as Eastern Horseshoe Bats. The tunnel is a circular shaped partially concrete lined (first 4 m) and natural rock surface structure of approximately 3.2 m wide diameter and a length of approximately 220 m. It contains the Chichester Dam water pipeline which is approximately 1.2 m wide diameter pipe running the length of the tunnel. It runs north – south and has an unimpeded entrance at each end. Surrounding land use includes the Dungog WTP, the township of Dungog and cleared farmland with remnant patches of woodland vegetation. The Williams River is located approximately 1.4 km east of the tunnel.

Ultrasonic and visual surveys undertaken over a single day and night in September 2020 for this study confirmed that the Dungog WTP roost is still active with approximately 2,000 individual bats roosting within the tunnel, the majority of which were Large Bent-winged Bats, with smaller numbers of Little Bent-winged Bats also present. There were significant guano deposits on the floor of the tunnel and on top of the water pipeline, as well as clearly stained areas on the roof of the tunnel indicating that large numbers of bats regularly roost within the tunnel (Plate 26). The Dungog WTP Tunnel roost has the capacity to accommodate an additional 1000+ bats. It is in a more protected location than the Brookfield Tunnel, is darker and more humid, with standing water to a depth of 10 cm throughout the tunnel. It is likely that it is used year round by Bent-winged Bats of both species. It is unknown whether breeding occurs at this location, but this could be determined from surveys conducted during December.

**Plate 26: Dungog WTP Tunnel showing multiple clusters of roosting Bent-winged Bats, staining on rock surface from repeated roosting by bats and thick coating of guano on water pipe**

The M1 Tunnel beneath the Pacific Highway at Pambalong Nature Reserve is located 27 km south of Balickera Tunnel. It is a much shorter concrete tunnel, approximately 6 m in height, 6 m wide at the base and 100 m in length (Plate 27). Pambalong Nature Reserve is a freshwater wetland at the western edge of Hexham Swamp, and is an integral part of a chain of wetland reserves that includes the internationally significant Ramsar-listed Hunter Estuary Wetlands.

Previous visual and ultrasonic surveys of the site as part of the assessment for the Richmond Vale Rail Trail by GHD (2020) identified 60 roosting Southern Myotis across 8 roost locations as well as potentially a few roosting Little Bent-winged Bats. During the current surveys in Sept 2020, at least five separate roost locations within expansion joints on the ceiling of the tunnel were identified. Each of these locations contained clusters of 15 plus bats, individuals and pairs of bats and the total number of bats present was estimated to be between 50 and 60 bats, comprised of a mix of Southern Myotis and Little Bent-winged Bats, with one other non-threatened species; *Chalinolobus morio* (Chocolate Wattled Bat) also roosting in the tunnel.

The M1 Tunnel does not represent a suitable alternative roost site for large numbers of either of the Bent-winged Bat species because it is very exposed, often visited by people and is planned to become part of the Richmond Vale Rail Trail. Despite recommended mitigation methods related to lighting and scheduling of the construction works, the proposed levels of disturbance that will accompany the construction and operation of the Richmond Vale Rail Trail at this site are unlikely to promote the continued presence of Southern Myotis at this site. This site is too far from Balickera Tunnel to provide alternative roosting and breeding habitat for Southern Myotis excluded and displaced by tunnel remediation works at Balickera.

**Plate 27: M1 Tunnel beneath the Pacific Highway, near Pambalong Nature Reserve**

The Richmond Vale Rail Trail Tunnels are located along the disused Richmond Vale rail line in the vicinity of Lenaghan, located 31.5 km to 33 km south of Balickera Tunnel. There are three tunnels and are all brick lined, approximately 4 m wide, 5 m in height and vary in length between 100 m and 372 m (Plate 28 to Plate 30). Previous surveys of the site in spring 2016 and January 2017 as part of the assessment for the Richmond Vale Rail Trail by GHD (2020) identified the presence of a number of microbat species. Surveys conducted for this study recorded the presence of at least two roosting bats (likely to be Bent-winged Bats; Plate 30) and a fresh pile of guano within Tunnel 3 (Plate 31). Ultrasonic results gathered during this study also indicate high levels of activity from a number of microbat species in the vicinity of Tunnel 2 and Tunnel 3. The timing of activity suggests that Tunnel 2 and Tunnel 3 are providing roosting habitat for small numbers of Little and Large Bent-winged Bats and Eastern Horseshoe Bats.

There were a small number of gaps, cracks, or crevices observed within the brick lining of the three tunnels, and only one fresh guano pile observed in Tunnel 3. However, rainfall prior to the surveys was likely to have washed any older guano from the tunnel floor of Tunnel 3. The floor of Tunnel 2 was largely submerged under pools of water obscuring any guano deposits that might have formed. Whilst these tunnels appear to provide roosting habitat for Little and Large Bent-winged Bats, it is unlikely that numbers would exceed 200 bats at any one time due to the periodic disturbance posed by human visitation. It is most likely that individuals or small clusters of Little and Large Bent-winged Bats and Eastern Horseshoe Bats are the most regular residents. The security of these roost sites is not guaranteed with the proposed development of the Richmond Vale Rail Trail. Flight distances from Balickera (> 30 km) and large areas of unfavourable foraging habitat on the intervening land, predominantly cleared for agricultural purposes put these tunnels at the limit of standard nightly flight ranges from Balickera by Little Bent-winged Bats, and certainly not attainable in a single night's flight by Southern Myotis. These tunnels are unlikely to provide alternative roosting habitat for bats excluded and displaced from Balickera Tunnel but may make up one of a series of temporary roost sites for smaller numbers of bats.

**Plate 28: Internal view of Richmond Vale Rail Tunnel 1**

**Plate 29: Entrance of Richmond Vale Rail Trail Tunnel 2**

**Plate 30: A single bat roosting in Richmond Vale Tunnel 3**

**Plate 31: Fresh guano deposit on the floor of the Richmond Vale Tunnel 3**

**Table 5-16: Regional microbat survey results**

| Site Name | Date | Survey methods | Bats present | Southern Myotis | Little Bent-winged Bat | Large Bent-winged Bat | Distance from Balickera Tunnel (km) |
|---|---|---|---|---|---|---|---|
| Pacific Highway Bridges over Balickera Canal | 26/1/2021 | Visual Inspection and Ultrasonic | NO | YES – not a roosting or breeding site, foraging only | YES – not a roosting or breeding site, foraging only | YES – not a roosting or breeding site, foraging only | 1 |
| 9 Mile Creek Bridge | 9/9/2020 | Visual inspection | NO | NO – no roosting habitat present, foraging only | NO – no roosting habitat present, foraging only | NO – no roosting habitat present, foraging only | 1.5 |
| Grahamstown Culvert | 9/9/2020 | Visual inspection | NO | NO – no roosting habitat present | NO – no roosting habitat present | NO – no roosting habitat present | 6.3 |
| Seaham Bridge | 10/9/2020 | Visual inspection | NO | NO – no roosting habitat present | NO – no roosting habitat present | NO – no roosting habitat present | 6.4 |
| Grahamstown Spillway | 9/9/2020 | Visual inspection | NO | NO – no roosting habitat present | NO – no roosting habitat present | NO – no roosting habitat present | 6.7 |
| Grahamstown Drain Overpass | 9/9/2020 | Visual inspection | YES | YES – 70+ bats in numerous locations - breeding site | NO – potential roost for individuals or small numbers | NO – potential roost for individuals or small numbers | 11 |
| Brookfield Tunnel | 10/9/2021 | Visual Inspection and Ultrasonic | YES | NO - no habitat present, too far from permanent water supply for SM to roost at this location | YES – approximately 1000 bats present, not a breeding site | YES – less than 50 bats present, not a breeding site | 19 |
| M1 Bridge Pambalong | 7/9/2020 | Visual inspection | NO | NO – no roosting habitat present | NO – no roosting habitat present | NO – no roosting habitat present | 26 |
| M1 Tunnel Pambalong | 7/9/2020 | Visual Ultrasonic and stag watch | YES | YES – tunnel contains between 5 and 10 roosts, containing 1 to 15 bats | YES – tunnel contains between 5 and 10 roosts, containing 1 to 15 bats | NO – potential roost for individuals or small numbers | 27 |

| Site Name | Date | Survey methods | Bats present | Southern Myotis | Little Bent-winged Bat | Large Bent-winged Bat | Distance from Balickera Tunnel (km) |
|---|---|---|---|---|---|---|---|
| Dungog WTP Tunnel | 10/9/2020 | Visual Inspection and Ultrasonic | YES | NO | YES – less than 100 bats present, unknown whether it is a breeding site | YES – up to 2000 bats present, unknown whether it is a breeding site | 29.5 |
| Bushrangers Cave | 7/10/2020 | Visual inspection | NO | NO – potential historical roost, no current evidence of use | NO – potential historical roost, no current evidence of use | NO – potential historical roost, no current evidence of use | 31.5 |
| Richmond Vale Rail Tunnel 1 | 7/10/2020 | Visual Inspection and Ultrasonic | NO | POTENTIAL – potential roost | YES – potential roost for individuals or small numbers, not a breeding site | YES – potential roost for individuals or small numbers, not a breeding site | 31.5 |
| Richmond Vale Rail Tunnel 2 | 7/10/2020 | Visual Inspection and Ultrasonic | NO | POTENTIAL – potential roost | YES – potential roost for small numbers to 200 bats, not a breeding site | YES – potential roost for small numbers to 200 bats, not a breeding site | 32 |
| Richmond Vale Rail Tunnel 3 | 7/10/2020 | Visual Inspection and Ultrasonic | YES | POTENTIAL – potential roost | YES – potential roost for small numbers to 200 bats not a breeding site | YES - potential roost for small numbers to 200 bats not a breeding site | 33 |

#### *5.4.2.1 Additional regional microbat roost sites known from previous surveys*

Previous surveys have listed a number of potential alternative roost sites for the Little Bent-winged Bat and Large Bent-winged Bat that were not investigated during this study. Table 5-17 below provides a summary of all known roost sites by distance from Balickera Tunnel that have been previously documented with updates on the status of those roosts, where known. The Little and Large Bent-winged Bat roosts known from previous records are also shown in Figure 5-7.

Of the alternative roosts within 33 km of Balickera Tunnel only Pilchers Mountain Caves and Blue Gum Hills Derelict Mine were unable to be visited during the current study. Pilchers Mountain Caves is a viable Little Bent-winged Bat roost capable of accommodating several hundred to thousands of bats. Advice from DPI (L. Gonsalves 2021 pers. comm.) has indicated that Blue Gum Hills Derelict Mine is inhabited by bats but there were very few Large Bent-winged Bats calls recorded during ultrasonic surveys undertaken at the mine entrance in autumn 2017. It is likely that the mine is used by fewer than 100 Little and Large Bent-winged Bats on an infrequent basis.

Within a 50 km radius of Balickera Tunnel there are several potential alternative roosts that were not able to be visited during this study including Yacaaba Headland Sea Caves, Sugarloaf State Conservation Area (SCA) and Bulahdelah Mountain Alum Mines. It is assumed that Yacaaba Headland Sea Caves are still viable because they are unlikely to have been disturbed owing to the difficulty of accessing the caves. The Alum Mines are viable and known to be inhabited by bats (L. Gonsalves pers. comm.). However, studies undertaken by DPI in 2017 involving thermal camera footage of emergence and ultrasonic analysis indicated that there were no Little Bent-winged Bats or Large Bent-winged Bats present during Autumn 2017. The status of the roost at Sugarloaf SCA is unknown. Roosts further than this distance are not expected to be accessible by Little Bent-winged Bats in the immediate period following exclusion because of distance and flight times but may form part of the network of roost sites utilised whilst the tunnel is inaccessible to bats.

There are numerous alternative roosts for Large Bent-winged Bats available within nightly flight range (50 km – 65 km) including quite a few that are known to be roosts for individuals or small numbers of bats only (Table 5-17). There are estimated to be between 300 and 500 Large Bent-winged Bats roosting within Balickera Tunnel. Brookfield Tunnel, Pilchers Mountain Caves and Dungog WTP are all currently viable roosts for this species with ample capacity to accommodate any Large Bent-winged Bats displaced from Balickera Tunnel.

In addition to the Southern Myotis maternity roost located under the Pacific Highway Bridge over Grahamstown Drain during this study, there are two other viable maternity roosts available to Southern Myotis excluded from Balickera Tunnel. One is located under the Pacific Highway Bridge over Twelve Mile Creek, also within nightly flight range (10 - 12km) of Balickera Tunnel (Table 5-17). The second is located under the Clarencetown Bridge over the Williams River, and it is known to have capacity to accommodate at least an additional 50 Southern Myotis. A further two Southern Myotis roosts are known within 10 km of Balickera Tunnel, Wattle Creek Bridge and Tumbledown Bridge but the status of these was not able to be determined during this study (Table 5-17). Therefore, there are multiple alternative roosts for Southern Myotis within nightly flight range of Balickera Tunnel.

**Table 5-17: Summary of regional microbat roosts, including those surveyed by ELA.**

| Name of roost | Species | Roost Type: Bent-winged Bats / Southern Myotis | Date of most recent record | Distance from Balickera Tunnel (km) | Source | Current status | Notes |
|---|---|---|---|---|---|---|---|
| Twelve Mile Creek | Southern Myotis | Breeding | Jan-21 | 4 | TfNSW | Viable | R. Martin 2021 |
| Wallaroo State Forest Thunderbolts Cave | No bats observed | Potential roost | Jan-95 | 5 | Ecotone 2000 | Unknown | |
| Clarencetown culvert | Southern Myotis | Unknown | Jul-18 | 6 | Atlas | Unknown | |
| Clarencetown culvert | Southern Myotis | Unknown | Jul-18 | 6 | Atlas | Unknown | |
| Clarencetown Bridge | Southern Myotis | Unknown | Jun-02 | 10 | Atlas | Unknown | |
| Wattle Creek Bridge | Large Bent-winged Bat, Southern Myotis | Breeding (SM), Non-breeding (LargeBWB) | Jul-18 | 10 | Atlas | Unknown | |
| Tumbledown Bridge | Large Bent-winged Bat, Southern Myotis | Breeding (SM), Non-breeding (LargeBWB) | Jul-18 | 10 | Atlas | Unknown | |
| Grahamstown Drain Bridge | Southern Myotis (70+) | Breeding | Sep-20 | 11 | ELA 2020-2021 | Viable | |
| Clarencetown culvert | Southern Myotis | Unknown | Jul-18 | 11 | Atlas | Unknown | |
| Clarencetown culvert | Southern Myotis | Unknown | Jul-18 | 15 | Atlas | Unknown | |
| Brookfield Tunnel | Large Bent-winged Bat (2 dead), Eastern Horseshoe Bat (10) | Non-breeding | Jan-95 | 19 | Ecotone 2000 | Viable | ELA 2020-2021 |
| Dunmore Bridge | Southern Myotis | Breeding | Oct-13 | 19 | Atlas | Unknown | |
| Stockton Bridge | Large Bent-winged Bat (10) | Non-breeding | Sep-98 | 24 | Ecotone 2000 | Unknown | |
| Blue Gum Hills Derelict Mine | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | May-14 | 26 | Atlas | Viable | L. Gonsalves 2021 |
| M1 Tunnel | Southern Myotis | Breeding | Nov-17 | 27 | Atlas | Viable | ELA 2020-2021 |
| Pilchers Mountain | Little Bent-winged Bat, Large Bent-winged Bat, Eastern Horseshoe Bat | Breeding (?), Non-breeding | Apr-21 | 28 | Historical | Viable | A. Rowles 2021 |
| Edgeworth | Large Bent-winged Bat | Non-breeding (Large) | Dec-01 | 29 | Atlas | Unknown | |
| Dungog WTP | Large Bent-winged Bat (600+), Eastern Horseshoe Bat (1) | Breeding (?), Non-breeding | Jun-99 | 30 | Ecotone 2000 | Viable | ELA 2020 - 2021 |

| Name of roost | Species | Roost Type: Bent-winged Bats / Southern Myotis | Date of most recent record | Distance from Balickera Tunnel (km) | Source | Current status | Notes |
|---|---|---|---|---|---|---|---|
| Richmond Vale Rail Trail Tunnel 1 | No bats observed | Potential non-breeding roost (SM, Little and Large BWB, Eastern Horseshoe Bat) | Oct-20 | 31 | GHD 2020 | Viable | ELA 2020 - 2021 |
| Richmond Vale Rail Trail Tunnel 2 | No bats observed | Potential non-breeding roost (SM, Little and Large BWB, Eastern Horseshoe Bat) | Oct-20 | 32 | GHD 2020 | Viable | ELA 2020 - 2021 |
| Richmond Vale Rail Trail Tunnel 3 | Large Bent-winged Bat (2) | Non-breeding (Little and LargeBWB, SM, Eastern Horseshoe Bat) | Oct-20 | 33 | GHD 2020 | Viable | ELA 2020 - 2021 |
| Valley Creek Bridge, Monkerai | Southern Myotis | Unknown | Mar-18 | 33 | Atlas | Unknown | |
| Luskintyre Bridge | Southern Myotis | Breeding | Jan-19 | 35 | Atlas | Unknown | |
| Monkerai culvert | Southern Myotis | Unknown | Apr-18 | 35 | Atlas | Unknown | |
| Jesmond culvert | Little Bent-winged Bat (300+) | Non-breeding | | 36 | TfNSW | Viable | J. Stokes 2021 |
| Yacaaba Headland Sea Caves | Little Bent-winged Bat (100+), Large Bent-winged Bat (100+) | Non-breeding | Mar-98 | 37 | Ecotone 2000 | Unknown | |
| Leconfield | Large Bent-winged Bat | Non-breeding | | 38 | Atlas | Unknown | |
| Monkerai culvert | Large Bent-winged Bat | Non-breeding | Apr-18 | 39 | Atlas | Unknown | |
| Monkerai culvert | Large Bent-winged Bat, Southern Myotis | Breeding (SM), Non-breeding (LargeBWB) | Apr-18 | 39 | Atlas | Unknown | |
| Monkerai culvert | Southern Myotis | Unknown | Apr-18 | 41 | Atlas | Unknown | |
| Elderslie Bridge | Large Bent-winged Bat | Non-breeding (Large) | Dec-17 | 43 | Atlas | Unknown | |
| Monkerai culvert | Southern Myotis | Unknown | Apr-18 | 43 | Atlas | Unknown | |
| Monkerai culvert | Southern Myotis | Unknown | Apr-18 | 43 | Atlas | Unknown | |
| Monkerai culvert | Large Bent-winged Bat | Non-breeding | Apr-18 | 44 | Atlas | Unknown | |
| Monkerai culvert | Southern Myotis | Unknown | Apr-18 | 44 | Atlas | Unknown | |
| Sugarloaf SCA | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jun-08 | 46 | Atlas | Unknown | |
| Kitchener culvert | Southern Myotis | Unknown | Mar-04 | 47 | Atlas | Unknown | |

| Name of roost | Species | Roost Type: Bent-winged Bats / Southern Myotis | Date of most recent record | Distance from Balickera Tunnel (km) | Source | Current status | Notes |
|---|---|---|---|---|---|---|---|
| Bulahdelah Mountain Alum Mines | Little Bent-winged Bat, Large Bent-winged Bat, Eastern Horseshoe Bat | Non-breeding | Oct-98 | 48 | Ecotone 2000 | Viable | L. Gonsalves 2021 |
| Markwell Road Bridge | Southern Myotis | Breeding | Oct-14 | 49 | Atlas | Unknown | |
| Cureeki Creek Gold Mines | Little Bent-winged Bat, Large Bent-winged Bat, Eastern Horseshoe Bat (15) | Non-breeding | Oct-98 | 67 | Ecotone 2000 | Unknown | |
| Krambach Natural Cave | Large Bent-winged Bat (300+), Eastern Horseshoe Bat | Non-breeding | Aug-99 | 82 | Ecotone 2000 | Viable | B. Law 2021 |
| Endless Cave Kincumber | Large Bent-winged Bat (17), Eastern Horseshoe Bat (10) | Non-breeding | Apr-00 | 95 | Ecotone 2000 | Unknown | |
| Copeland Tops Derelict Mine - Adit A | Little Bent-winged Bat (<30) | Non-breeding | May-17 | 115 | DPI | Viable | L. Gonsalves 2021 |
| Copeland Tops Derelict Mine - Hidden Treasure | Large Bent-winged Bat (<30), Eastern Horseshoe Bat (100+) | Non-breeding | May-17 | 115 | DPI | Viable | L. Gonsalves 2021 |
| Big Hill | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 190 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Yessabah | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 193 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Moparrabah | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 200 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Willi Willi Caves | Little Bent-winged Bat, Large Bent-winged Bat | Breeding | Jan-68 | 200 | Dwyer (1968) Australian J. Zoology | Viable | NSW DPIE 2021 |
| Carrai | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 202 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Camp | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 206 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Cangai | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 355 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Bonalbo | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 445 | Dwyer (1968) Australian J. Zoology | Unknown | |
| Old Tooloom | Little Bent-winged Bat, Large Bent-winged Bat | Non-breeding | Jan-68 | 470 | Dwyer (1968) Australian J. Zoology | Unknown | |

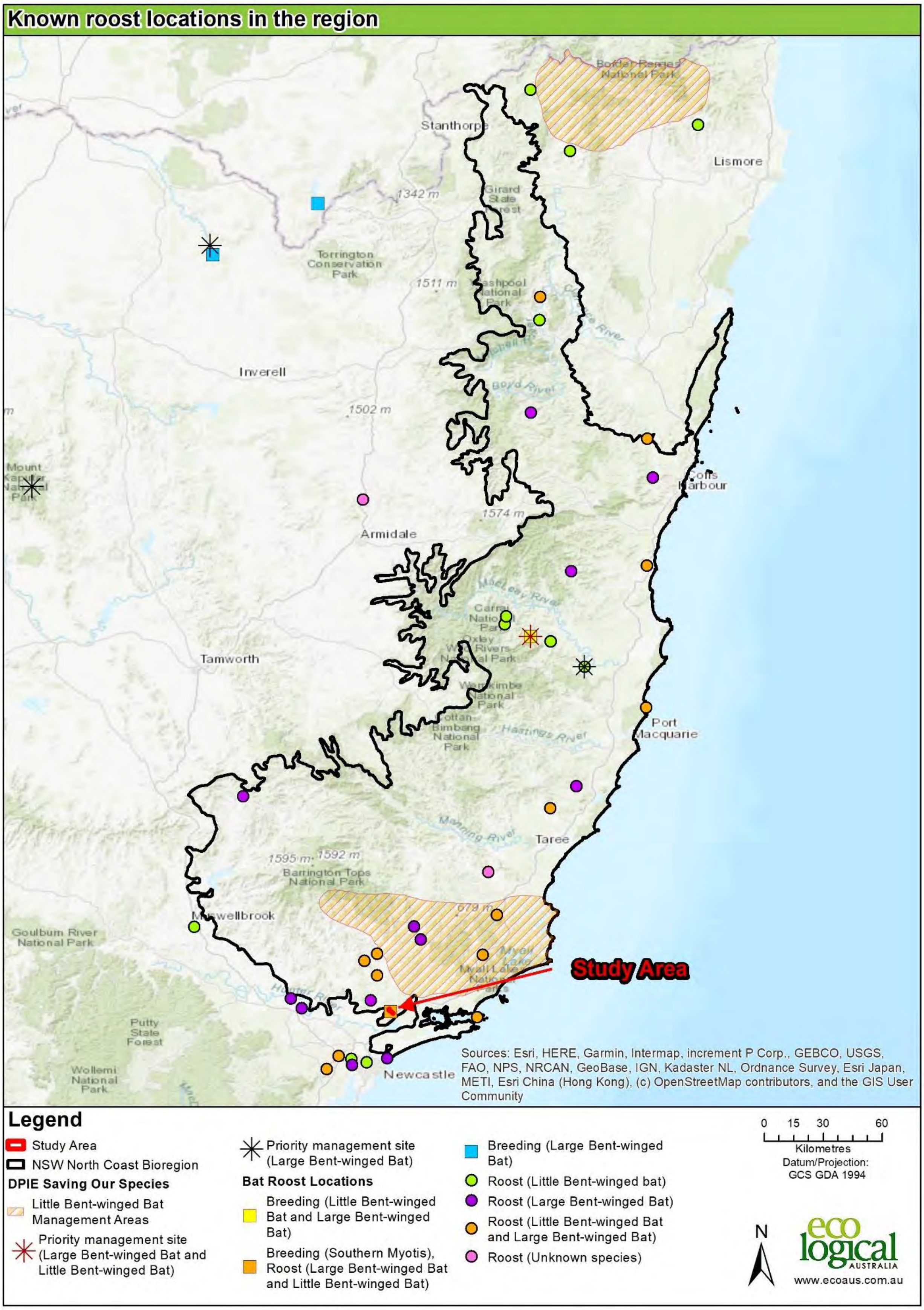



**Figure 5-7. Regional distribution of previously known Little and Large Bent-winged Bat roosts surrounding Balickera Tunnel**

### 5.4.3 Arboreal and terrestrial mammal surveys

Terrestrial and arboreal mammal surveys detected 11 mammal species (excluding microbats), including five exotic species of mammals within the study area. Native mammal species recorded included:

- Eastern Grey Kangaroo (*Macropus giganteus*)
- Red-necked Wallaby (*Macropus rufogriseus*)
- Swamp Wallaby (*Wallabia bicolor*)
- Common Brushtail Possum (*Trichosurus vulpecula*)
- Sugar Glider (*Petaurus breviceps*)
- Grey-headed Flying-fox.

The Grey-headed Flying-fox is listed as Vulnerable under the BC Act and EPBC Act and was observed flying over the study area on several occasions and heard foraging in forest habitat adjacent to the study area. This species may utilise the study area on occasion for foraging during periods of nectar availability but, does not use the site for roosting or breeding.

Koala was not recorded during spotlighting surveys within the study area. However, due to the high number of records within the locality and suitable habitat within the study area, Koala was assessed as likely to use the study area on occasion.

Exotic species recorded were Dog (*Canis lupus familiaris*), Red Fox (*Vulpes vulpes*), Fallow Deer (*Dama dama*), Rusa Deer (*Cervus timorensis*) and Black Rat (*Rattus rattus*).

### 5.4.4 Amphibian surveys

Amphibian habitat within the study area includes the Balickera Canal, an ephemeral drainage line near the downstream portal. A small dam in the vicinity of the upstream portal and adjacent to the study area was also surveyed.

A total of seven species of amphibian were recorded within the study area. Common species encountered included Emerald-spotted Tree Frog (*Litoria peronii*) and Eastern Sedge Frog (*Litoria fallax*).

No threatened amphibian species were recorded within the study area and the amphibian species recorded within the study area are considered to be common in the region. A complete list of amphibian species recorded is shown in Appendix E.

### 5.4.5 Diurnal bird surveys

Diurnal birds observed or heard within the study area are generally common for open forests and partially cleared habitats of the region. Surveys were conducted over multiple seasons to increase likelihood of detecting species which may occur in the study area seasonally or on occasion.

A total of 50 bird species were observed or heard within the study area.

Three species listed as Vulnerable under the BC Act were observed within the study area, including:

- White-bellied Sea-Eagle:
    - Recorded on several occasions associated with Balickera Canal, including flying directly over the canal. A pair was recorded and calling for a perch in a tree 250 m west of the upstream portal during June 2020

- Little Lorikeet:
  - Recorded flying over study area on one occasion. Likely to forage in study area.
- Grey-crowned Babbler (eastern subspecies):
  - Observed on one occasion in the north west of the study area.

Due to the absence of large hollow-bearing trees within the study area, no call-playback surveys for threatened owls such as the Powerful Owl and Masked Owl were undertaken. In consideration of the large home range of these species, suitable foraging habitat in the study area and records within the locality, it is likely that they would use forest habitat in the study area for foraging on occasion.

No threatened species listed under the EPBC Act were recorded.

A complete list of bird species recorded is shown in Appendix E.

## 5.5 Identification of affected species

Section 5 of the CERs requires the SIS to refine the list of subject species, given the outcome of current and previous surveys, to identify which subject species (species, populations or communities) may be directly or indirectly affected (including cumulatively) by the proposal, in accordance with Section 7.6(2)(b) of the *BC Regulation*.

A total of 27 threatened fauna species, 11 threatened flora species, and three TECs, were considered as subject species for this SIS (Section 3.3 and Appendix B). Based on the assessment of likelihood of occurrence and considering the results of field surveys, the following species are known or likely to occur within the study area and are likely to be affected by the proposal:

- Little Bent-winged Bat
- Large Bent-winged Bat
- Southern Myotis
- Eastern False Pipistrelle
- Eastern Coastal Free-tailed Bat
- Koala
- Grey-headed Flying-fox
- Little Lorikeet
- White-bellied Sea-Eagle
- Powerful Owl
- Grey-crowned Babbler (eastern subspecies)
- Masked Owl.

The location of all threatened species identified within the study area is shown on Figure 5-8.

The potential impact of the proposal on these affected species is addressed in Section 6.

## 5.6 Subject species not identified as affected species within this SIS

If adequate surveys/studies have been undertaken to demonstrate that a subject species does not occur in the study area, or if not resident, will not utilise habitats on site on occasion, or if off-site, be influenced by off-site impacts of the activity, the species does not have to be considered further. Subject species that were not identified as affected species are detailed in Appendix B.

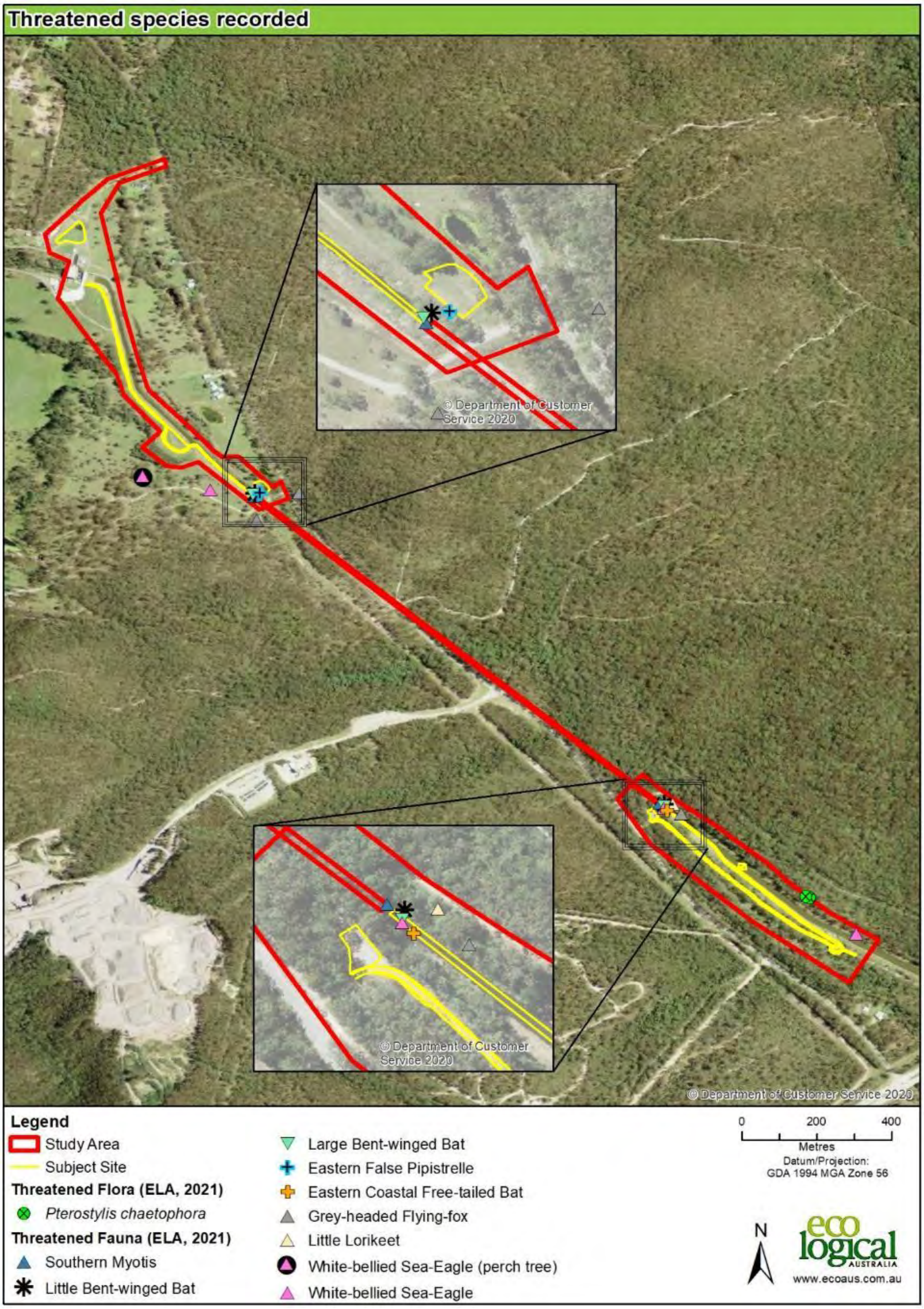



**Figure 5-8: Threatened species recorded within the SIS study area**

# 6. Assessment of likely impacts

## 6.1 Assessment of likely affected species

The following assessment of likely impacts on threatened species follows the CERs for the SIS which outline that an assessment of impacts must include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes and changes in surface water flows. These actions or impacts may occur on or off the subject land. The assessment must also include any fire protection zones required.

## 6.2 Little Bent-winged Bat

### 6.2.1 Conservation status

#### *6.2.1.1 Local, regional and state conservation status*

The Little Bent-winged Bat is listed as Vulnerable under the BC Act. The species is not listed under the EPBC Act. The Little Bent-winged Bat has been recorded on the NSW BioNet database from within 57 conservation reserves within the region. In NSW, 23% of the species' distribution within NSW occurs within conservation reserves (DPIE 2021a).

#### *6.2.1.2 Key threatening processes*

The following key threatening processes (KTP) are listed in NSW under the BC Act for the Little Bent-winged Bat and may result from the proposal:

- Clearing of native vegetation
- Predation by the *Felis catus* (feral cat)
- Predation by the *Vulpes vulpes* (European red fox)
- Loss of hollow-bearing trees
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

The KTP ‘clearing of native vegetation’ is relevant to the proposal.

#### *6.2.1.3 Habitat requirements*

The Little Bent-winged Bat utilises moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, *Melaleuca* swamps, dense coastal forests and *Banksia* scrub for foraging. The species is generally found in well-timbered areas.

Little Bent-winged Bats roost over winter in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings or tree hollows during the day, and at night forage in densely vegetated habitats. The species congregates in the thousands with Large Bent-winged Bats in a single known maternity cave in NSW to breed over summer, showing high maternity roost fidelity (Churchill 2008).

#### *6.2.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species. The Little Bent-winged Bat is classified as a landscape managed species under the DPIE Saving Our Species (SoS) program (DPIE 2021b). The aim of the SoS program is to ensure that the species is secure in the wild in NSW and that its NSW geographic range is extended or maintained and to maintain its conservation status under the BC Act.

The key threats to Little Bent-winged Bats are:

- Disturbance of colonies, especially in nursery or hibernating caves
- Destruction of caves that provide seasonal or potential roosting sites.
- Changes to habitat, especially surrounding maternity/nursery caves and winter roosts.
- Predation from foxes, particularly around maternity caves, winter roosts and roosts within culverts, tunnels and under bridges.
- Predation from feral cats, particularly around maternity caves, winter roosts and roosts within culverts, tunnels and under bridges
- Introduction of exotic pathogens such as the White-nosed fungus.
- Hazard reduction and wildfire fires during the breeding season.
- Large scale wildfire or hazard reduction can impact on foraging resources.
- Poor knowledge of reproductive success and population dynamics.

The proposal includes a number of identified threats to Little Bent-winged Bats with the most significant being disturbance of colonies, especially in nursery or hibernating caves. Tunnel remediation works, if not completed following the specifications for preservation and replication of roosting habitat, would also cause destruction of a seasonal roosting site. These threats are addressed and minimised through the timing of works, exclusion of bats from the tunnel prior to works and methodology by which tunnel remediation works will be undertaken (as outlined in this SIS and specifically in the MMP Appendix J).

The proposal may increase the risk of introducing exotic pathogens by way of human and vehicular traffic within the tunnel. Hygiene measures will be applied by construction staff to minimise the risk of pathogens entering the site during constriction and these are outlined in the MMP (Appendix J).

Critical actions for the recovery of this species have been identified by SoS in an action toolbox. One critical action relevant to this SIS is to identify important maternity or hibernation roost sites (e.g. caves, tunnels, bridges, drains, culverts) and negotiate with relevant landholders or land managers to enter into an agreement that protects these sites from disturbance or degradation. This should include provision to check and seek expert advice if the bats are present prior to undertaking maintenance works. Hunter Water are complying with this action by completing the SIS.

One key management site for this threatened species has been identified; Willi Willi Cave located within the Kempsey local government area (LGA). This cave is likely the maternity roost for female Little Bent-winged Bats at Balickera Tunnel and so actions undertaken at this site should benefit the Balickera colony. As necessary, and as a further means of offsetting impacts from tunnel remediation works to Little Bent-winged Bats roosting at Balickera, cost-effective and beneficial management actions can be undertaken at this site.

#### *6.2.1.5 Assessment of representation within conservation reserves in the region*

The Little Bent-winged Bat is well represented within conservation reserves within the region, with 241 of 1,534 records (16%) from within conservation reserves. There are records of this species from the following conservation reserves in the same region as the study area:

- Booti Booti National Park
- Columbey State Conservation Area
- Hunter Wetlands National Park
- John Gould Nature Reserve
- Karuah National Park
- Myall Lakes National Park
- The Glen Nature Reserve
- Tilligerry State Conservation Area
- Wallaroo National Park
- Wallingat National Park
- Worimi National Park
- Worimi State Conservation Area.

#### *6.2.1.6 Species distribution*

The Little Bent-winged Bat is distributed between northern Queensland to southern NSW, along the Great Dividing Range (BatMap 2021, Atlas of Living Australia 2021). In late spring, pregnant females disperse from the east coast and migrate to maternity roosts in caves (Dwyer 1968), where they give birth and raise young over summer before returning east in autumn (Dwyer 1963; Hoye and Spence 2004). There is only one known maternity cave in NSW, at Willi Willi inland from Kempsey, 200 km from the subject site. The subject site occurs towards the southern end of their distribution. The roost at Balickera Tunnel represents the most southerly roost of its size known to be permanently inhabited by Little Bent-winged Bats and is therefore likely a critical resource important for the continued survival of this species.

### 6.2.2 Local and regional abundance

The species is known to be in relatively high local (71 records) and regional (1,534 records) abundance (Figure 6-1). Within 50 km of the study area, this study and several previous studies have recorded several other roost sites including:

- Brookfield Tunnel, 20 km NW (up to 1000 bats during current study, ELA 2021; 160 - 200 individuals, Biosis 2018)
- Blue Gum Hills Derelict Mine, 26 km S (< 50 bats, L. Gonsalves pers. comm.)
- M1 Tunnel Pambalong, 27 km S (15 bats)
- Pilchers Mountain caves, 28 km NW (unknown population, likely to be > 500 bats, estimated capacity > 2000 bats)
- Dungog WTP Tunnel, 30 km N (up to 200 bats during current study, ELA 2021; less than 100 bats, Ecotone 2000)
- Richmond Vale Rail Tunnels, three tunnels located 31 to 33 km SW (< 200 bats)
- Jesmond culvert, 36 km S (300+ bats)
- Yacaaba Headland Sea Cave, 37 km E (100+ bats, Ecotone 2000, estimated capacity >500 bats)

- Sugarloaf State Conservation Area, 46 km S (unknown population, likely to be < 200 bats)
- Bulahdelah Mountain Alum Mines, 48 km NE (unknown population, likely to be < 100 bats).

This study has estimated the population at the Balickera Tunnel to range between a low of 2000 individuals during summer and peaking at between 5000 and 6000 individuals over winter. This is the most southerly roost of its size permanently inhabited by Little Bent-winged Bats in Australia. There are only five known maternity roosts of this species (Dwyer, 1968). The largest maternity roost at Mt Etna in Queensland is known to contain approximately 100,000 bats which is thought to represent 80% of the breeding population in Australia (IUCN Red List, 2019). The only known maternity roost in NSW at Willi Willi caves was estimated to contain 6850 individuals at peak occupancy by Dwyer (1968). Although over 50 years old, the population estimate for Willi Willi caves is not much higher than the estimate for the peak occupancy recorded at Balickera Tunnel during this study. Balickera Tunnel contains roosting habitat for approximately 5% of the breeding population of Little Bent-winged Bats and because of its location at the southern end of the species range must be considered a significant roost site.

### 6.2.3 Assessment of habitat

#### *6.2.3.1 Description of habitat values*

The Balickera Tunnel includes natural rock substrate and vertical cylindrical 20 cm diameter holes within the concrete lined sections, both of which provide suitable roosting habitat for the Little Bent-winged Bat. The majority of the roosting habitat is located within 500 m of the upstream end of the tunnel. The main Little Bent-winged Bat roosting areas are located within the first and second natural rock sections between chainage 173 m and 290 m and between 304 and 493 m from the upstream portal. The main roost is located approximately 240 m from the upstream portal, with smaller clusters and scattered individuals in the vicinity of this roost. The roosting habitat within the tunnel supports sub-adults, adult males and females and pregnant females.

Additionally, Balickera Canal provides a source of water to Little Bent-winged Bats roosting within the tunnel. The proposal will alter flow regimes within Balickera Canal for the duration of works (maximum of five months). A coffer dam installed 200 m from the downstream portal will be used to dewater the canal upstream of the coffer dam prior to commencement of tunnel remediation works. Water levels within the canal fluctuate regularly in relation to the water levels present within Grahamstown Dam and the pumping regime applied at Balickera pumping station. It is unlikely that dewatering the canal within the tunnel will affect local populations of Little Bent-winged Bats because access to water on the downstream side of the coffer dam will be retained and bats will be excluded from the tunnel for the duration of works.

Open forest is present in the vicinity of the tunnel with connectivity to large areas of remnant forest within the adjacent Wallaroo State Forest and Wallaroo National Park. These areas provide foraging habitat for the species.

#### *6.2.3.2 Discussion of habitat utilisation*

Little Bent-winged Bats have been consistently recorded using the Balickera Tunnel based on surveys conducted between 1995 and 2021. The species is considered to be a year round resident but the tunnel is not used as a maternity roost. The population of Little Bent-winged Bats halves over summer to an estimated 2000 bats when females leave to give birth and raise young in a maternity cave elsewhere. There are very few females present between December and February. The population builds up gradually over autumn, when males outnumber females, and reaches peak occupancy of 5000 - 6000 bats throughout winter and early spring when sex ratio's approach 1:1.

Little Bent-winged Bats forage within forested areas in the vicinity of the tunnel and broader locality.

#### *6.2.3.3 Extent of habitat removal*

The proposed upgrade of the Balickera Tunnel will involve the installation of a new shotcrete / concrete lining in the existing concrete lined sections and the installation of new rock bolts and / or new shotcrete / concrete lining (up to 20% of the tunnel surface) in low rock quality areas along the unlined (natural rock) sections. This will remove suitable roosting habitat for microbats.

Some of the natural rock surfaces and vertical holes in concrete lined sections used as roosting habitat by Little Bent-winged Bats will be permanently changed following the application of shotcrete and rock bolting. The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species of bat at the conclusion of the tunnel remediation works, either in original format or a combination of original format and replicated roosting habitat.

In the short term however (for a maximum of 5 months), all microbats will be excluded from the site during works to minimize the risk of harm or death. This will result in a temporary loss of roosting habitat throughout the exclusion. During this time, the species is likely to relocate to other known roosts in the surrounding area. Existing roost sites within the tunnel are expected to be suitable for roosting following completion of works. The exclusion will occur for a maximum of five months between December and the end of April, when the population is at a minimum and pregnant females would have migrated to maternity roosts to give birth.

In terms of cumulative impacts, there are no works planned for Brookfield Tunnel or Dungog WTP Tunnel, both Hunter Water assets representing two of the largest alternative roost sites available for Little Bent-winged Bats within nightly flight range. There was a reported collapse within Pilchers Mountain Caves which is also a large capacity roost site. Recent surveys recorded a large number of Little Bent-winged Bats and a smaller number of Large Bent-winged Bats roosting within the cave. The cave is within a reserve managed by Dungog Council and will remain protected and accessible to bats for the foreseeable future.

Blue Gum Hills Derelict Mine has a limited capacity and is inhabited largely by Eastern Horseshoe Bats (L. Gonsalves pers.comm.). The M1 Tunnel at Pambalong and the Richmond Vale Rail Trail Tunnels at Stockrington are at risk from development and not likely to be suitable as alternative roost sites in the medium to long term. Yacaaba Sea Caves is a moderate capacity roost site located within a state reserve managed by NPWS and will remain protected and accessible to bats for the forseaable future. Both Sugarloaf SCA and Buladelah Mountain Alum Mine are moderate sized roosts either on reserved land or protected and will also be available to bats for the foreseeable future.

Jesmond culvert is a moderate capacity winter roost for Little Bent-winged Bats. It is in unknown condition and it is possible there may be culvert upgrade works planned in the next 5 to ten years. However, given the availability of Little Bent-winged Bat roosting habitat within a 50km radius and the large capacity of secure roosts, there is expected to be capacity for bats from Balickera as well as any Little Bent-winged Bat colonies impacted by works outside of the Balickera Tunnel remediation project.

As well as temporary loss of roosting habitat, the proposal will result in a small loss of foraging habitat. The proposal will result in the loss of 0.05 ha of foraging habitat in the adjacent forests – a minimal amount relative to the surrounding habitat available.

#### *6.2.3.4 Consideration of corridors*

The Little Bent-winged Bat is highly mobile and forages in forested areas. The locality is heavily timbered, and the proposed work is unlikely to impact corridors of movement used by this species.

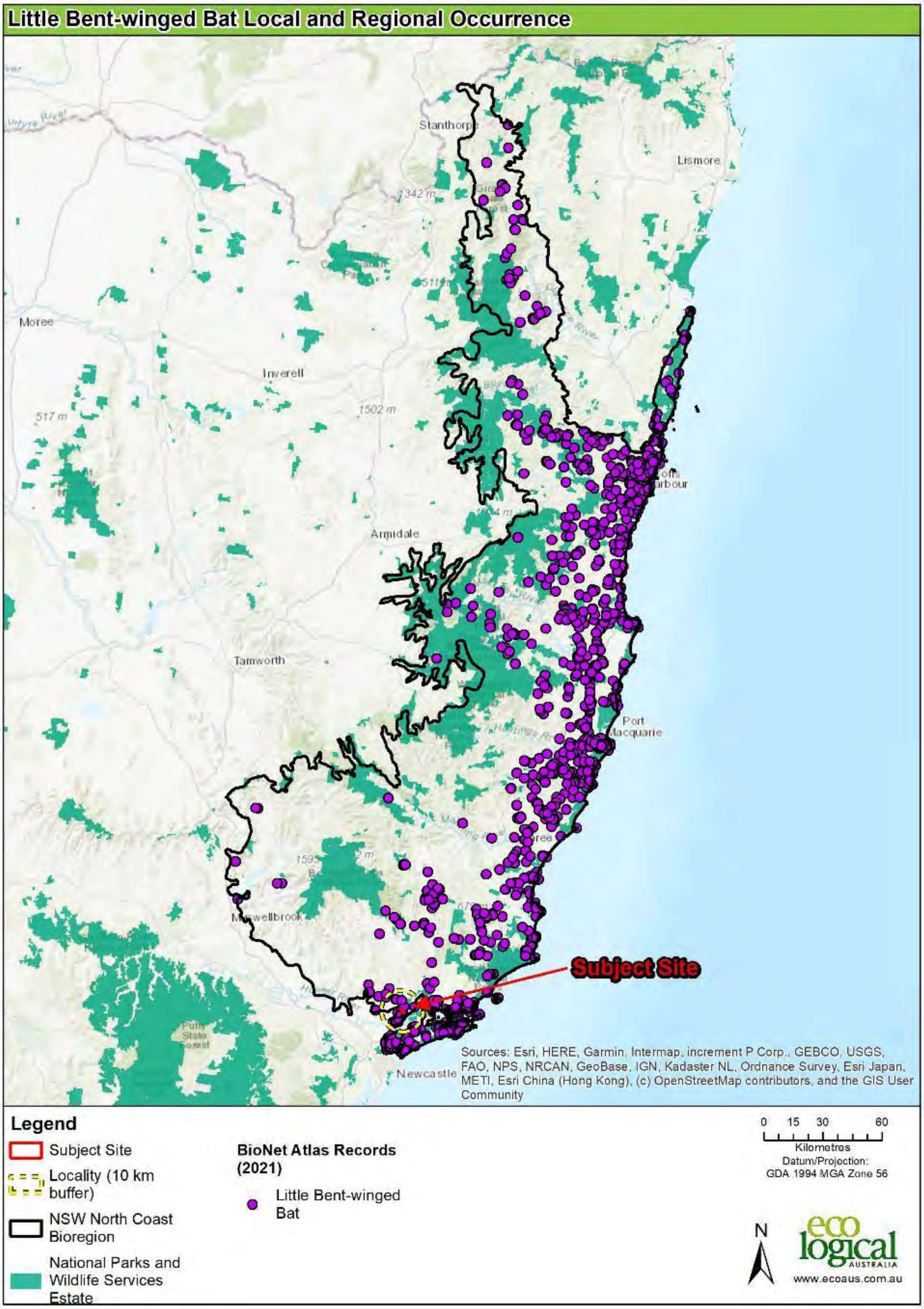



**Figure 6-1: Little Bent-winged Bat local and regional occurrence**


**Figure 6-2: Little Bent-winged Bat habitat**

## 6.3 Large Bent-winged Bat

### 6.3.1 Conservation status

#### *6.3.1.1 Local, regional and state conservation status*

Large Bent-winged Bat is listed as Vulnerable under the BC Act. The species is not listed under the EPBC Act. The Large Bent-winged Bat has been recorded on the NSW BioNet database from within 52 conservation reserves within the region.

#### *6.3.1.2 Key threatening processes*

The following KTP are listed in NSW under the BC Act for the Large Bent-winged Bat and may result from the proposal:

- Clearing of native vegetation, predation by the *Felis catus* (feral cat)
- Predation by the *Vulpes vulpes* (European red fox)
- Loss of hollow-bearing trees
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition

The KTP ‘clearing of native vegetation’ is relevant to the proposal.

#### *6.3.1.3 Habitat requirements*

Large Bent-winged Bats utilise moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, *Melaleuca* swamps, dense coastal forests and *Banksia* scrub for foraging. The species is generally found in well-timbered areas.

Over winter, Large Bent-winged Bats will use caves, culverts, bridges, abandoned mines and tunnels as hibernation / winter roosts (Churchill 2008). At night they forage in densely vegetated habitats in the surrounding area. Individuals use a network of roosts throughout the year. They congregate in the thousands in a small number of caves in NSW, often shared with Little Bent-winged Bats, to breed over summer. The species use the same maternity roost year after year. Females disperse to maternity roosts in limestone caves in late spring/early summer and return to coastal roots in March/April (Mills 2021).

#### *6.3.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species. The Large Bent-winged Bat is classified as a site managed species under the SoS program (DPIE, 2021b). The aim of the SoS program is to ensure that the species is secure in the wild for 100 years and to maintain its conservation status under the BC Act. The nearest managed site for the Large Bent-winged Bat to Balickera Tunnel is Willi Willi Cave, located within the Kempsey LGA, approximately 200 km north of the tunnel.

The key threats to Large Bent-winged Bats are:

- Disturbance by recreational cavers and general public accessing caves and adjacent areas particularly during winter or breeding.
- Loss of high productivity foraging habitat.
- Introduction of exotic pathogens, particularly white-nose fungus.

- Cave entrances being blocked for human health and safety reasons, or vegetation (particularly blackberries) encroaching on and blocking cave entrances.
- Hazard reduction and wildfire fires during the breeding season.
- Predation by feral cats.

The proposal may increase the risk of introducing exotic pathogens by way of human and vehicular traffic within the tunnel. Hygiene measures will be applied by construction staff to minimise the risk of pathogens entering the site during constriction and these are outlined in the MMP (Appendix J).

#### *6.3.1.5 Assessment of representation within conservation reserves in the region*

The Large Bent-winged Bat is well represented within conservation reserves within the region (306 records of 1114 records - 27%). In the local region to the study area, there are records of these species from:

- Barrington Tops National Park
- Columbey National Park
- Copeland Tops State Conservation Area
- Curracabundi National Park
- Ghin-Doo-Ee National Park
- Hunter Wetlands National Park
- Juugawaarri Nature Reserve
- Karuah National Park
- Little Broughton Island Nature Reserve
- Myall Lakes National Park
- Wallaroo National Park
- Worimi State Conservation Area

#### *6.3.1.6 Species distribution*

The Large Bent-winged Bat's distribution extends from southern Queensland to northern Victoria, along the Great Dividing Range (with a small number of scattered recordings outside this range, BatMap and Atlas of Living Australia 2021). In late spring, pregnant females disperse from the east coast and migrate to one of three known maternity roosts in caves in NSW, where they give birth and raise young over summer before returning east in autumn (Dwyer 1963; Hoye and Spence 2004). The subject site occurs in the core of their winter distribution, with no known maternity roosts in the local area.

### 6.3.2 Local and regional abundance

The species is known to be in relatively high local (11 records) and regional abundance (1114 records) (Figure 6-3). In the local area, and within the 60 km nightly flight range for Large Bent-winged Bats, studies have recorded 20 other roost sites including:

- Wattle Creek Bridge, 10 km N (unknown population, likely to be < 30 bats)
- Tumbledown Bridge, 10 km NE (unknown population, likely to be < 30 bats)
- Brookfield Tunnel, 20 km N (< 100 individuals during current study, ELA 2021; 200 – 250 individual, Biosis 2018)
- Stockton Bridge, 24 km S (10 bats, Ecotone 2000)

- Blue Gum Hills Derelict Mine, 26 km S (< 50 bats, L. Gonsalves pers. comm.)
- Pilchers Mountain caves, 28 km NE (unknown population, likely to be < 200 bats, estimated capacity > 2000 bats)
- Edgeworth culvert, 29 km S (unknown population, likely to be < 50 bats)
- Dungog WTP, 30 km N (approx. 2000 bats during current study, ELA 2021; 600+ bats, Ecotone 2000)
- Richmond Vale Rail Tunnels, 31 – 33 km SW (< 200 bats)
- Yacaaba Headland Sea Cave, 37 km NE (100+ bats, Ecotone 2000)
- Leconfield, 38 km W (unknown population, BioNet 2021)
- Monkerai culverts, 39 km,41 km and 44 km (unknown population, likely to be <30 bats)
- Elderslie Bridge, 43 km (unknown population, BioNet 2021)
- Sugarloaf State Conservation Area, 46 km SW (unknown population, likely to be < 200 bats)
- Kitchener, 47 km (unknown population, BioNet 2021)
- Bulahdelah Mountain Alum Mines, 48km NE (unknown population, likely to be < 100 bats).

This study has estimated the population at the Balickera Tunnel to range between a low of 200 individuals during summer to a peak of 500 individuals over winter. There are thought to be in excess of 100,000 mature individual Large Bent-winged Bats in Australia and there are three large maternity roosts containing upwards of 20,000 individuals spread throughout the east coast and tablelands of NSW (Mills 2021). Balickera Tunnel provides roosting habitat for a very small portion (<1%) of the extant population in Australia and is not regarded as a nationally significant roost site, despite its importance on a local and regional scale.

### 6.3.3 Assessment of habitat

#### *6.3.3.1 Description of habitat values*

The Balickera Tunnel includes natural rock substrate and vertical holes within the concrete, suitable roosting habitat for the Large Bent-winged Bat. The occurrence of suitable roosting habitat is particularly prevalent in the upstream end of the tunnel and the majority of individuals roost within the first natural rock section from upstream portal, between 176 m and 290 m from the upstream portal. The main roost is estimated to be approximately 240 m from the upstream portal, with smaller clusters and scattered individuals in the vicinity of this roost.

Balickera Canal provides a source of water to Large Bent-winged Bats roosting within the tunnel. The proposal will alter flow regimes within Balickera Canal for the duration of works (maximum of five months). A coffer dam installed 200 m from the downstream portal will be used to dewater the canal upstream of the coffer dam prior to commencement of tunnel remediation works. Water levels within the canal fluctuate regularly in relation to the water levels present within Grahamstown Dam and the pumping regime applied at Balickera pumping station. It is unlikely that dewatering the canal within the tunnel will affect local populations of Little Bent-winged Bats because access to water on the downstream side of the coffer dam will be retained and bats will be excluded from the tunnel for the duration of works.

Open forest habitat present in the vicinity of the tunnel with connectivity to large areas of remnant forest within the adjacent Wallaroo State Forest and Wallaroo National Park provides foraging habitat for the species (Figure 6-4).

#### *6.3.3.2 Discussion of habitat utilisation*

Large Bent-winged Bats have been consistently recorded using the Balickera Tunnel based on surveys conducted between 1995 and 2021. The species is considered to be a year round resident, but the tunnel is not used as a maternity roost. The population of Large Bent-winged Bats is assumed to reduce over summer to an estimated 200 bats when females leave to give birth and raise young in an unknown maternity cave, most likely Will Willi Cave that is the nearest known breeding site. The ultrasonic data gathered during this study indicates a drop in the activity of Large Bent-winged Bats over the spring period which coincides with the timing for females migrating to maternity caves. There are very few Large Bent-winged Bats present between December and February (Ecotone 2000). The population builds up gradually over autumn and reaches peak occupancy of up to 500 bats throughout winter and early spring. It is likely that the species uses the Balickera Tunnel in conjunction with alternative roost sites in the surrounding areas, as the species will travel up to 65 km in one night and may ustilise multiple roosts (Dwyer 1966).

Large Bent-winged Bats forage within forested areas in the vicinity of the tunnel and broader locality.

#### *6.3.3.3 Extent of habitat removal*

The proposed upgrade of the Balickera Tunnel will involve the installation of a new shotcrete / concrete lining in the existing concrete lined sections and the installation of new rock bolts and / or new shotcrete / concrete lining (up to 20% of the tunnel surface) in low rock quality areas along the unlined (natural rock) sections. This will remove suitable roosting habitat for microbats.

Some of the natural rock surfaces and vertical holes in concrete lined sections used as roosting habitat by Large Bent-winged Bats will be permanently changed following the application of shotcrete and rock bolting. The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species of bat at the conclusion of the tunnel remediation works, either in original format or a combination of original format and replicated roosting habitat.

In the short term however (for a maximum of 5 months), all microbats will be excluded from the site during works to minimize the risk of harm or death. This will result in a temporary loss of roosting habitat throughout the exclusion. During this time, the species is likely to relocate to other known roosts in the surrounding area. Existing roost sites within the tunnel are expected to be suitable for roosting following completion of works. The exclusion will occur for a maximum of five months between December and the end of April, when the population is at a minimum and pregnant females would have migrated to maternity roosts to give birth.

In terms of cumulative impacts to Large Bent-winged Bats, there are no works planned for Brookfield Tunnel or Dungog WTP Tunnel, both Hunter Water assets representing two of the largest alternative roost sites available for Large Bent-winged Bats within nightly flight range. There was a reported collapse within Pilchers Mountain Caves which is also a large capacity roost site. Recent surveys recorded a large number of Little Bent-winged Bats and a smaller number of Large Bent-winged Bats roosting within the cave. The cave is within a reserve managed by Dungog Council and will remain protected and accessible to bats for the foreseeable future.

The Richmond Vale Rail Trail Tunnels at Stockrington are at risk from development and not likely to be suitable as alternative roost sites in the medium to long term. Yacaaba Sea Caves is a moderate capacity roost site, located within a state reserve managed by NPWS and will remain protected and accessible to bats for the forseaable future.

Many of the Large Bent-winged Bat roosts within a 50km radius of the tunnel are smaller roosts in culverts and bridges, are in an unknown condition and may require upgrade or maintenance that could impact Large Bent-winged Bat roosting habitat in the near future (< 5 years). Given the availability of Large Bent-winged Bat roosting habitat within a 50km radius and the large capacity of secure roosts, there will be capacity for bats displaced from Balickera as well as any Large Bent-winged Bat colonies impacted by works outside of the Balickera Tunnel remediation project.

As well as temporary loss of roosting habitat, the proposal will result in a small loss of forested foraging habitat. The proposal will result in the loss of 0.05 ha of foraging habitat – a relatively small area given the large extensions of available foraging habitat in the surrounding area.

#### *6.3.3.4 Consideration of corridors*

The Large Bent-winged Bat is highly mobile and forages in forested areas. The locality is heavily timbered and the proposal is unlikely to impact corridors of movement used by this species.

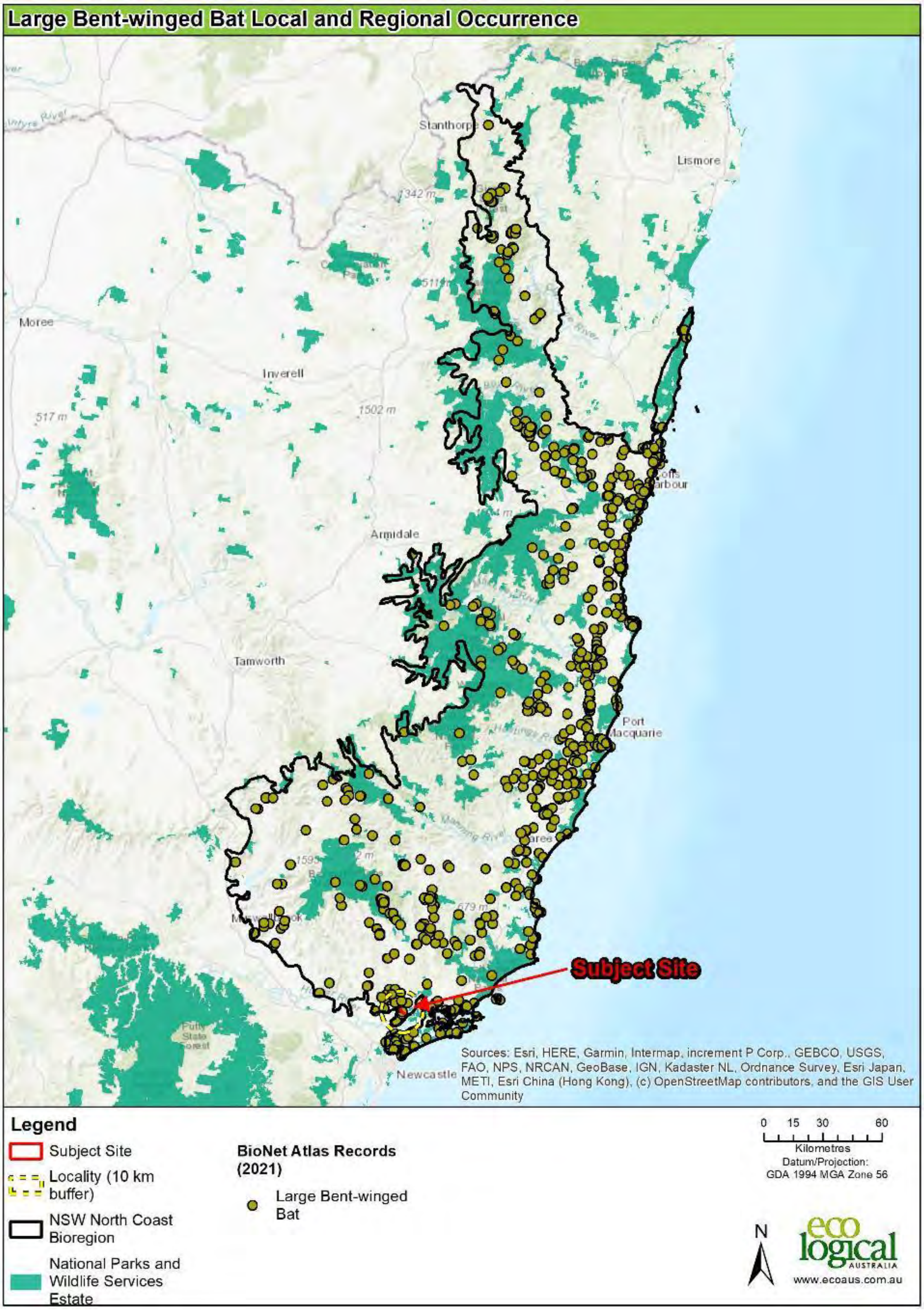



**Figure 6-3: Large Bent-winged Bat local and regional occurrence**


**Figure 6-4: Large Bent-winged Bat habitat**

## 6.4 Southern Myotis

### 6.4.1 Conservation status

#### *6.4.1.1 Local, regional and state conservation status*

Southern Myotis is listed as Vulnerable under the BC Act. The species is not listed under the EPBC Act. The Southern Myotis has been recorded on the NSW BioNet database from within 20 conservation reserves within the region. In NSW, 20% of the species' distribution occurs within conservation reserves (DPIE 2021a).

#### *6.4.1.2 Key threatening processes*

The following KTP are listed in NSW under the BC Act for the Southern Myotis:

- Clearing of native vegetation
- Predation by the *Felis catus* (feral cat)
- Predation by the *Vulpes vulpes* (European red fox),
- Loss of hollow-bearing trees
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

The KTP 'clearing of native vegetation' is relevant to the proposal.

#### *6.4.1.3 Habitat requirements*

The Southern Myotis utilises habitat near water, generally roosting in caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage. Roosting habitat is often used across years and occupied year-round, but each colony will have a network of roosts within foraging range (Churchill 2008). Southern Mytois show high maternity roost fidelity however, situated usually over or within 100 m from water (Campbell 2009).

Southern Myotis forage over streams and pools catching insects and small fish by raking their feet across the water surface. The species' close association with waterways reflects this highly specialised foraging behaviour (Thompson and Fenton 1982).

#### *6.4.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species. Southern Myotis is classified as a landscape managed species under the SoS program (DPIE, 2021b). The aim of the SoS program is to ensure that the species is secure in the wild in NSW and that its NSW geographic range is extended or maintained and to maintain its conservation status under the BC Act.

The key threats to Large Bent-winged Bats are:

- Loss or disturbance of roosting sites.
- Clearing adjacent to foraging areas.
- Application of pesticides in or adjacent to foraging areas.
- Reduction in stream water quality affecting food resources

The proposal includes two of the identified threats to Southern Myotis; the loss or disturbance of roosting sites and clearing adjacent to foraging areas.  In addition, dewatering of the tunnel to allow works to proceed will reduce the amount of foraging habitat available to Southern Myotis. Tunnel remediation works, if not completed following the specifications for preservation and replication of roosting habitat, would cause a loss of roosting sites.

The timing of works, provision of alternative Southern Myotis roosting habitat (bat boxes) in close proximity to the tunnel, exclusion of bats from the tunnel prior to works and methodology by which tunnel remediation works will be undertaken, minimise impacts to Southern Myotis and their roosting habitat and address the threat posed by the potential loss or disturbance to roost sites.  There will not be any hollow-bearing trees cleared for the proposal. The area of vegetation to be removed is minimal (0.05 ha), although it will be undertaken adjacent to the downstream portal of Balickera Canal. Balickera Canal is a known foraging area for Southern Myotis.  A portion of the canal will be dewatered for the duration of the works via a coffer dam installed 200 m from the downstream tunnel portal.  Water levels fluctuate regularly within Balickera Canal, dependent upon water levels in Grahamstown Dam.  The loss of 200 m of foraging habitat from the dewatered section of the canal is not a significant impact to local Southern Myotis populations because there are extensive foraging resources available in the remaining canal downstream of the coffer dam, in Grahamstown Dam and along the Williams River, all within foraging range of local Southern Myotis population. Water quality within the canal downstream of the coffer dam is not expected to be significantly affected by works because erosion and sediment control practices as per the Blue Book will be employed during construction and operation of the coffer dam.

Critical actions for the recovery of this species have been identified by SoS in an action toolbox.  One critical action applicable to this SIS is to liaise with the relevant authorities and land managers regarding wooden bridges, wharves, tunnels, aqueducts and other structures acting as bat habitat. When undertaking any major works, this should be done at a time outside of the breeding (October-February) and overwintering period. Replacement of any impacted roosting habitat is required and can take the form of bat boxes placed under new structures or structures in close proximity to the original roost.

This SIS is not consistent with the critical action to ensure major works are conducted outside the breeding season for Southern Myotis. Southern Myotis breed twice over summer at this location (Ecotone 2000).  The first breeding event occurs relatively synchronously between females in the colony during October / November and the second event occurs during January / February.  Based upon the most accurate population estimate for Southern Myotis recorded by Ecotone (2000), the colony contained between 60 and 80 bats.  This SIS has allowed for growth of the colony over time and has estimated that the colony could contain approximately 200 individuals at peak occupancy at the end of the second breeding event. If it is assumed that at the start of the breeding season there will be a maximum of 80 adult females of breeding age present and 90-95% of those giving birth to a single pup in October / November then approximately 75 pups could be born during the first breeding event, with a maximum of 75 pups also born during the second breeding event.

The figures used as estimates for the number of breeding females in a colony and the number of breeding females birthing young during a breeding event are within the range reported in the scientific literature for other species in the Myotis genus (Linton and MacDonald 2018) and within the range observed in several Southern Myotis colonies along the eastern coast of NSW (Alicia Scanlon pers. comm.)

Actions will be taken to minimise the loss of any Southern Myotis as a result of an exclusion undertaken during the breeding season. These actions are centred on timing the exclusion to coincide with weaning and attainment of independent flight (approx. 8 weeks after birth) of pups born during the first breeding event in October / November. It was estimated that there could be a loss of up to 75 Southern Myotis pups if all pups from the first breeding event do not survive the exclusion process. It was considered reasonable to assume a 5% loss of adult bats through the exclusion process which would mean a loss of a further five adult Southern Myotis at this time (based upon 80 adult females and 20 adult males present at time of exclusion). The first breeding event is believed to be more important than the second. This is because a higher proportion of females will breed during the first event. The second breeding event is more easily affected by the reduced condition of females who have already given birth to one pup and devoted significant energy to lactation. If the disturbance was enough to cause a complete failure of the breeding season for Southern Myotis there is the potential that 155 Southern Myotis could be lost, including five adults and 150 pups (75 born and 75 unborn pups aborted due to the stress involved in the exclusion process).

These losses were then compared to estimates of losses for adult Little Bent-winged Bats if the exclusion was conducted in March, outside of the breeding season for Southern Myotis but at a time when at least 5000 Little Bent-winged Bats would be present. Under this scenario, and applying the 5% loss rate due to exclusion, up to 250 Little Bent-winged Bats, predominantly adults, could be lost. In addition, the value of adult bats to the population exceeds that of young or juveniles in both species because the survival rate of adult bats is greater than for juveniles.

The SIS does comply with the requirement to replace any roosting habitat impacted by works through the installation of bat boxes beneath a structure within close proximity to the original roost and by ensuring at least 75% of the roosting habitat within the tunnel is either retained or recreated during remediation works.

The SIS complies with one other critical action to recover this species by promoting roosting habitat in new artificial structures within the species range and monitoring it’s use. The requirement to install bat boxes beneath the Pacific Highway Bridge over Balickera Canal is consistent with this action.

##### *6.4.1.5 Assessment of representation within conservation reserves in the region*

The Southern Myotis is moderately well represented within conservation reserves within the region with 69 records of 1521 records (5%) located across 20 different conservation reserves. More locally, there are records in several reserves including:

- Columbey National Park
- Hunter Wetlands National Park
- Myall Lakes National Park
- The Glen Nature Reserve
- Woko National Park
- Worimi Regional Park.

Within the region, the species is widespread.

#### *6.4.1.6 Species distribution*

The Southern Myotis is patchily distributed in a broad coastal band in northern and eastern Australia and is closely associated with waterways (Lumsden and Menkhorst 1995; Churchill 2008). The subject site occurs in the core of their distribution.

### 6.4.2 Local and regional abundance

The species is known to be in moderate local and relatively high regional abundance. There are 1,521 records within the region, four records within the locality and 15 records within 10 km of the study area (Figure 6-5). In the local area and within the nightly flight range of Southern Myotis (10-12 km), studies have recorded eight other roost sites including:

- Twelve Mile Creek Bridge, 4 km NE (breeding site, TfNSW)
- Clarencetown culverts, 6 km N (unknown population and breeding status, 2018)
- Clarencetown Bridge maternity colony, 10 km N (30-50 bats, breeding site recorded during bridge works in 2016/2017 F. Lemckert and J. Stokes pers. comm., BioNet Atlas record, 2016)
- Wattle Creek Bridge, 10 km N (unknown population and breeding status, 2018)
- Tumbledown Bridge, 10 km NW (unknown population and breeding status, 2018)
- Grahamstown Drain Overpass 11 km S (70 individuals, breeding site recorded during current study, ELA 2021)
- Clarencetown culvert, 11 km N ((unknown population and breeding status, 2018).

This study has estimated the population of Southern Myotis at the Balickera Tunnel as ranging between 50-200 bats. There are thought to be in excess of 10,000 Southern Myotis in Australia (IUCN Red List 2021). Balickera Tunnel provides roosting habitat for a small portion (2%) of the extant population in Australia, despite its importance on a local and regional scale.

### 6.4.3 Assessment of habitat

#### *6.4.3.1 Description of habitat values*

The Balickera Tunnel includes natural rock and vertical holes within the concrete suitable as roosting habitat for the Southern Myotis. The occurrence of suitable roosting habitat is particularly prevalent in the upstream, western end of the tunnel. The roosting habitat within the tunnel supports individuals year-round, including during for breeding.

Additionally, the connecting canal and waterbodies provide suitable foraging habitat for the Southern Myotis as the species forages over pools of water in small streams, rivers and lakes, using large feet to trawl for prey along water surfaces (Dwyer 1970; Thompson and Fenton 1982) (Figure 6-6).

#### *6.4.3.2 Discussion of habitat utilisation*

The Southern Myotis has been consistently recorded using the Balickera Tunnel based on surveys conducted between 1995 and 2021. Southern Myotis are present year round and would undertake extended torpor bouts over winter. The species was recorded breeding in the tunnel between late October and February (Ecotone 2000). In this study the Southern Myotis was recorded through all seasons, including high levels of ultrasonic call activity during the breeding period.

The Southern Myotis predominantly roost in holes within concrete lined sections of the tunnel. The majority of these sites are within the upstream half of the tunnel and at least some of these are likely to be used for breeding. It is likely that the species uses the Balickera Tunnel in conjunction with alternative roost sites in the surrounding areas.

#### *6.4.3.3 Extent of habitat removal*

The proposed upgrade of the Balickera Tunnel will involve the installation of a new shotcrete / concrete lining in the existing concrete lined sections and the installation of new rock bolts and / or new shotcrete / concrete lining (up to 20% of the tunnel surface) in low rock quality areas along the unlined (natural rock) sections. This will remove suitable roosting habitat for microbats.

Some of the natural rock surfaces and potentially all of the vertical holes in concrete lined sections used as roosting and breeding habitat by Southern Myotis will be permanently changed following the application of shotcrete and rock bolting. The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of Southern Myotis roosting and breeding habitat (40 of the 106 vertical holes in the concrete lined sections), the specifications (dimensions and shape) of the roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species of bat at the conclusion of the proposal, either in original format or a combination of original format and replicated roosting habitat.

In the short term however (for a maximum of 5 months), all microbats will be excluded from the site during works to minimize the risk of harm or death. This will result in a temporary loss of roosting habitat throughout the exclusion. During this time, the species is likely to relocate to other known roosts in the surrounding area, or to take up alternative roosting habitat in the form of bat boxes that will be installed beneath the Pacific Highway Bridge over Balickera Canal prior to commencement of works. Roost sites within the tunnel (in original format or recreated roosts) are expected to be suitable for roosting following completion of works.

The exclusion will occur for a maximum of five months between December and the end of April, which is during the breeding season for Southern Myotis. Exclusion of bats from the tunnel during this time will disrupt the breeding cycle and impact at least one breeding event, potentially causing the entire reproductive output for the season to be lost. This could equate to a loss of 155 Southern Myotis, comprising five adult bats, 75 pups from the first breeding event and 75 unborn pups from the second breeding event. However, Southern Myotis will breed in bat boxes and has been known to breed in boxes the first breeding season after boxes are installed (ELA 2012).

Balickera Canal is a known foraging area for Southern Myotis. A portion of the canal will be dewatered for the duration of the works via a coffer dam installed 200 m from the downstream tunnel portal. Water levels fluctuate regularly within Balickera Canal, dependent upon water levels in Grahamstown Dam. The loss of 200 m of foraging habitat from the dewatered section of the canal is not a significant impact to local Southern Myotis populations because there are extensive foraging resources available in the remaining canal downstream of the coffer dam, in Grahamstown Dam and along the Williams River, all within foraging range of local Southern Myotis population. Water quality within the canal downstream of the coffer dam is not expected to be significantly affected by works because erosion and sediment control practices as per the Blue Book will be employed during construction and operation of the coffer dam.

As well as the loss of roosting habitat, the proposal will result in a temporary loss of foraging habitat within the Balickera Canal between the coffer dam and Balickera Pumping Station. Balickera Canal is a known foraging area for Southern Myotis. A portion of the canal will be dewatered for the duration of the works via a coffer dam installed 200 m from the downstream tunnel portal. Water levels fluctuate regularly within Balickera Canal, dependent upon water levels in Grahamstown Dam. The temporary loss of foraging habitat from the dewatered section of the canal is not a significant impact to local Southern Myotis populations because there are extensive foraging resources available in the remaining canal downstream of the coffer dam, in Grahamstown Dam and the Williams River, all within foraging range of local Southern Myotis population. Water quality within the canal downstream of the coffer dam is not expected to be significantly affected by works because erosion and sediment control practices as per the Blue Book will be employed during construction and operation of the coffer dam.

The proposal will also result in the loss of 0.05 ha of forest foraging habitat in the vicinity of the canal downstream of the tunnel for the modified access track.

There are no known proposals that will impact or reduce the amount of Southern Myotis roosting habitat within nightly flight range of Balickera Tunnel. Clarencetown Bridge was recently upgraded (2016/2017) and is unlikely to require works that would significantly impact Southern Myotis in the next 5 to ten years). The Pacific Highway Bridges at Twelve Mile Creek and Grahamstown Drain were in good condition and are unlikely to require maintenance or significant upgrades that would impact Southern Myotis roosting habitat within the near future (next 5 – ten years). Some smaller roosts in culverts and Wattle Creek Bridge at Clarencetown and Tumbledown Bridge are in unknown condition and may require upgrade or maintenance that could impact Southern Myotis roosting habitat in the near future (< 5 years). Given the availability of Southern Myotis roosting habitat in the area surrounding Clarencetown, there is expected to be capacity for bats from Balickera and any other Southern Myotis colonies to be accommodated.

#### *Consideration of corridors*

Southern Myotis generally forages along waterways and adjacent vegetation. The Balickera Canal and Balickera Tunnel are likely to provide a corridor of movement for the species between Grahamstown Dam and the Williams River. During construction this corridor will be modified by dewatering the canal and blocking the tunnel. Southern Myotis may still use this corridor by moving through forested areas above the tunnel.

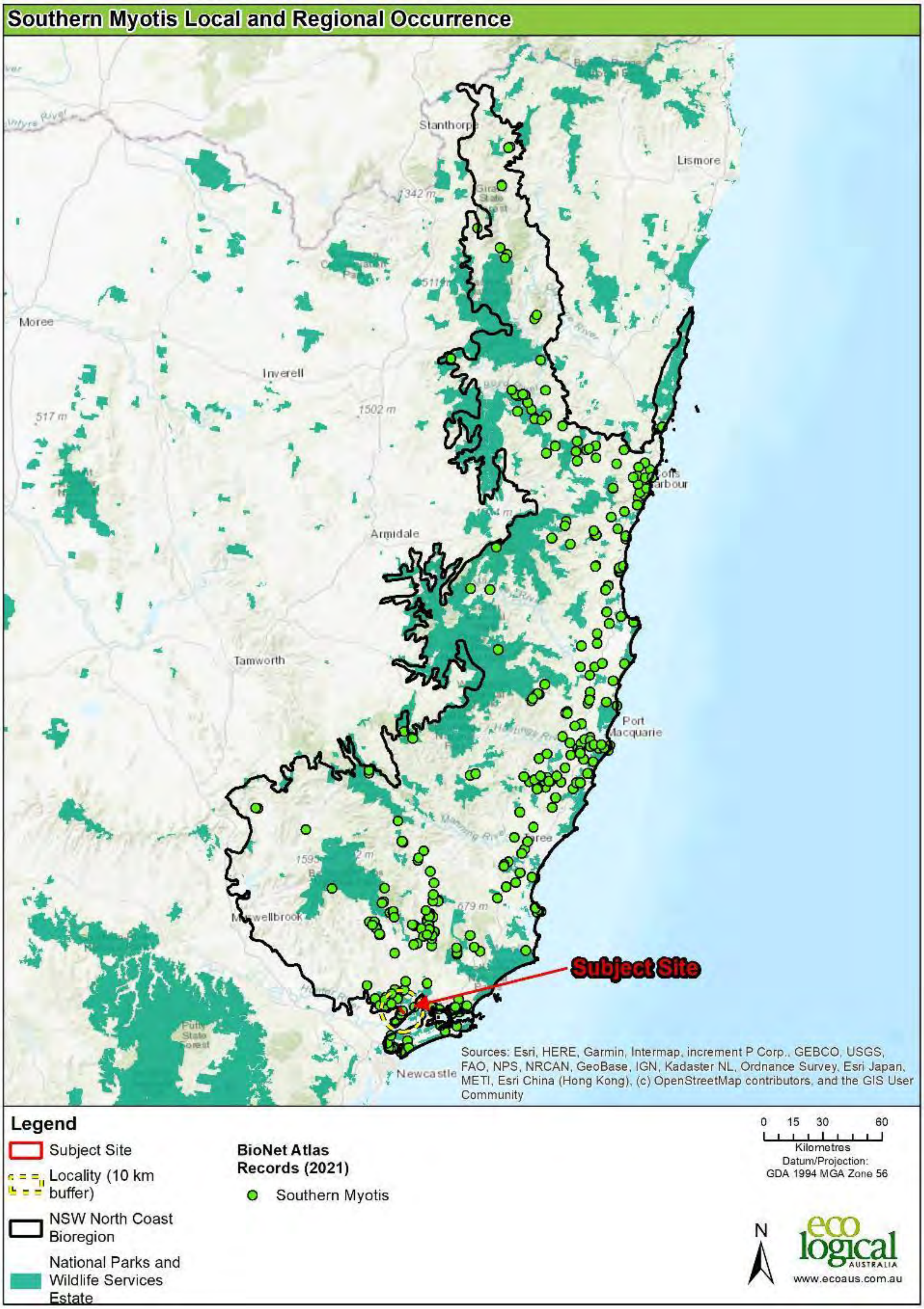



**Figure 6-5: Southern Myotis Local and Regional Occurrence**

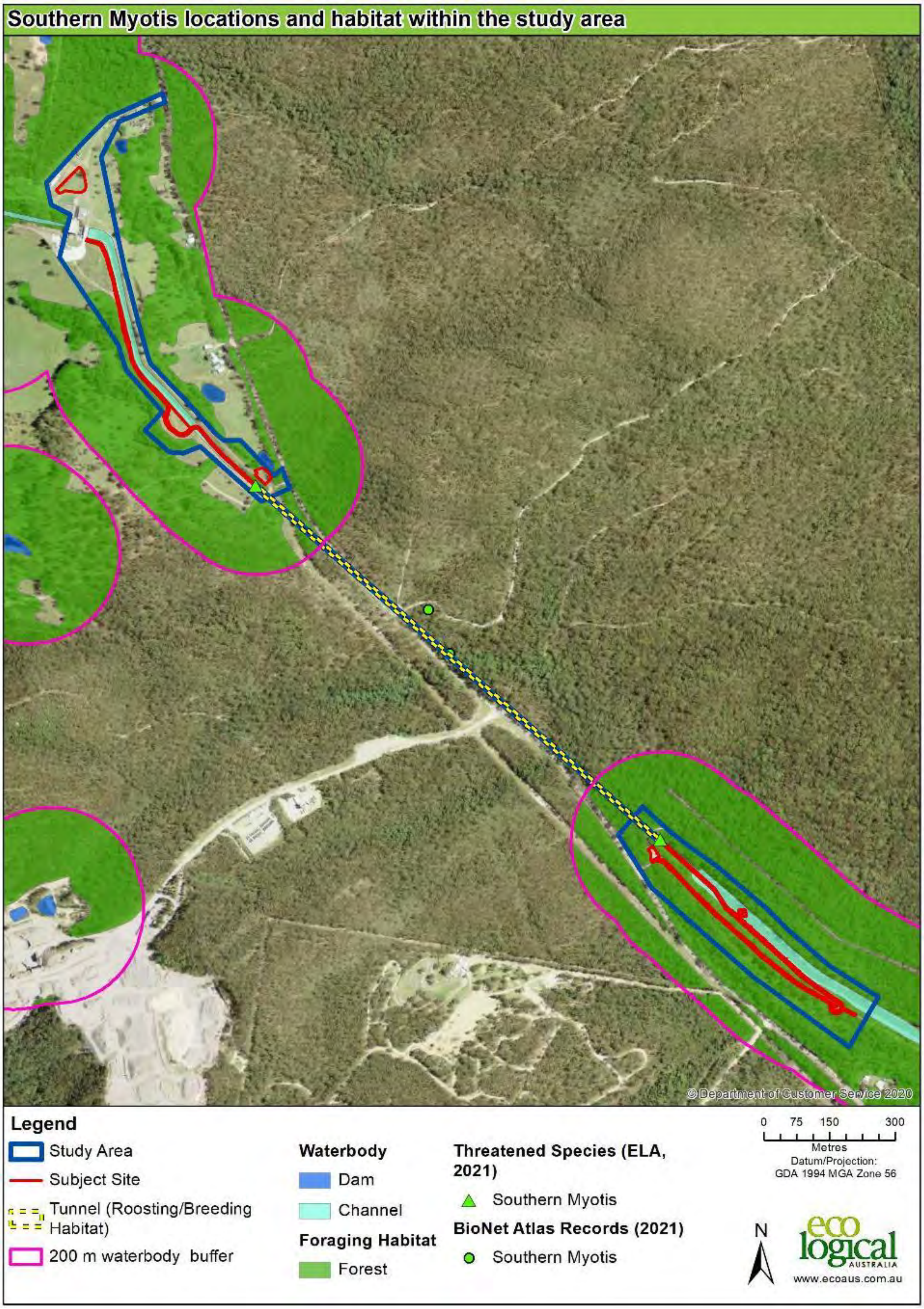



**Figure 6-6: Southern Myotis Habitat**

## 6.5 Eastern False Pipistrelle

### 6.5.1 Conservation status

#### *6.5.1.1 Local, regional and state conservation status*

Eastern False Pipistrelle is listed as Vulnerable under the BC Act. The species is not listed as threatened under the EPBC Act. The Eastern False Pipistrelle has been recorded on the NSW BioNet database from within 30 conservation reserves within the region. In NSW, 64% of the species' distribution within NSW occurs within conservation reserves (DPIE 2021b). The species is well represented in conservation reserves within the region (Figure 6-7).

#### *6.5.1.2 Key threatening processes*

The known threats for the Eastern False Pipistrelle include:

- Clearing of native vegetation
- Disturbance to winter roosting and breeding sites
- Loss of roosting habitat, such as hollow-bearing eucalypts
- Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners
- Loss and fragmentation of foraging habitat, particularly extensive areas of continuous forest and areas of high productivity.

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.5.1.3 Habitat requirements*

The Eastern False Pipistrelle prefers moist habitats, with trees taller than 20 m. Individuals are known to roost in eucalypt hollows but have also been found under loose bark on trees or in buildings. Roost requirements are poorly known and paddock trees should be flagged as potential roosts. This species hunts beetles, moths, weevils and other flying insects above or just below the tree canopy.

#### *6.5.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species. A targeted strategy for managing this species has been developed under the SoS program (DPIE, 2021b).

#### *6.5.1.5 Assessment of representation within conservation reserves in the region*

The Eastern False Pipistrelle is well represented within conservation reserves in the region. Of 248 records in the region, 158 (64%) are from within 30 conservation reserves. More locally the species has been recorded from the following reserves:

- Columbey State Conservation Area
- Hunter Wetlands National Park
- Barrington Tops National Park
- Myall Lakes National Park.

#### *6.5.1.6 Species distribution*

The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania.

### 6.5.2 Local and regional abundance

The species is considered to have moderate to low local (7 records) and regional (248 records) abundance. The species was recorded on one occasion within the study area.

### 6.5.3 Assessment of habitat

#### *6.5.3.1 Description of habitat values*

Habitat for the Eastern False Pipistrelle in the study area consists of foraging habitat in the form of regenerating forests near wetlands. The Eastern False Pipistrelle often roost in tree hollows instead of tunnels or caves. There were no hollows observed within the study area, indicating the absence of breeding and roosting habitat within the study area.

#### *6.5.3.2 Discussion of habitat utilisation*

No hollow bearing trees or suitable man-made structures that could be used as roosting or breeding habitat occur within study area. This species was only recorded once - in summer (January 2021) at the upstream portal. The single record was obtained during extensive ultrasonic call recording surveys over multiple seasons. This species is considered to use the regenerating open forest within the study area occasionally as foraging habitat only. Forest areas or remnant trees outside of the study area potentially provide roosting and foraging habitat for the species.

#### *6.5.3.3 Extent of habitat removal*

Direct habitat removal is limited to approximately 0.05 ha of forest foraging habitat to allow vehicular access to the tunnel during construction. No roosting or breeding habitat will be impacted.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.5.3.4 Consideration of corridors*

The native vegetation within the study area may be used as a foraging corridor and act as flyways for hunting bats. However, the proposal is unlikely to create any barriers to movement for this highly mobile species.

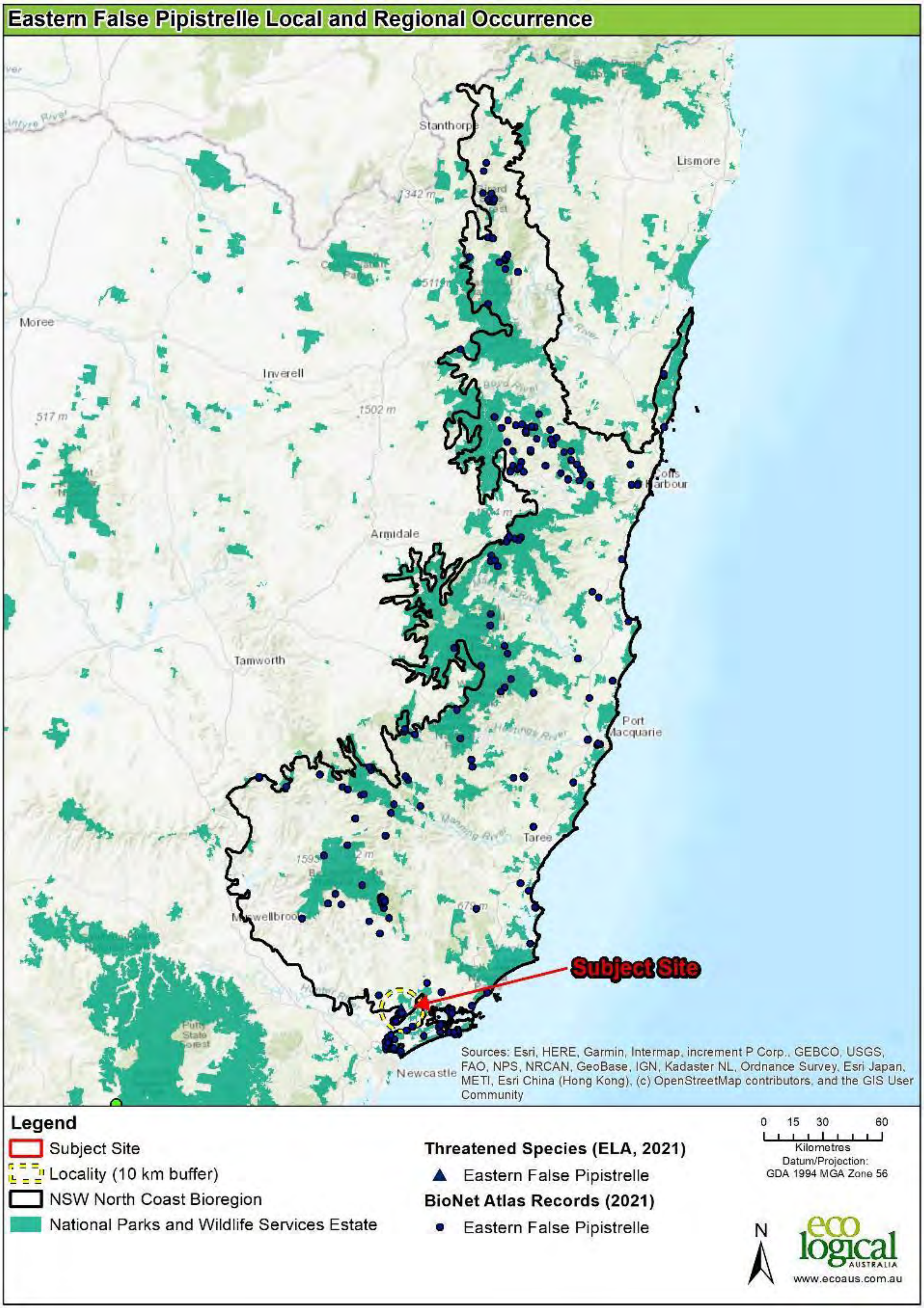



**Figure 6-7: Eastern False Pipistrelle local and regional occurrence**


**Figure 6-8: Eastern False Pipistrelle habitat**

## 6.6 Eastern Coastal Free-tailed Bat

### 6.6.1 Conservation status

#### *6.6.1.1 Local, regional and state conservation status*

Eastern Coastal Free-tailed Bat is listed as Vulnerable under the BC Act. The species is not listed as threatened under the EPBC Act. The Eastern Coastal Free-tailed Bat has been recorded on the NSW BioNet database from within seven conservation reserves within the region and 4% of the species' distribution within the region occurs within the NSW National Parks and Wildlife Service estate.

#### *6.6.1.2 Key threatening processes*

The following threats have been identified for the Eastern Coastal Free-tailed Bat:

- Clearing of native vegetation
- Loss of hollow-bearing trees
- Application of pesticides in or adjacent to foraging areas.
- Artificial light sources spilling onto foraging and/or roosting habitat
- Large scale wildfire or hazard reduction burns on foraging and/or roosting habitat.

The KTP ‘Clearing of native vegetation’ is relevant to the proposal.

#### *6.6.1.3 Habitat requirements*

Eastern Coastal Free-tailed Bats utilise dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range.

Eastern Coastal Free-tailed Bats roost mainly in tree hollows but will also roost under bark or in man-made structures. This species is usually solitary but also recorded roosting communally and is likely insectivorous. Whilst this species does breed in hollows it will usually change breeding sites regularly (every few days), rendering it very difficult to confirm breeding sites. It has been known to occasionally aggregate in large breeding groups (including in buildings). The species has been found to use paddock trees at Ravensworth State Forest in the Hunter Valley, and such trees may provide critical roosts in some areas (DPIE 2021a).

#### *6.6.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species, however a targeted strategy for managing this species has been developed under the SoS program (DPIE, 2021b).

#### *6.6.1.5 Assessment of representation within conservation reserves in the region*

The Eastern Coastal Free-tailed Bat is not well represented within conservation reserves based on available records. The species has been recorded 17 times from within seven conservation reserves within the region, although several of these are from relatively local reserves to the study area including:

- Columbey National Park
- Hunter Wetlands National Park
- Karuah National Park
- Tomaree National Park
- Barrington Tops National Park.

#### *6.6.1.6 Species distribution*

The Eastern Coastal Freetail-bat is found along the east coast from south Queensland to southern NSW.

### 6.6.2 Local and regional abundance

The species is considered to have moderate local (23 records) and regional (427 records) abundance. The species was recorded on one occasion within the study area (Figure 6-9).

### 6.6.3 Assessment of habitat

#### *6.6.3.1 Description of habitat values*

The Eastern Freetail-bat is not known to roost in tunnels, caves or mines. The species was only recorded on one occasion from significant survey effort over multiple seasons within the study area. Therefore, this species is considered to be an occasional visitor to the study area and is not considered to use the tunnel as roosting or breeding habitat.

Forest habitat within the study area provides foraging habitat for the species (Figure 6-10). No hollows suitable for roosting or breeding were recorded in the study area, however they are likely to be present within the broader patch of connected habitat which includes Wallaroo State Forest and National Park.

#### *6.6.3.2 Discussion of habitat utilisation*

No hollow bearing trees or suitable man-made structures that could be used as roosting or breeding habitat occur within study area. Given this species was recorded once at the downstream portal only during targeted surveys (over extensive ultrasonic call recording surveys over multiple seasons), this species is considered to use the regenerating open forest within the study area occasionally as foraging habitat only.

#### *6.6.3.3 Extent of habitat removal*

Direct habitat removal is limited to approximately 0.05 ha of forest foraging habitat to allow vehicular access to the tunnel during construction. No roosting or breeding habitat will be impacted. As well as temporary loss of roosting habitat, the proposal will result in a small loss of foraging habitat. The proposal will result in the loss of 0.05 ha of foraging habitat – a relatively small area given the large extensions of available foraging habitat in the surrounding area.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.6.3.4 Consideration of corridors*

The native vegetation within the study area may be used as a foraging corridor and act as flyways for hunting bats. However, the tunnel upgrade works, temporary canal dewatering and minor tree removal proposed is unlikely to create any barriers to movement for this highly mobile species.

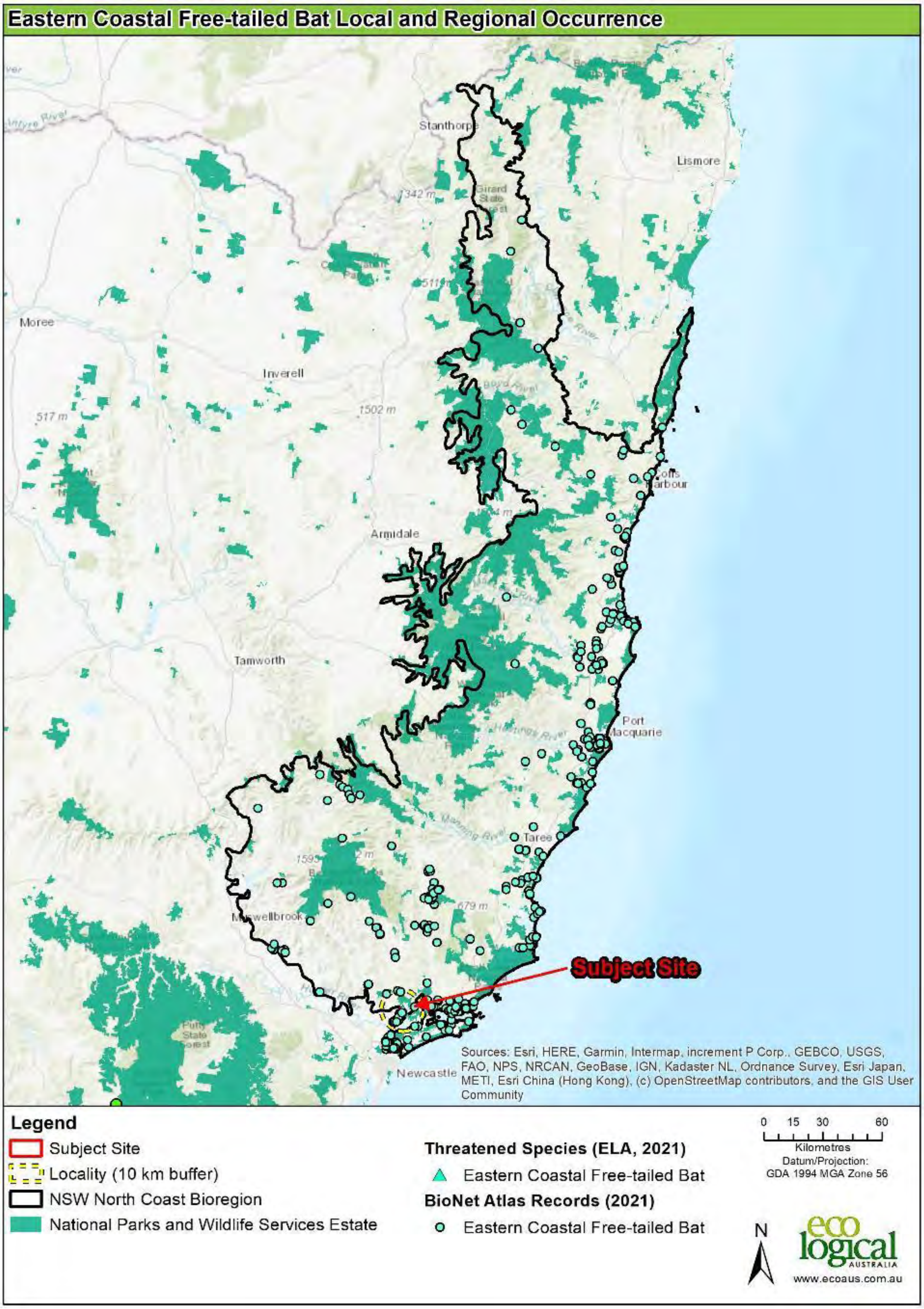



**Figure 6-9: Eastern Coastal Free-tailed Bat local and regional occurrence**


**Figure 6-10: Eastern Coastal Free-tailed Bat habitat**

## 6.7 Koala

### 6.7.1 Conservation status

#### *6.7.1.1 Local, regional and state conservation status*

The Koala is listed as Vulnerable under the BC Act and EPBC Act.  The Koala has been recorded in a large number of conservation reserves in the region. However, substantial areas of Koala habitat including that within conservation reserves were affected by fires in 2019 and early 2020.

Populations within the locality are estimated to be relatively small and patchily dispersed. Historical estimates in 1996 suggested a population size of 350-500 animals across the entire Port Stephens LGA and several anecdotal reports suggest a declining population (ELA, 2013).

#### *6.7.1.2 Key threatening processes*

The following threatening processes have been considered relevant to the Koala (DECC, 2008):

- Clearing of Native Vegetation
- Forest Eucalypt Dieback associated with over-abundant psyllids and bell miners,
- Ecological consequences of high frequency fires
- Human-caused Climate Change
- Predation by the European Red Fox *Vulpes vulpes.*

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.7.1.3 Habitat requirements*

The koala inhabits a range of eucalypt forest and woodland communities, including coastal forests, the woodlands of the tablelands and western slopes, and the riparian communities of the western plains (DECC, 2008). Primary feed tree species for Koalas in the North Coast Koala Management Area have been documented as:

- *Eucalyptus microcorys* (Tallowwood)
- *E. parramattensis* (Parramatta Red Gum)
- *E. tereticornis*
- *E. bancroftii* (Orange Gum)
- *E. robusta* (Swamp Mahogany)
- *E. amplifolia* (Cabbage Gum) (DECC, 2008).

#### *6.7.1.4 Recovery plans or threat abatement plans*

A recovery plan has been prepared for the Koala (DECC, 2008).

#### *6.7.1.5 Assessment of representation within conservation reserves in the region*

The Koala is well represented in conservation reserves in the region having been recorded from 123 separate conservation reserves, with 1173 of 2977 (39%) regional records from conservation reserves. The following conservation reserves have 30 or more Koala records:

- Barrington Tops National Park
- Bongil Bongil National Park
- Chaelundi National Park

- Crowdy Bay National Park
- Gir-um-bit State Conservation Area
- Gumbaynggirr National Park
- Gumbaynggirr State Conservation Area
- Hat Head National Park
- Innes Ruins Historic Site
- Karuah National Park
- Lake Innes Nature Reserve
- Limeburners Creek National Park
- Myall Lakes National Park
- New England National Park
- Nymboi-Binderay National Park
- Roto House Historic Site
- Sea Acres National Park
- Tilligerry Nature Reserve
- Tilligerry State Conservation Area
- Tomaree National Park
- Washpool National Park.

#### *6.7.1.6 Species distribution*

The Koala has a patchy distribution in eastern Australia, from north-eastern Queensland to south-eastern South Australia and to the west of the Great Dividing Range. On the NSW North Coast, the Port Stephens LGA has been regarded as an important koala population centre along with Port Macquarie, Coffs Harbour, Ballina, Lismore and Tweed (DECC, 2008)

### 6.7.2 Local and regional abundance

The level of information available on koala populations is variable across the state and there is no mechanism in place to collect consistent data. In addition, populations can change quite rapidly, making historical population estimates less relevant when assessing conservation status. A regional summary of koala populations in the upper mid-north coast of NSW from 2013 estimated the population to be greater than 1000 in the coastal Coffs Harbour and northern Bellingen area and between 500 and 1000 in the Coffs Harbour Hinterland (Predavec, 2016). Large fires in 2019 and 2020 covered 5.5 million hectares in NSW (7% of the State) with 30% of the most suitable Koala habitat in the North Coast region affected by the fires (DPI, 2020). Most estimates predict a severe impact on eastern NSW Koala populations as a result of these fires.

Locally, population estimates have historically been derived for the Port Stephens LGA with estimates of population size prior to 1996 suggesting well below 1000 individuals distributed over the entire Port Stephens LGA area and likely between 350-500 animals in total (ELA, 2013) (Figure 6-11).

### 6.7.3 Assessment of habitat

#### *6.7.3.1 Description of habitat values*

Habitat for Koala in the study area consists of several koala feed tree species that are known to be used for foraging and shelter (Figure 6-12). These species are:

- *Angophora costata* (Smooth-barked Apple)
- *Eucalyptus tereticornis* (Forest Red Gum)
- *Eucalyptus siderophloia* (Grey Ironbark)
- *Eucalyptus punctata* (Grey Gum)
- *Eucalyptus moluccana* (Grey Box).

#### *6.7.3.2 Discussion of habitat utilisation*

There are a large number of Koala records in the locality and despite not being detected during fieldwork for the current study, it is likely Koala occasionally use the study area for food and shelter.

#### *6.7.3.3 Extent of habitat removal*

In total 0.05 ha of potential foraging habitat including several *Eucalyptus tereticornis* trees will be removed by the proposal to provide access to the downstream section of tunnel.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### 6.7.3.4 Consideration of corridors

Trees and forested land adjoin both sides of the study area and the proposed work is unlikely to create any barrier to Koala movement in the area.

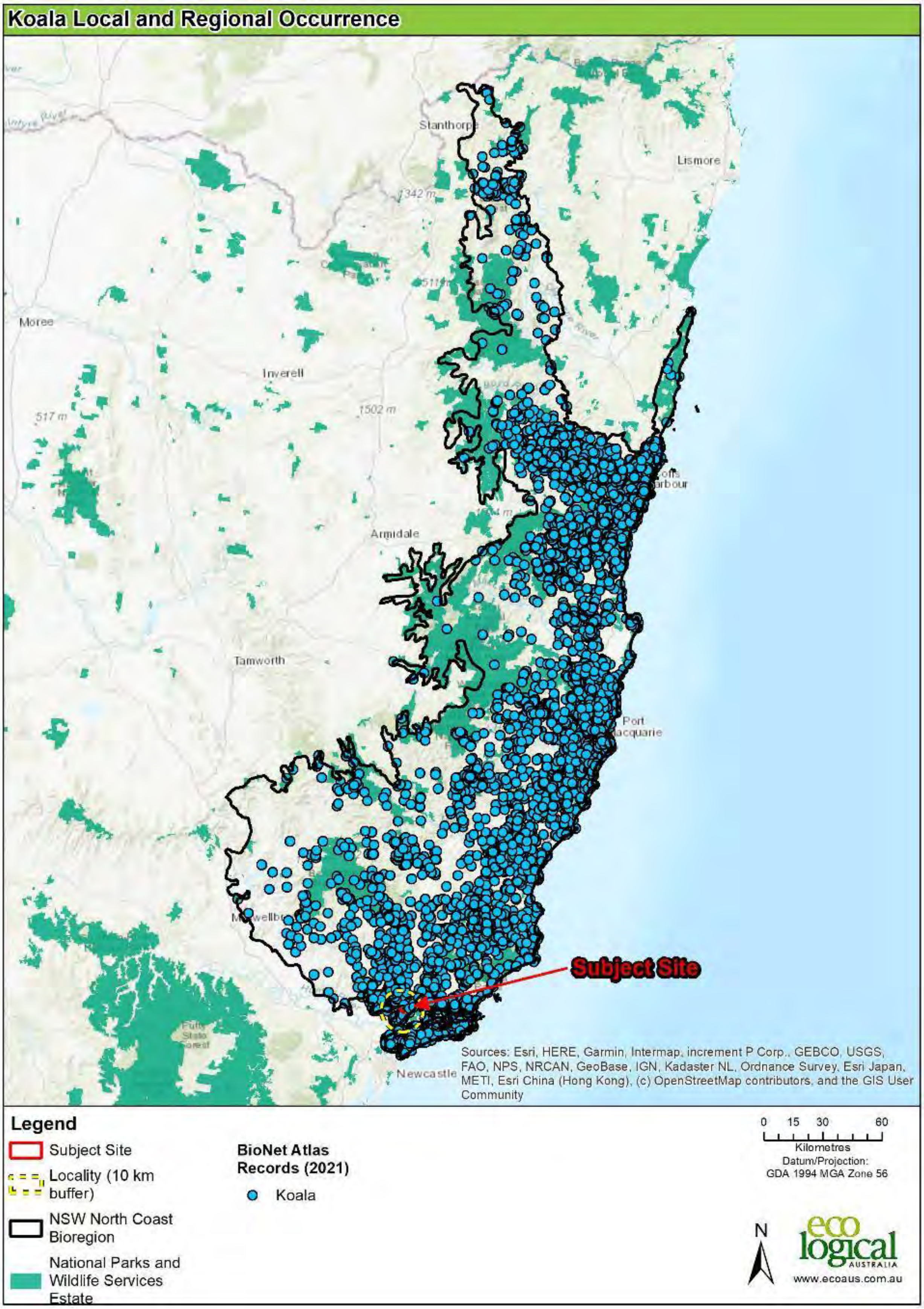



Figure 6-11: Koala local and regional occurrence

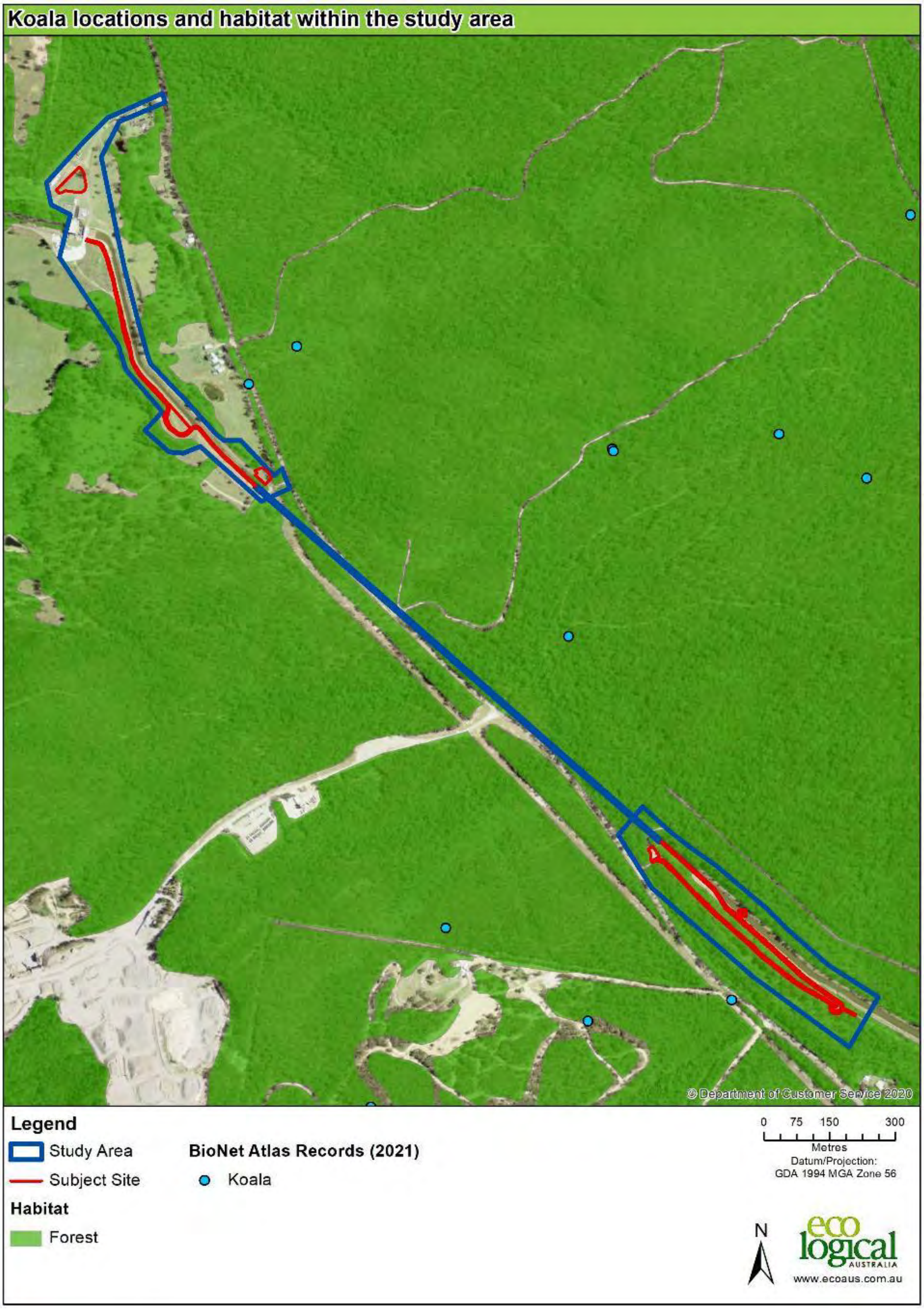



**Figure 6-12 Koala habitat**

## 6.8 Grey-headed Flying-fox

### 6.8.1 Conservation status

#### *6.8.1.1 Local, regional and state conservation status*

Grey-headed Flying-fox is listed as Vulnerable under the BC Act and EPBC Act.

In NSW less than 15% of potentially suitable forest for the Grey-headed Flying-fox occurs in conservation reserves and only 5% of Flying-fox camp sites are similarly reserved (NSW Scientific Committee, 2001). The nearest active camps are located 8.5 km north of the study area at Clarencetown, 10.5 km south at Raymond Terrace and 16.5 km north at Glen William (DAWE, 2021a). None of these camps are located in conservation reserves. Both Raymond Terrace and Glen William are considered Nationally Important Flying-fox camps. Nationally important camps are those that have contained ≥ 10,000 Grey-headed Flying-foxes in more than one year in the last 10 years or have been occupied by more than 2,500 Grey-headed Flying-foxes permanently or seasonally every year for the last 10 years.

Historically a camp existed close to the study area in Wallaroo State Forest, but no individuals have been present at this site during surveys in recent years (DAWE, 2021a).

#### *6.8.1.2 Key threatening processes*

The following threats are listed for the Grey-headed Flying-fox:

- Loss of roosting and foraging sites
- Electrocution on powerlines, entanglement in netting and on barbed-wire
- Heat stress
- Conflict with humans
- Incomplete knowledge of abundance and distribution across the species' range
- Illegal shooting.

The KTP ‘Clearing of native vegetation’ is relevant to the proposal.

#### *6.8.1.3 Habitat requirements*

The Grey-headed Flying-fox is a canopy-feeding frugivore, blossom-eater and nectarivore of rainforests, open forests, woodlands, Melaleuca swamps and Banksia woodlands. Grey-headed Flying-foxes congregate in large numbers at roosting sites (camps) that may be found in rainforest patches, Melaleuca stands, mangroves, riparian woodland or planted vegetation in urban areas (NSW Scientific Committee, 2001). Important winter and spring vegetation communities are those that contain the following species:

- *Eucalyptus tereticornis*
- *E. albens*
- *E. crebra*
- *E. fibrosa*
- *E. melliodora*
- *E. paniculata*
- *E. pilularis*
- *E. robusta*

- *E. seeana*
- *E. sideroxylon*
- *E. siderophloia*
- *Banksia integrifolia*
- *Castanospermum australe*
- *Corymbia citriodora*
- *C. eximia*
- *C. maculata*
- *Grevillea robusta*
- *Melaleuca quinquenervia*
- *Syncarpia glomulifera.*

#### *6.8.1.4 Recovery plans or threat abatement plans*

There is a National Recovery Plan for the Grey-headed Flying-fox. The overall objectives of the Grey-headed Flying-fox recovery plan are:

- To improve the Grey-headed Flying-foxes national population trend by reducing the impact of the threats outlined in this plan on Grey-headed Flying-foxes through habitat identification, protection, restoration and monitoring
- To assist communities and Grey-headed Flying-foxes to coexist through better education, stakeholder engagement, research, policy and continued support to fruit growers (DAWE, 2021b).

#### *6.8.1.5 Assessment of representation within conservation reserves in the region*

The Grey-headed Flying-fox has been recorded from 60 conservation reserves in the region and more locally from the following reserves:

- Barrington Tops National Park
- Boondelbah Nature Reserve
- Booti Booti National Park
- Columbey State Conservation Area
- Darawank Nature Reserve
- Ghin-Doo-Ee National Park
- Hunter Wetlands National Park
- John Gould Nature Reserve
- Karuah National Park
- Khappinghat Nature Reserve
- Medowie State Conservation Area
- Myall Lakes National Park
- Snapper Island Nature Reserve
- Tilligerry Nature Reserve
- Wallaroo National Park
- Wallingat National Park
- Worimi National Park
- Worimi Regional Park

- Worimi State Conservation Area.

Very few camps are located in conservation reserves in the region and locality.

#### *6.8.1.6 Species distribution*

The Grey-headed Flying-fox is endemic to Australia, with a distribution ranging from Ingham in Queensland, to Adelaide in South Australia (DAWE, 2021b). The species is regularly found in northern NSW from the coast to the tablelands and western slopes of the Great Dividing Range and the tablelands of southern Queensland. However, patterns of occupancy and relative abundance within the Grey-headed Flying-fox distribution vary widely over different seasons and from year to year (DAWE, 2021b). The study area is located roughly at the centre of the species distribution.

### 6.8.2 Local and regional abundance

The Grey-headed Flying-fox is considered to be a single, mobile population with individuals distributed across Queensland, NSW, Victoria, South Australia and the ACT. A 2015 estimate of population size from counts at Grey-headed Flying-fox camps suggest a population of 680,000 (±164,500) individuals.

At the last documented count (during February 2020), the Clarencetown camp had between 500 and 2,500 individuals and the Glen William had less than 500 individuals. The Raymond Terrace camp had 10,000 – 16,000 individuals in November 2019 (DAWE 2021a) (Figure 6-13).

### 6.8.3 Assessment of habitat

#### *6.8.3.1 Description of habitat values*

Habitat for the Grey-headed Flying-fox in the study area consists primarily of flowering Eucalyptus, Corymbia and Angophora trees. An area of forest dominated by *Eucalyptus tereticornis* occurs near the southern portal. *Eucalyptus tereticornis* is regarded as an important winter and spring food source for the Grey-headed Flying-fox (Figure 6-14).

#### *6.8.3.2 Discussion of habitat utilisation*

The Grey-headed Flying-fox is likely to utilise the study area for foraging purposes throughout the year.

#### *6.8.3.3 Extent of habitat removal*

In total, 0.05 ha of Grey-headed Flying-fox foraging habitat including several *Eucalyptus tereticornis* trees will be removed by the proposal in order to provide access to the downstream section of tunnel.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.8.3.4 Consideration of corridors*

The study area and associated vegetation is unlikely to form a movement corridor for the Grey-headed Flying-fox. This species can traverse a wide range of land use areas and the species can regularly travel over 10 km to feed from their roost before returning the same night (DAWE, 2021b).

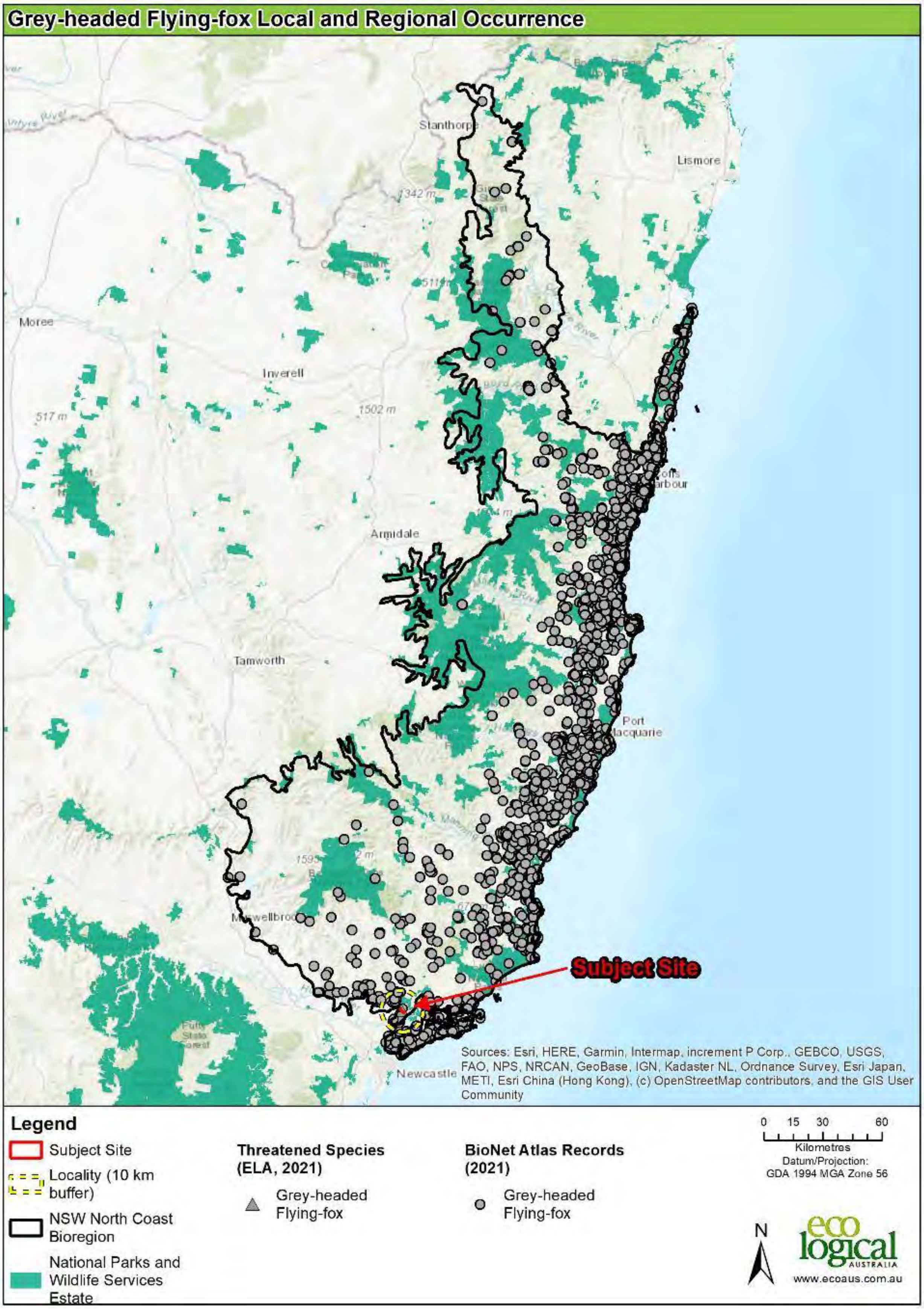



**Figure 6-13: Grey-headed Flying Fox local and regional occurrence**


**Figure 6-14: Grey-headed Flying Fox habitat**

## 6.9 White-bellied Sea-Eagle

### 6.9.1 Conservation status

#### *6.9.1.1 Local, regional and state conservation status*

White-bellied Sea-Eagle is listed as Vulnerable under the BC Act. The species is not listed as threatened under the EPBC Act. The White bellied sea-eagle has been recorded on the NSW BioNet database from within 59 conservation reserves within the region. Within NSW, 28% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate) (DPIE, 2021).

#### *6.9.1.2 Key threatening processes*

The following threats have been identified for the White-bellied Sea-eagle:

- Clearing of native vegetation
- Disturbance to nesting sites
- Removal of dead wood and dead trees
- Entanglement in, or ingestion of anthropogenic debris in marine and estuarine environments
- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands
- Deliberate and accidental poisoning, through industrial and agricultural chemicals and vertebrate pest control is also listed as a threat to the species (DPIE, 2019).

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.9.1.3 Habitat requirements*

Habitat for the White-bellied Sea-eagle are generally centred on large waterways, dams, lakes, swamps and the ocean where prey species are located. The species generally uses tall trees adjacent to these foraging habitats in which to nest.

#### *6.9.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species but a targeted strategy for managing this species has been developed under the SoS program (DPIE, 2021a).

#### *6.9.1.5 Assessment of representation within conservation reserves in the region*

The White-bellied Sea-eagle has been recorded 567 times from within 59 conservation reserves within the region. Within the wider locality the species has been recorded in close proximity to Wallaroo National Park, Medowie State Conservation Area and Seaham Swamp Nature Reserve.

#### *6.9.1.6 Species distribution*

In NSW the White-bellied Sea-eagle is widespread along the east coast, and along all major inland rivers and waterways. The species is not at the limit of its known distribution.

### 6.9.2 Local and regional abundance

The local and regional abundance of the White-bellied Sea eagle has not been estimated, but the species is still regarded as reasonably common in the locality and bioregion. The species is often observed in and adjacent to major waterways, wetlands and beaches with adjacent forest areas (Figure 6-15).

### 6.9.3 Assessment of habitat

#### *6.9.3.1 Description of habitat values*

Habitat for the White-bellied Sea-Eagle in the study area consists of foraging habitat in the form of open water along Balickera canal. Adjacent forest and trees lining the canal provide potential perch sites. No current White-bellied Sea-eagle nests have been observed in the study area (Figure 6-16).

#### *6.9.3.2 Discussion of habitat utilisation*

The White-bellied Sea-eagle has been observed several times in the current study flying over and along Balickera Canal. The study area is located between two major habitat areas; the Williams River and Grahamstown Dam and the canal is possibly used as a corridor to travel between these two habitat areas. The White-bellied Sea-Eagle is likely to occasionally forage in the canal which has been observed to contain potential prey such as eels.

Forest areas or remnant trees within the locality are likely to provide potential nesting sites for the species. No nests are present within the study area. Two individual White-bellied Sea-Eagle were heard calling together approximately 250 m west of the upstream portal in June 2020. The proposal will be undertaken between December and April which is outside of the breeding season for the species.

#### *6.9.3.3 Extent of habitat removal*

Direct habitat removal is limited to approximately 0.05 ha of forest to allow vehicular access to the tunnel and some temporary removal of foraging habitat when sections of the canal are dewatered during construction. Approximately 700 m of canal upstream and 200 m downstream of tunnel will be dewatered during the construction works.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.9.3.4 Consideration of corridors*

The study area may be used as a corridor between Grahamstown Dam and the Williams River by the White-bellied Sea-eagle. However, the tunnel upgrade works, temporary canal dewatering and minor tree removal proposed are unlikely to create any barriers to movement for this highly mobile species.

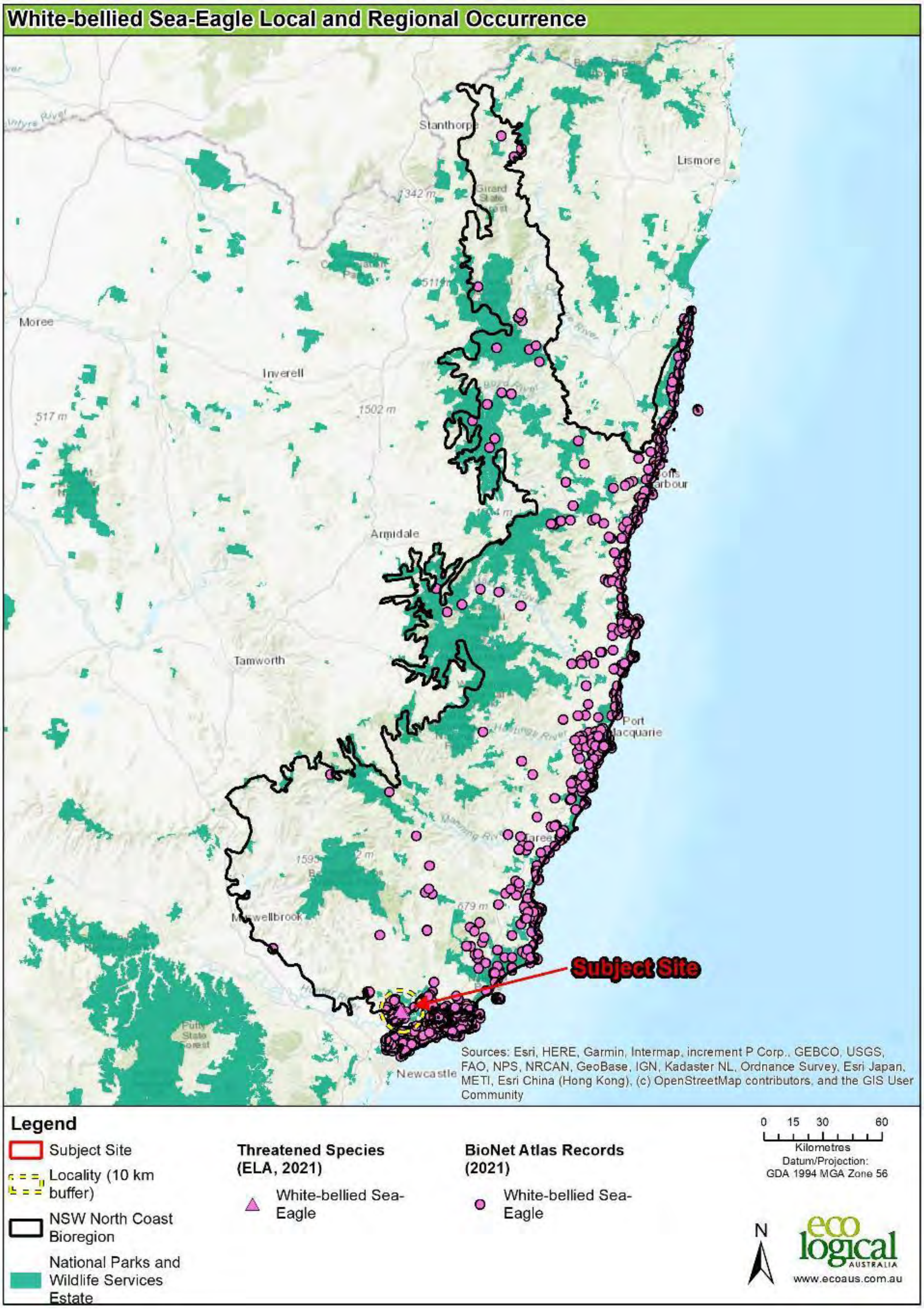



**Figure 6-15: White-bellied Sea-Eagle local and regional occurrence**


**Figure 6-16: White-bellied Sea-Eagle habitat**

## 6.10 Powerful Owl

### 6.10.1 Conservation status

#### *6.10.1.1 Local, regional and state conservation status*

The Powerful Owl is listed as Vulnerable under the NSW BC Act. It is not listed under the Commonwealth EPBC Act. An estimated 42% of the Powerful Owls current distribution occurs in NSW National Parks and Wildlife Service estate (DPIE, 2021b) and has been recorded in 74 conservation reserves in the region. The North Coast region is a stronghold for the Powerful Owl which is more than twice as abundant in north-eastern NSW as in south-eastern NSW and on the western slopes (DEC, 2006). Within the Hunter Region the population trend from 2010-2016 was recorded as 'stable, possibly increasing' by Roderick and Stuart (2016).

#### *6.10.1.2 Key threatening processes*

The following threats have been identified for the Powerful Owl:

- Historical loss and fragmentation of suitable forest and woodland habitat from land clearing for residential and agricultural development
- Inappropriate forest harvesting practices that have changed forest structure and removed old growth hollow-bearing trees
- High frequency hazard reduction burning may also reduce the longevity of individuals by affecting prey availability
- Road kills
- Secondary poisoning
- Predation of fledglings by foxes, dogs and cats.

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.10.1.3 Habitat requirements*

The Powerful Owl lives in forests and woodlands occurring in the coastal, escarpment, tablelands and western slopes environments of NSW. However, records of the Powerful Owl are sparse inland and most concentrated on the coast and tablelands. The owls appear to prefer older mid to late successional forest more than 60 years old and are associated with tall, moist eucalypt forests of the eastern tableland edge and the mosaic of wet and dry sclerophyll forests occurring on undulating, gentle terrain nearer the coast (DEC, 2006). Diurnal roosting sites are commonly in dense foliage in sheltered gullies while nesting typically occurs in large tree hollows of greater than 45 cm diameter and more than 100 cm deep (DEC, 2006).

#### *6.10.1.4 Recovery plans or threat abatement plans*

A recovery plan has been developed for the large forest owls (DEC, 2006). The Powerful Owl is now a landscape managed species under the SoS program (DPIE, 2021b). DPIE consider that many of the threats to Powerful Owl are addressed by NSW planning, native vegetation, and biodiversity legislation, policy and programs (DPIE, 2021b). Currently, no management sites have been identified for this threatened species.

#### *6.10.1.5 Assessment of representation within conservation reserves in the region*

The Powerful Owl is well represented in conservation reserves in the region with records from 74 conservation reserves including the nearby Wallaroo and Karuah National Parks.

#### *6.10.1.6 Species distribution*

The Powerful Owl primarily occupies the eastern side of the Great Dividing Range from Mackay in Queensland to south-western Victoria.

### 6.10.2 Local and regional abundance

No quantitative information regarding local and regional abundance is available for the Powerful Owl. Research undertaken in the late 1980's and early 1990's by Kavanagh and Debus have estimated the minimum population size in NSW at that time to be 2,000 pairs or at least 10,000 individuals (DEC, 2006) (Figure 6-17).

### 6.10.3 Assessment of habitat

#### *6.10.3.1 Description of habitat values*

Habitat for the Powerful Owl in the study area consists of forest and tree areas in which to hunt prey (Figure 6-18).

#### *6.10.3.2 Discussion of habitat utilisation*

The Powerful Owl is likely to utilise the study area for foraging purposes throughout the year. No large tree hollows suitable for nesting and few suitable areas of dense canopy in which Powerful Owl may roost are present. Suitable habitat in the study area is mostly restricted to the southern portal.

Lands adjacent to the study area such as Wallaroo State Forest and National Park form a large area of forest that is likely to support several pairs of Powerful Owls. Habitat in the area is linked to other state forests and national parks to the north and south.

#### *6.10.3.3 Extent of habitat removal*

In total 0.05 ha of Powerful Owl foraging habitat will be removed by the proposal in order to provide access to the downstream section of tunnel.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area.  There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest.  There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts.  The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.10.3.4 Consideration of corridors*

The study area and associated vegetation is unlikely to form a movement corridor for the Powerful Owl. Powerful Owls are likely to be able to disperse over tens of kilometres through a mosaic of forested and cleared land (DECC 2006).

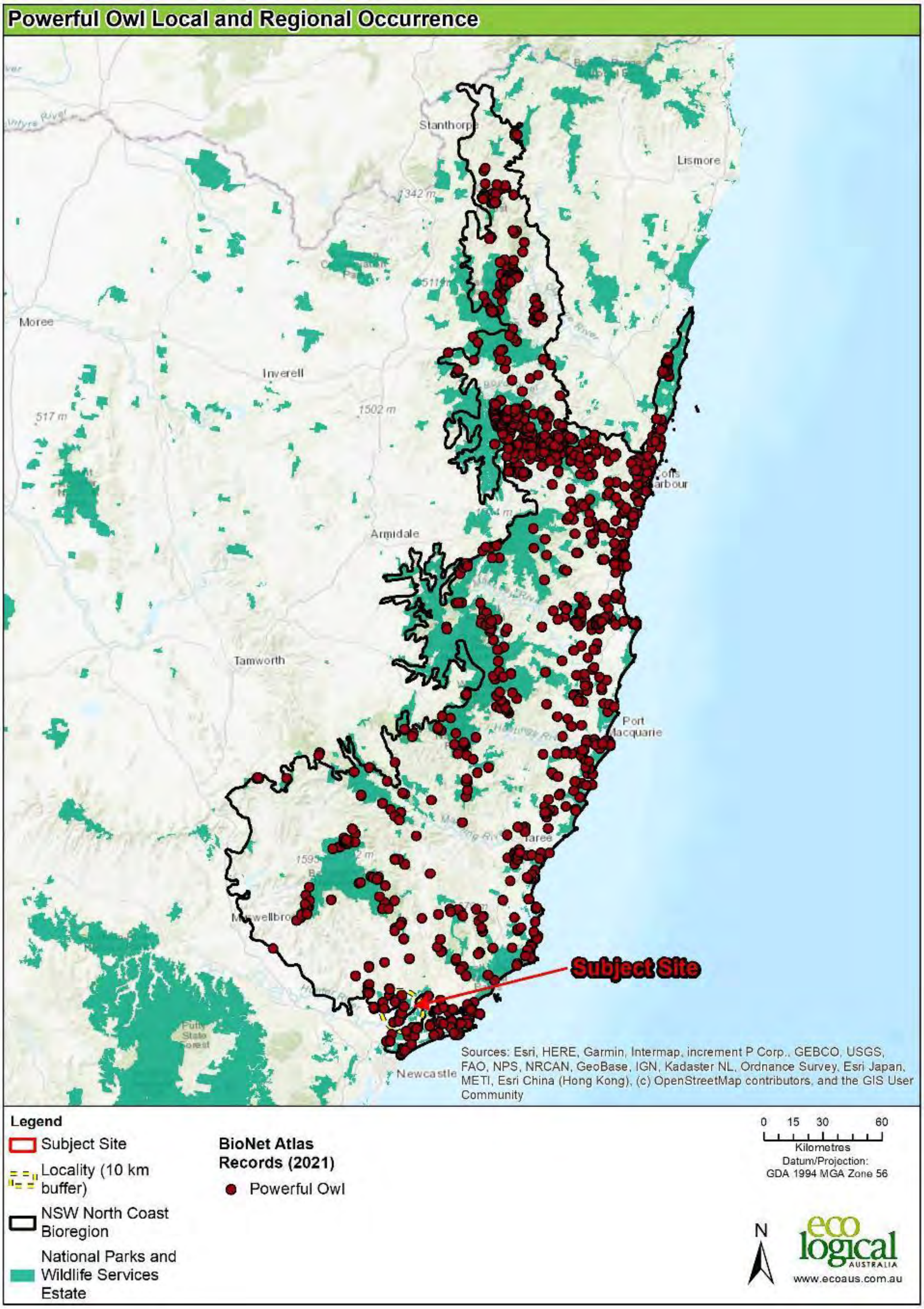



**Figure 6-17: Powerful Owl local and regional occurrence**


**Figure 6-18: Powerful Owl habitat**

## 6.11 Masked Owl

### 6.11.1 Conservation status

#### *6.11.1.1 Local, regional and state conservation status*

Masked Owl is listed as Vulnerable under the BC Act and is not listed as threatened under the EPBC Act. In NSW, 28% of the Masked Owl's distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Masked Owls present special problems for researchers and forest managers. They are difficult to study because they are nocturnal, wide-ranging and naturally uncommon throughout their distribution. They are considered sensitive to logging and other forms of habitat disturbance since they are among the top order carnivores in the forest ecosystems of eastern Australia and many of their main prey species and nesting requirements depend on elements of old-growth forest (Debus 1994, Kavanagh 1997, Milledge 2004). Early assessments of their conservation status by Lunney *et. al.* (2000) suggested populations and their current distributions have declined. Within the Hunter area the Masked Owl is considered a rare resident, with the population trend from 2010-2016 recorded as 'probably stable' by Roderick and Stuart (2016) who note that much of the core range of the species in the area lies within areas zoned for conservation. The species has been recorded in 65 separate conservation reserves in the region.

#### *6.11.1.2 Key threatening processes*

The following threats have been identified for the Masked Owl:

- Loss of mature hollow-bearing trees and changes to forest and woodland structure, which leads to fewer such trees in the future
- Clearing of habitat for grazing, agriculture, forestry or other development
- A combination of grazing and regular burning is a threat, through the effects on the quality of ground cover for mammal prey, particularly in open, grassy forests
- Secondary poisoning from rodenticides
- Being hit by vehicles.

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.11.1.3 Habitat requirements*

Masked Owl's live in dry eucalyptus woodlands and forests from sea level to 100 m. This forest owl often hunts along the edges of forest, including roadsides. The typical diet consists of tree-dwelling and ground mammals, especially rats. Pairs have a large home-range of 500 to 1000 ha. Masked Owls roost and breed in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting (DPIE 2017a).

#### *6.11.1.4 Recovery plans or threat abatement plans*

The Masked Owl is assessed under the *Approved NSW Recovery Plan for the Large Forest Owls* (DEC 2006) and is targeted under the 'Save our Species' program (DPIE 2021e).

#### *6.11.1.5 Assessment of representation within conservation reserves in the region*

There are 984 records of Masked Owl within the region, including 224 (23%) from within 65 different conservation reserves. The species is considered to be well represented within conservation reserves in the region and has been recorded from several conservation reserves in the locality and surrounding area including Karuah National Park, Tilligerry Nature Reserve, Worimi Regional Park, The Glen Nature Reserve and Tomaree National Park.

#### *6.11.1.6 Species distribution*

The Masked Owl is endemic to temperate mainland Australia (DEC 2006). The distribution of the Masked Owl extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution (DPIE 2017). The three large forest owls all have their NSW distributions centred on, or most concentrated in, the forests of the coast, escarpment and tablelands and are widespread throughout these environments (Debus 1994, Debus and Rose 1994, DEC Atlas of NSW Wildlife). In addition, the Masked Owl occur at lower population densities in the drier forests and woodlands of the western slopes of NSW (Kavanagh 2002) and the Masked Owl is sparsely distributed on the western plains. Potential habitat for the Masked Owl is mostly in conservation reserves and state forests, although this species is also found throughout large areas of forest or woodland on other public lands and on private land, including suburban bushland.

### 6.11.2 Local and regional abundance

No estimates of the abundance of Masked Owl in the locality and region are available. The species is considered a rare resident in the Hunter by Roderick and Stuart (2016). There are 984 records of Masked Owl in the region and six records from within the locality (Figure 6-19).

### 6.11.3 Assessment of habitat

#### *6.11.3.1 Description of habitat values*

Habitat for the Masked Owl in the study area includes foraging habitat in the form of forests and edges of forest including roadsides where they hunt rats and other small mammals. No hollow bearing trees suitable for breeding were recorded in the study area (Figure 6-20).

#### *6.11.3.2 Discussion of habitat utilisation*

Records occur within the locality for the Masked Owl. The species has the potential to forage in the study area in forest, along the forest edge and roadsides. No hollow bearing trees occur in the study area and the species is unlikely to use the area for breeding. The locality has some large forest areas such as the Wallaroo National Park and Wallaroo State Forest which provide a range of potential foraging and breeding resources for the Masked Owl.

#### *6.11.3.3 Extent of habitat removal*

In total 0.05 ha of potential foraging habitat will be removed by the proposal to provide access to the downstream section of tunnel. The quantity of foraging habitat to be removed is considered extremely minimal considering the large areas of habitat adjacent to the study area.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.11.3.4 Consideration of corridors*

The Masked Owl travels widely over a range of forested and sparsely wooded habitat. The small area of habitat to be removed is unlikely to fragment or disrupt an important corridor for the species.

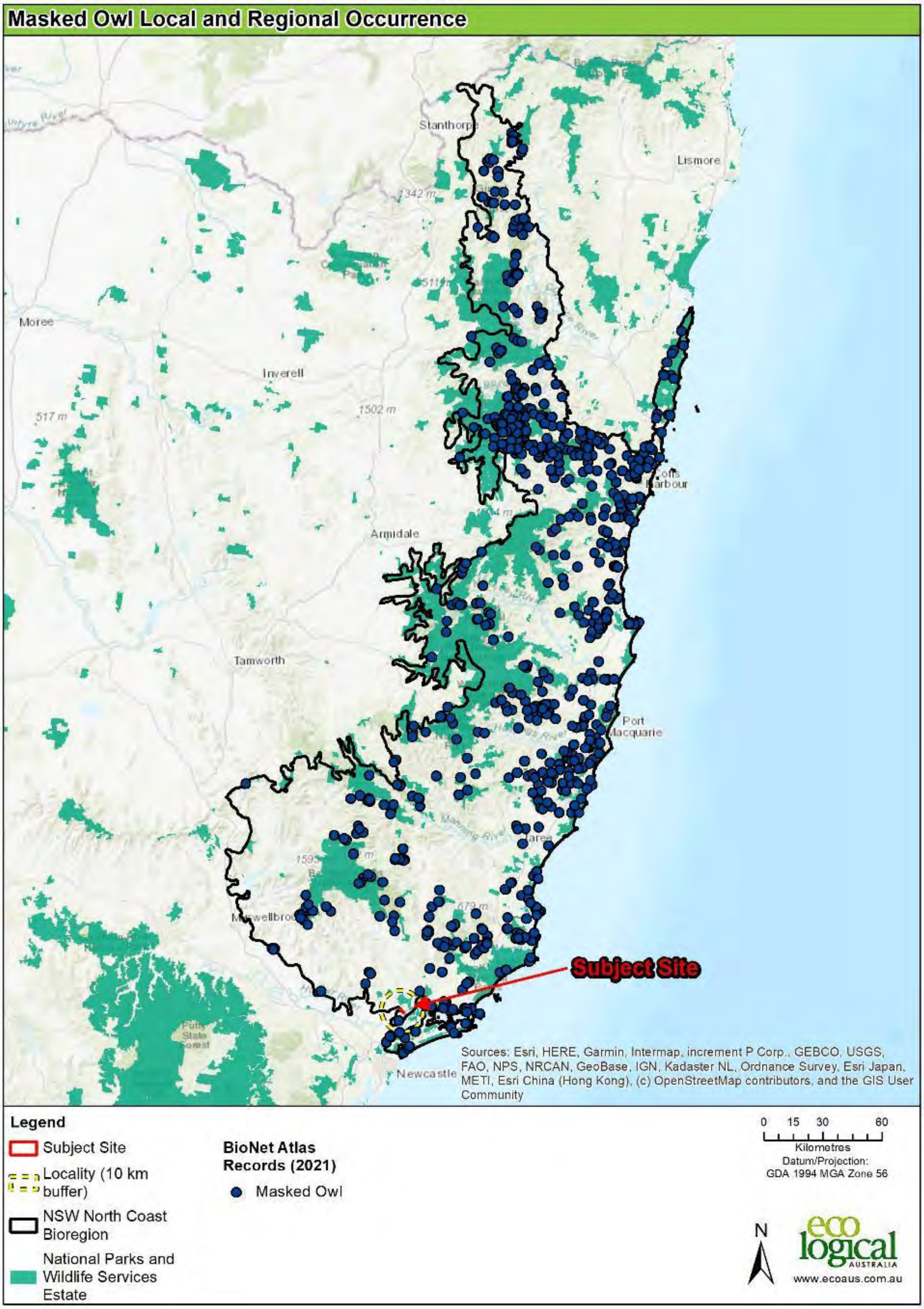



**Figure 6-19: Masked Owl local and regional occurrence**


**Figure 6-20: Masked Owl habitat**

## 6.12 Little Lorikeet

### 6.12.1 Conservation status

#### *6.12.1.1 Local, regional and state conservation status*

Little Lorikeet is listed as Vulnerable under the BC Act and is not listed as threatened under the EPBC Act. The species is often regarded as nomadic and movements are heavily influenced by season and food availability. In NSW 21% of the Little Lorikeets' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate) (DPIE, 2021b). The species has been recorded in 47 separate conservation reserves in the region.

#### *6.12.1.2 Key threatening processes*

The following threats have been identified for the Little Lorikeet:

- Clearing of native vegetation
- Loss of hollow-bearing trees
- Removal of dead wood and dead trees'
- Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners
- Competition from feral honeybees
- Ecological consequences of high frequency fires
- Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species.

The KTP 'Clearing of native vegetation' is relevant to the proposal.

#### *6.12.1.3 Habitat requirements*

Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. However, during times of poor flowering in the west or heavy Eucalypt flowering on the coast, large numbers can be observed in coastal forests. Nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts.

#### *6.12.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for the Little Lorikeet and no management sites have been identified for this threatened species.

#### *6.12.1.5 Assessment of representation within conservation reserves in the region*

The species has been formally recorded in 47 separate conservation reserves in the bioregion. However, as the Little Lorikeet is a wide-ranging nomadic species, this statistic is unlikely to be representative of conservation success.

#### *6.12.1.6 Species distribution*

The distribution of the Little Lorikeet extends from just north of Cairns, around the east coast of Australia, to Adelaide. In NSW Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range (NSW Scientific Committee, 2009). The locality is not on the edge of the species' range. In NSW, most breeding records come from the western slopes of the Great Dividing Range.

### 6.12.2 Local and regional abundance

No estimates of the abundance of Little Lorikeet in the locality and region are available and the nomadic nature of the species make population estimates uncertain. Over the range of the Little Lorikeet 'it appears that there has been at least a moderate reduction in population size…' (NSW Scientific Committee, 2009).

There are 787 BioNet records of Little Lorikeet in the region dating from 1971 – 2021, and only six records from within the locality (Figure 6-21).

### 6.12.3 Assessment of habitat

#### *6.12.3.1 Description of habitat values*

Habitat for the Little Lorikeet in the study area includes mature gum trees and forest that provide flowers in which the species can forage. No hollow-bearing trees were recorded within the study area and the species is unlikely to nest in the study area (Figure 6-22).

#### *6.12.3.2 Discussion of habitat utilisation*

The Little Lorikeet has been recorded flying over the study area and in surrounding forest areas. The species is likely to forage in the study area when flowers are present. No hollow-bearing trees were recorded within the study area as such the species is unlikely to use the study area for breeding. The locality has some large forest areas such as the Wallaroo National Park (2780 ha) and Wallaroo State Forest which border the study area and provide a range of potential foraging and breeding resources for the Little Lorikeet.

#### *6.12.3.3 Extent of habitat removal*

In total 0.05 ha of potential foraging habitat including several *Eucalyptus tereticornis* (Forest Redgum) trees will be removed by the proposal to provide access to the downstream section of tunnel. The quantity of foraging habitat to be removed is considered extremely minimal considering the large areas of habitat adjacent to the study area.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.12.3.4 Consideration of corridors*

The Little Lorikeet travels widely over a range of forested and sparsely wooded habitat in small flocks. The small area of habitat to be removed is unlikely to be fragment or disrupt an important corridor for the species.

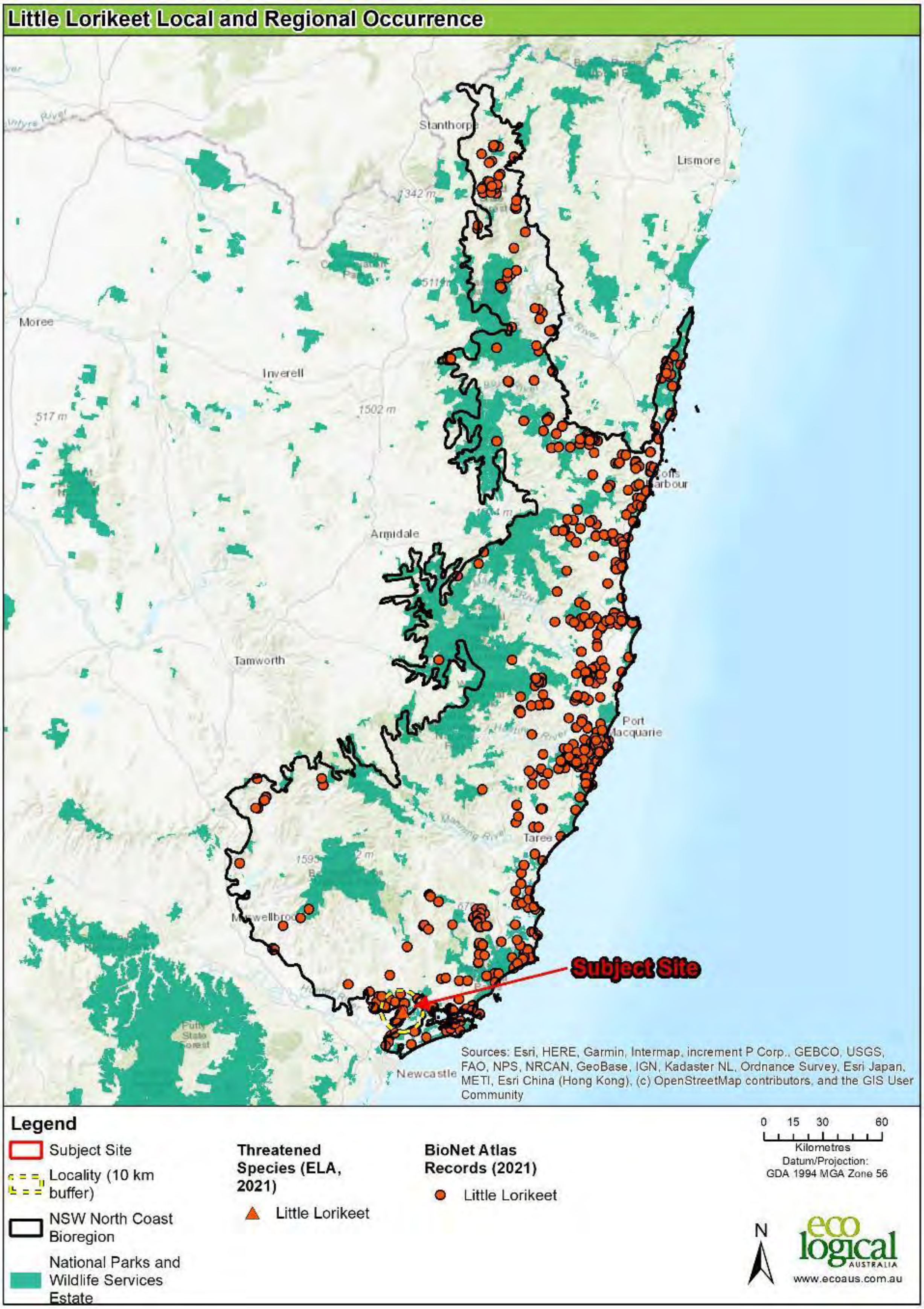



**Figure 6-21: Little Lorikeet local and regional occurrence**


**Figure 6-22: Little Lorikeet habitat**

## 6.13 Grey-crowned Babbler

### 6.13.1 Conservation status

#### *6.13.1.1 Local, regional and state conservation status*

Grey-crowned Babbler is listed as Vulnerable under the BC Act. The Grey-crowned Babbler is poorly conserved in reserves in the region and locality.

#### *6.13.1.2 Key threatening processes*

The following threats have been identified for the Grey-crowned Babbler:

- Clearing of native vegetation
- Removal of dead wood and dead trees
- Predation by feral cats
- Predation by the European Red Fox
- Herbivory and environmental degradation caused by feral deer
- Ecological consequences of high frequency fires and associated Human-caused Climate Change
- Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata.*

The KTP ‘Clearing of native vegetation’ is relevant to the proposal.

#### *6.13.1.3 Habitat requirements*

The Grey crowned Babbler is associated with open Box-Gum Woodlands on the slopes, Box-Cypress-pine and open Box Woodlands on alluvial plains and open forests and woodlands on fertile soils in coastal regions.

#### *6.13.1.4 Recovery plans or threat abatement plans*

There is no Recovery Plan or Threat Abatement Plan for this species.

#### *6.13.1.5 Assessment of representation within conservation reserves in the region*

The Grey-crowned Babbler is poorly conserved in conservation reserves in the region with only 25 records in seven conservation reserves. This is likely due to the species preference for open forests and woodlands on fertile soils in coastal regions which are poorly conserved habitats.

These conservation reserves in the North Coast bioregion with records of Grey-crowned Babbler are listed below:

- Chaelundi National Park
- Columbey State Conservation Area
- Coolongolook Nature Reserve
- Guy Fawkes River State Conservation Area
- Nymboida National Park
- Worimi National Park
- Yuraygir National Park.

Additional records from conservation reserves are present in the nearby Sydney Basin Bioregion

#### *6.13.1.6 Species distribution*

The eastern subspecies of the Grey-crowned Babbler (temporalis) occurs from Cape York south through Queensland, NSW and Victoria (DPIE, 2017). In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range and into the western plains. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW (DPIE, 2017). Records of the Grey-crowned Babbler in the North Coast bioregion are concentrated in the far north of the region and south into the Hunter Valley with few records on the mid-north coast. There are few records of Grey-crowned Babbler east of study area in the locality and most records appear to be associated with open forest/woodland on the periphery of the Williams River floodplain.

### 6.13.2 Local and regional abundance

The abundance of the species at a local and regional level has not been quantified. Most records of the species are associated with the south-western end of the bioregion in the northern Hunter Valley.

Only three other records of Grey-crowned Babbler are located within 5 km of the study area with several records within 10 km to the south and west in vegetation remnants closer to the Williams River. It is likely that the species is largely absent from shrubby forest areas and inhabit grassy open forest and woodland associated with the edges of floodplains in the locality (Figure 6-23).

### 6.13.3 Assessment of habitat

#### *6.13.3.1 Description of habitat values*

Habitat for the Grey-crowned Babbler in the locality consists of partially cleared forest and farmland with the species also likely to use grassy open forest and woodland areas. The Grey-crowned Babbler was recorded on the periphery of the study area adjacent to an area of partially cleared and grazed forest (Figure 6-24).

#### *6.13.3.2 Discussion of habitat utilisation*

The Grey-crowned Babbler potentially forages on the edges of the upstream portion of the study area. None of the species conspicuous nests were observed in the study area and no observations of the species were made in the more heavily forested downstream portion of the study area

#### *6.13.3.3 Extent of habitat removal*

In total 0.05 ha of potential foraging habitat including several *Eucalyptus tereticornis* (Forest Red Gum) trees will be removed by the proposal to provide access to the downstream section of tunnel. No Grey-crowned Babbler individuals were observed in the immediate vicinity of the clearing and the quantity of foraging habitat to be removed is considered extremely minimal considering the larger areas of habitat adjacent to the study area.

Cumulative effects of the proposal should be considered in the context of other existing or likely developments or activities in the area. There is one potential project known in close proximity to the proposal area, the Stone Ridge Quarry project located at off Italia Road in Wallaroo State Forest. There are no other known developments proposed adjacent or near to the site likely to contribute to cumulative impacts. The proposal would result in very minor contribution to the cumulative impacts on the species and its habitat in the region.

#### *6.13.3.4 Consideration of corridors*

No corridors for the Grey Crowned Babbler are likely to be impacted by the proposal.

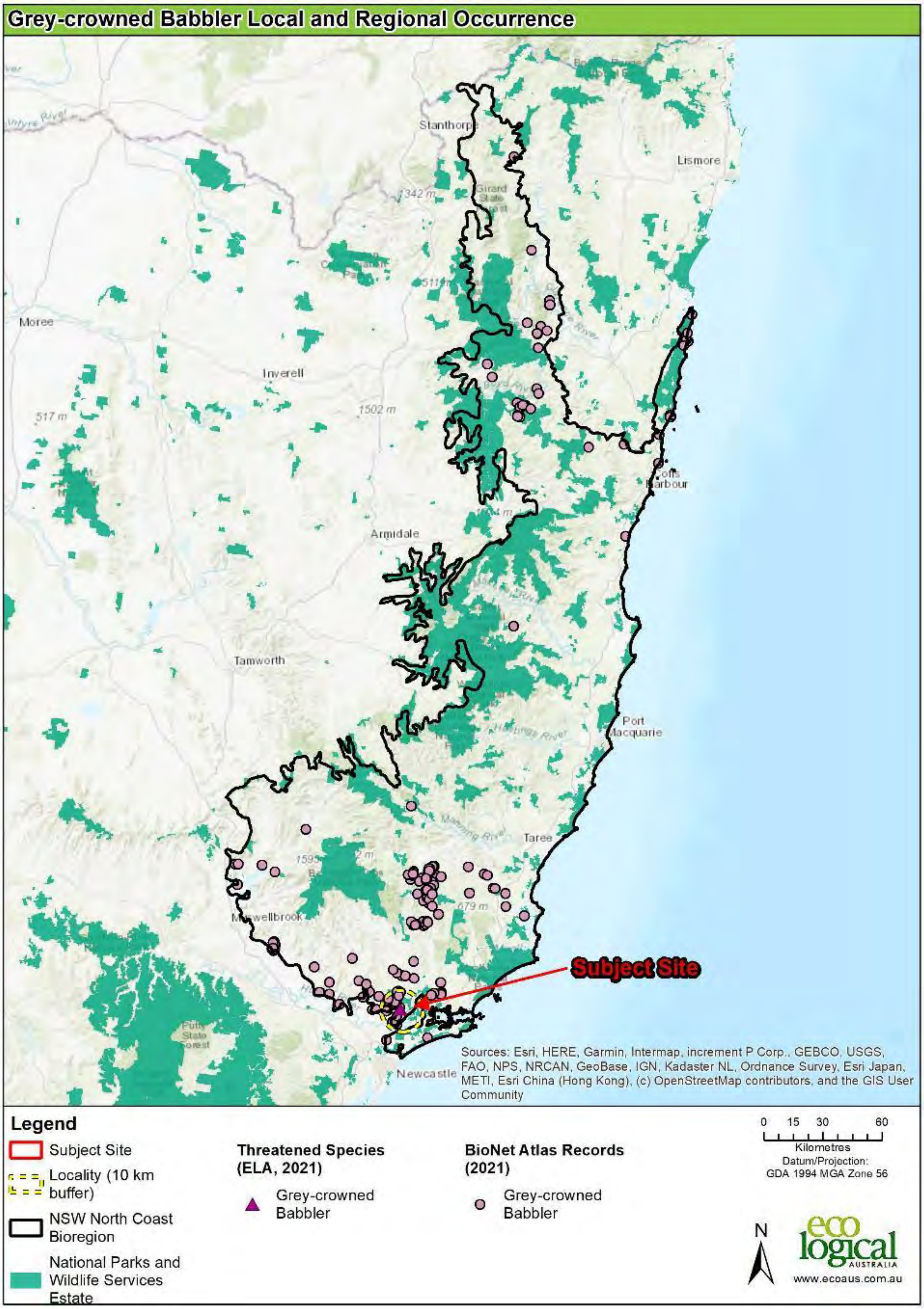



**Figure 6-23: Grey-crowned Babbler local and regional occurrence**


**Figure 6-24: Grey-crowned Babbler habitat**

## 6.14 Description of feasible alternatives

The CERs have identified a requirement for a description of any feasible alternatives to the action that are likely to be of lesser effect and to provide justification for carrying out the action in the manner proposed having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development.

The alternatives for the proposed tunnel remediation include:

- Taking no action
- Constructing a new tunnel
- Alternative timing and staging of works.

### 6.14.1 No action

Taking no action is not considered an appropriate alternative due to the critical social importance of the Balickera Canal for drinking water security for the Lower Hunter Region. Recent inspections by Douglas Partners (2007) and a further review by Pells Consulting (2015) have determined that there is no useful life left in the rock bolts in the natural rock sections, although there is at least a further 5 to 15 years in the concrete lined sections. If a significant rock fall occurred within the tunnel, there is potential that the region's water supply would be at risk. There is also a potential that the rock fall could cause significant injury or death to bats roosting in the tunnel at the time and / or restrict or prevent microbats from accessing roost sites in the tunnel. A 1 in 100 flood event would lead to the tunnel being flooded to 500 m. The majority of the bat roosting habitat is located towards the upstream portal and although such a flood event is unlikely to cause significant injury or death to bats roosting in the tunnel at the time it would restrict or prevent microbats from accessing roost sites in the submerged part of the tunnel.

There is a unique window of opportunity that exists currently to take the tunnel offline because water levels remain at capacity and this will remain the case as long as Grahamstown Dam remains above 85% capacity. Once the water level drops below this level, there is an increased risk that taking the tunnel and canal offline may jeopardise the water supply to the Lower Hunter Region. However, alternative timing and staging is discussed in 6.14.3 to minimise impacts to threatened species.

### 6.14.2 Construction of a new tunnel

Construction of a new tunnel to replace the existing tunnel is not considered to be a feasible alternative due the significant cost and time involved in such a proposal and the potential for other significant environmental impacts associated with such a large scale project. Remediation of the existing tunnel is considered to be the most appropriate method to ensure continued water supply into Grahamstown Dam.

An option for construction of a short purpose built blind tunnel adjacent to the upstream portal that would provide dedicated roosting habitat for microbats was also considered. Creation of artificial tunnels purpose built for Bent-winged Bats has not previously proven to be successful for large numbers of either Little or Large Bent-winged Bats. Both Bent-winged Bat species are occasionally recorded in bridge and culvert structures, more often as individuals or in small numbers. There are a number of large road structures such as bebo arches (curved cave like culverts) and concrete culverts on the Pacific Highway in northern NSW inhabited by large colonies (2000+) of Little Bent-winged Bats over winter

(GeoLINK 2014, 2015). These structures were not built as dedicated microbat roosting habitat. However, Little Bent-winged Bats have roosted in the expansion joints (where they are > 20 mm wide) between concrete sections of the bebo arches and culverts for many years over winter (> 7 years).

One of these structures, a bebo arch at Glenugie was recently removed under the guidance of a microbat management plan implemented by the author of this SIS as part of a Pacific Highway upgrade project for Transport for New South Wales (TfNSW) (ELA 2020). In this project a large colony of Little Bent-winged Bats (1,000 – 2,000) were required to be excluded from a winter roost site within a bebo arch culvert. There were no bats present at the time of the removal of the bebo arch and it was replaced with a series of concrete box culverts. The author worked with TfNSW to design in situ roosting opportunities for the displaced colony of Little Bent-winged Bats in newly built culvert structures similar to, and within 100 m of the original roost. The replacement box culverts at Glenugie were designed to be inhabited by large numbers of Little Bent-winged Bats (up to 2000) through incorporation of maximum joint spacing (>20mm) of 4 expansion joints within the central (darkest) section of each of the eight culvert cells (ELA in preparation). Little Bent-winged Bats began to roost within the newly built culvert system in the winter following completion of works and recent autumn monitoring data (2021) indicates that the number of bats roosting in the new culverts has increased from an initial 30 – 50 bats in 2018 to now approximately 1000 bats which is more than 50% of the numbers recorded using the original culvert that was removed.

An upgrade of stormwater culverts at Dee Why that were inhabited by a regionally significant colony of Large Bent-winged Bats provides another example of a successful microbat exclusion, albeit on a smaller scale than planned at Balickera Tunnel. The Oaks Ave, Dee Why stormwater culvert upgrade was subject to an SIS (Niche 2016a) that recommended a suite of measures for creation of additional features to extend and promote Large Bent-winged Bat roosting habitat in unaffected areas of the culverts and create additional roosting habitat in other nearby structures (Niche 2016b). These measures included hard barriers installed within the culverts to protect bats from noise, disturbance and light during works, creation of roosting features (roughened surfaces) in areas of the culvert away from the works area, addition of lighting to discourage bats from roosting near the works area, and the addition of light baffles around the entrance to nearby structures where new roost features were installed (Niche 2016b). Results have indicated that these measures were successful both during the works and post works with Large Bent-winged Bats using some of the features created to encourage roosting in areas away from the works area and returning in similar numbers to the roost area following completion of works (F. Lemckert pers. comm.)

The author (Alicia Scanlon, ELA) believes that several factors are key to the successful creation of alternative roosts for Bent-winged Bats:

- Proximity of alternative roost to original roost
- Similarity of alternative roost type to original roost (e.g. bats were roosting within expansion joints of a concrete culvert and the newly created roost replicates the original roost)
- Availability of other alternative roost sites within the region so that bats have other roost options while transitioning between the original roost and the newly created roost
- Maintaining minimum disturbance levels at the new roost, or disturbance levels similar to those experienced at the original roost (roost must not be a place that people visit / pass through)

- Maintaining similar microclimatic conditions such as amount of light penetrating the roost, similar temperature and humidity profiles, presence / availability of a water source, sheltered aspect from prevailing winds
- Inaccessibility of the roosting locations to predators.

The cost of creating a smaller purpose built blind tunnel that satisfies the key factors listed above as an offshoot of the Balickera Canal was considered to be prohibitive in this case. This was because a newly created tunnel would need to be constructed within a hard rock substrate in order to both be built within close proximity to the existing tunnel and be on land owned by Hunter Water. Furthermore, any blind tunnel created from Balickera Canal would fall within the impact area of the proposed tunnel remediation work and would be subject to increased levels of disturbance from heavy plant, human and vehicular traffic, noise, lighting, vibration during construction. However, the internal tunnel environment would be somewhat buffered from these impacts as there would be no direct impacts within the tunnel itself.

There would be no guarantee that a purpose-built blind tunnel would be considered suitable and used as a roost site by the population of bats known to roost within Balickera Tunnel. Locating this tunnel further from the existing roost would reduce the likelihood that it would be used by bats from Balickera Tunnel. Given the uncertainty involved with the option of constructing a purpose-built blind tunnel and issues in locating a suitable site, this option was not considered to offer a practical solution.

### 6.14.3 Alternative timing and staging of works

Several approaches to the timing and staging of the tunnel remediation works were considered, including seasonal options, staging works so that only half the tunnel is worked on in a given works period, and completing the works over multiple years or seasons.

#### *6.14.3.1 Seasonal options*

Due to the combination of species, population numbers and breeding status of the threatened bat colonies present within the tunnel, there is no period when impact mitigation can be maximised for all species.

The preferred timing for tunnel remediation from a water supply perspective is the dry spring season when the canal and tunnel are less likely to be required to transfer water from the Williams River to the Grahamstown Dam and are more easily taken offline for remediation works to occur.

Spring is considered a high risk period for Bent-winged Bats due to the combination of peak population and the presence of pregnant female bats. Winter is also a high risk period for the tunnel bat populations due to the peak numbers of Little Bent-winged Bats and Large Bent-winged Bats present and the susceptibility of all species of bats to disturbance during this season when they may be in extended torpor and insect prey is less abundant. During autumn, females, independent sub-adults and some males return from summer maternity roost sites and the population size almost doubles in size from December to March. An exclusion conducted during autumn risks impacting larger numbers of Little and Large Bent-winged Bats than an exclusion conducted over summer.

Spring, summer and winter are all high risk periods for Southern Myotis. The presence of pregnant female bats during spring, birthing bats with dependent (non-flying) pups and juveniles unable to survive independently throughout late spring and summer and peak population size in late summer translates to a high degree of sensitivity to disturbance and impacts at roost sites over this period. Autumn is a time when independent young and males are dispersing from maternity colonies and bats are building up fat stores for winter. The least sensitive time to conduct an exclusion involving Southern Myotis is during April. During winter, Southern Myotis are less active and may enter extended bouts of torpor (up to two weeks) to conserve energy whilst food resources are scarce.

The total population of bats within the tunnel falls rapidly in December from roughly 5,500-6,000 to less than 3,000, when pregnant female Little Bent-winged Bats depart to maternity roosts. Little Bent-winged Bats account for the majority of the population roosting within Balickera Tunnel. The optimal time to conduct works to minimise impacts to Bent-winged Bats is therefore over the summer period (December to February) when numbers of both Bent-winged Bat species are at their lowest, and bats are departing winter roosts and migrating to maternity and summer roosts. Female Bent-winged Bats are largely absent from the colony over summer, having migrated to maternity roosts and food availability (insects) for bats remaining in the tunnel is high allowing bats to more easily cope with disturbance.

However, the optimal time to conduct works to minimise impacts to Southern Myotis is not during summer (a high risk period) but during autumn when individuals are dispersing from maternity colonies and there is still enough food available to build fat stores for the winter and sustain the search and assimilation into alternative roost sites.

The task is to design a strategy for the proposal which offers the best overall long-term conservation outcome. Microbats are a k-selected fauna group meaning that there is greater survivability of adults than young, adults are relatively long-lived and produce only a single young each year at best, with the exception of Southern Myotis which produces two young in two separate breeding events over summer each year in the northern part of its range (including across the Hunter region). The longer a reproductive adult bat can survive the more chance it has of greater lifetime reproductive output, and in some species from the genus Myotis, reproductive success has been shown to increase with age (Linton and Macdonald 2018). Adults are therefore more valuable than juveniles to the population at any given time. By selecting a strategy which protects the largest number of adult bats the greatest conservation outcomes can be achieved.

There are significantly higher numbers of Little Bent-winged Bats in the tunnel than Southern Myotis. In order to minimise impacts to the largest number of adult bats the best strategy for scheduling works will be to select a time when the least number of Little Bent-winged Bats will be present, which is December to February. Southern Myotis will be breeding in the tunnel over this period and it is likely that there will be some loss of pups, or dependent juveniles by scheduling the proposal to coincide with the breeding season of Southern Myotis.

However, there are some characteristics of the Southern Myotis reproductive cycle that may allow for a reduction in potential losses of pups and juveniles . Southern Myotis breed twice per year in northern NSW and only once in southern NSW and the zone of transition lies roughly between Sydney and the lower north coast. Evidence from monitored Southern Myotis roosts in the Clarencetown, Hunter Valley / Cessnock areas indicate that Southern Myotis will breed twice at Balickera, particularly if conditions are good. Under this scenario, births occur in mid – late October / early November and young are weaned and free flying by mid to late December. The second breeding event occurs in mid – late January / early February, with the young reaching independence by the end of March.

Careful scheduling of the final exclusion of the roost to coincide either with the period immediately prior to Southern Myotis giving birth in October / November, or with the attainment of juvenile independence following the first breeding event in late December/ early January, and prior to the second birthing event in mid – late January / early February should minimise losses of young during this period and allow bats to potentially relocate to other breeding roosts or to the bat boxes located less than 1 km downstream of the tunnel.

There are also some other factors which may reduce losses of individual Southern Myotis excluded from the tunnel during the breeding season. Most hollow roosting microbat species change roosts regularly (every day or every few days) and will move between a series of roosts within proximity to favoured foraging areas. This ecological strategy is thought to minimise the build-up of parasites within a roost and to reduce the likelihood of predators locating roosts, as well as facilitating social interactions. The situation for cave roosting species such as Little and Large Bent-winged Bats is that roost sites are in much shorter supply and switching roosts often is not always achievable. It may require multiple nights of travel for Bent-winged Bats to move between suitable permanent roost sites, utilising less suitable sites in the interim.

Southern Myotis are known to roost in both subterranean structures and tree hollows and therefore benefit from a broader range of potential roost sites than the Little and Large Bent-winged Bats. Southern Myotis are also known to readily roost and breed in a range of artificial alternative habitat types including bat boxes, bridges and culverts. There are numerous examples of successful passive translocations of Southern Myotis from original roosts to alternative roosts following exclusions, provided the alternative habitat can be provided in advance and in suitable locations. The author (Alicia Scanlon, ELA) has personally worked on several projects where colonies of 15+ individual Southern Myotis have been excluded from a roost and provided with alternative roosts in the form of bat boxes that were inhabited within a day of the roost exclusion occurring (ELA 2012). There were also cases where:

- newly installed bat boxes were inhabited by Myotis within weeks of installation (ELA 2011)
- the colony that formed within an alternative roost (bat box) bred and successfully raised young in the alternative roost during the next breeding season (ELA 2015)
- Southern Myotis returned to recreated habitat within a culvert they had been excluded from within days of it becoming available for use and subsequently breeding and successfully raising young during the following breeding season (ELA 2019).

Southern Myotis are also more likely to be able to find alternative habitat simply because their colony sizes are much smaller and there are therefore a larger number of potential roosting sites available across the landscape. There are several maternity colonies of Southern Myotis known from within 10 km of Balickera Tunnel and it is likely that individuals roosting in Balickera Tunnel will be aware of and potentially move between these roosts throughout the year. At least one of these has capacity to accommodate an influx of between 50 and 200 Southern Myotis that may be displaced from Balickera Tunnel. Southern Myotis do show strong fidelity to maternity roosts (V. Gorecki, pers. comm.), particularly those that have been historically inhabited (ELA 2007) and it is likely that the maternity colony within Balickera Tunnel will resist relocation until there is no option to return to the tunnel once it has been completely excluded to them.

There are several known alternative roost sites for Little Bent-winged Bats within nightly foraging range (approximately 33 km) of Balickera Tunnel. These include Brookfield Tunnel, another Hunter Water tunnel which provides for the passage of the Chichester Water pipeline through a hill at Brookfield. As discussed in Section 5.4.2 above, this tunnel contained a large number of Little Bent-winged Bats at the time of survey in September 2020. The tunnel is predominantly natural rock substrate, with concrete lined sections at either end. Little Bent-winged Bats were present in numbers up to 1,000. There appeared to be capacity for this tunnel to accommodate an additional 500 to 1,000 Little Bent-winged Bats. The tunnel is of lower roosting habitat value than the Balickera Tunnel because it is shorter, brighter, more easily accessible by predators and humans, more exposed to prevailing winds and does not contain any water resources. However, Little Bent-winged Bats, Large Bent-winged Bats and Eastern Horseshoe Bats have been known to roost within this tunnel since Ecotone conducted a survey in 2000.

There two other most suitable potential alternative Little Bent-winged Bat and Large Bent-winged Bat roost sites located within 33 km of Balickera Tunnel, including the Dungog WTP tunnel and Pilchers Mountain Caves. Both sites are known to be inhabited by the two Bent-winged Bat species as well Eastern Horseshoe Bats. The M1 Tunnel is considered unsuitable as a roost for large numbers of Bent-winged Bats because of the brightness, regular human visitation, and proposal of a cycleway through the tunnel. Blue Gum Hills Derelict Mine may be a suitable alternative but this site was not able to be visited during surveys for the SIS. This site does not appear to provide roosting habitat for large numbers of Bent-winged Bats. A survey conducted at Blue Gum Hills Mine in autumn 2017 by DPI (L. Gonsalves pers. comm.) recorded less than 10 calls per night from Bent-winged Bats indicating that very few Bent-winged Bats were using the site as roosting habitat.

Pilchers Mountain Caves have historically been a roost site for Bent-winged Bats but a collapse within the caves has led to uncertainty over the continued presence of roosting bats and was not able to be visited as part of this assessment. A recent ultrasonic survey conducted outside the entrance to the caves in April 2021 by Corymbia Ecology recorded Little Bent-winged Bats, Eastern Horseshoe Bats and some Large Bent-winged Bat calls indicating all three species continue to roost within the caves. The author has no further knowledge of the capacity of this roost site to accommodate additional Little Bent-winged Bats, but it is likely that there is space for a significant number of bats within the cave system. The cave could perhaps accommodate in the order of 500 – 1,000 individuals. The caves have historically been subject to periodic disturbance by cavers and scouting groups. It is unknown how often that type of human disturbance occurred or whether it continues to the present day.

Dungog WTP Tunnel, another Hunter Water owned site also provides for the passage of the Chichester Water pipeline through a hill at Dungog. As discussed in Section 5.4.2 above, this tunnel contained a large number of bats (up to 2,000), predominantly Large-Bent-winged Bats but also a smaller number of Little Bent-winged Bats at the time of survey in September 2020. The tunnel is predominantly natural rock substrate, with concrete lined sections at either end. The tunnel was partially flooded in September 2020 with approximately 10 cm of water covering the tunnel floor during survey, providing a very high humidity environment inside the tunnel. It is in a more protected location than Brookfield Tunnel, and the entrances are more secluded providing better roosting habitat for bats than Brookfield Tunnel. There appeared to be capacity for Dungog WTP Tunnel to accommodate an additional 1,000+ bats.

Whether Little Bent-winged Bats could occupy that space in a roost currently dominated by Large Bent-winged Bats is unknown.

It is presumed that the majority of bats roosting within Balickera Tunnel will have knowledge of alternative roost sites and that an amount of roost switching occurs from time to time by a portion of the population. It is therefore reasonable to assume that given the opportunity to relocate under optimal conditions, Bent-winged Bats roosting in Balickera Tunnel will be able to navigate safely from Balickera Tunnel to alternative roosts. What is unknown is how well, and how soon large numbers of Little Bent-winged Bats displaced en masse from Balickera Tunnel will be able to be assimilated into the local network of alternative roosts sites. The strategy of carefully excluding all bats from Balickera Tunnel prior to remediation works is considered to represent the lowest risk to the population of bats roosting in Balickera Tunnel as it relies on the natural instincts and ecology of the affected species. This strategy also requires a single direct disturbance event, artificially restricting access to the roost. Evolutionarily, microbats will occasionally experience the loss of a roost site quite suddenly under natural circumstances such as via bushfire, flood, rock fall or tree fall and it is expected that they will have strategies to cope with this eventuality.

#### *6.14.3.2 Staging of works so half the tunnel remains open to bats*

The option of staging works so that only half the tunnel is being worked upon at a time was considered to be the leading strategy for minimising impacts to bats prior to detailed discussions with Hunter Water on the implications of a staged approach to the works program. This option removes the risk involved in attempting to exclude all bats from the tunnel in order to conduct works. In order for this strategy to be successful, the impacts to bats that continue to roost within the tunnel during works has to be managed and minimised to an acceptable level. There must be some certainty that residual impacts to bats roosting in the tunnel during works will carry less risk than the strategy of excluding all bats from the tunnel.

Personnel are currently not permitted to enter the tunnel for safety reasons due to the condition of the tunnel and risk of rock fall. Therefore, all works must be undertaken working from the outer ends of the tunnel working towards the middle with personnel positioned behind specialist, supported tunnelling machinery. As such, it would be very difficult and pose a safety risk to personnel to access the central tunnel area and install, and maintain a curtain or barrier dividing the tunnel into a works area and a bat roosting area for the duration of works.

If a central curtain / barrier could be installed and works were staged so that only half the tunnel was an active work site at any one time, the proposal would take twice as long, estimated to increase from a 4-5 month period to a 10-12 month period including mobilisation and demobilisation. Because it is not possible to have the tunnel and canal offline for that length of time, the works would need to be carried out across a minimum two year period, with the tunnel offline for at least 4-5 months each time. This effectively means that the roost would be subject to a longer period of disturbance and that the disturbance to roosting bats would occur across multiple years.

It is also unknown whether or not bats would continue to roost within the open half of the tunnel throughout the active works given the high levels of disturbance that will be felt by the bats despite the inclusion of a curtain / barrier screening off the active works area. Therefore, there is a risk that this staged approach would result in the entire tunnel being unsuitable as a roost site for bats. In the experience of the author, the condition of bats can decrease during significant and prolonged disturbance events at roost sites, such as would occur during major construction / tunnel remediation works, placing them at greater risk of mortality. The noise and vibrations associated with tunnel remediation works will be extensive and involve industrial scale drilling into the rock substrate 24 hours a day for several months followed by pumping and spraying shotcrete.

The author has recorded colonies of Southern Myotis exposed to significant and prolonged disturbance in the form of construction activity in proximity to the roost, with increased parasite loads when compared to those unaffected by significant and prolonged disturbance. Bats from the affected colony were more easily agitated, quicker to become alert and active and emitted more social calls upon disturbance and were more prone to death upon capture during this period (ELA 2007). As in most animal species, high levels of stress, caused in this case by significant and prolonged disturbance outside the roost, lead to an increased risk of mortality.

As described above, there is a risk to the long-term health and life expectancy of bats that continue to roost within the tunnel during works. The author has observed multiple cases of bats continuing to roost in known and historical roosts despite high levels of disturbance. If this occurred at Balickera it is possible that upwards of 5,000 Little Bent-winged Bats could suffer from reduced fitness as a result.

For the reasons outlined above it was considered that there would be greater risks to bats and a higher level of uncertainty involved in staging the works so that half the tunnel remained open to bats rather than from excluding all bats from the tunnel prior to commencing works.

#### *6.14.3.3 Works across multiple years*

The option of completing the remediation works over multiple shorter periods (e.g. one – two months) over several seasons or years was also investigated. This was not considered a preferred option due to the potential for repeated stress and disturbance events over multiple years having a more significant impact on the local bat populations. Repeated disturbances are listed as a threat to the integrity of roosts for Little and Large Bent-winged Bats (DPIE 2021). This strategy is likely to cause a complete abandonment of the tunnel as a suitable roost because of repeated disturbance events. There are numerous examples of Bent-winged Bat roosts within cave systems being abandoned not long after cave tours were initiated.

## 6.15 Preferred option

The proposed approach of a single, full bat exclusion of Balickera Tunnel conducted during summer has been selected as the preferred option for the following reasons:

- Least number of threatened bats potentially injured or killed as a result of the exclusion process
- Minimum total number of bats present during this period, further reducing the risk of injury or harm to bats during the exclusion process.
- Active season for all bats with individuals more likely to survive disturbance / exclusion.
- A greater amount of alternative roosting habitat is available and can be made available for Southern Myotis than for either Bent-winged Bat species.
- Several of the suitable alternative roost sites within nightly flight range of the tunnel have capacity to accommodate the entire Southern Myotis colony (Grahamstown Drain, Clarencetown Bridge), as well as the newly created roost site using bat boxes beneath the Pacific

Highway bridge over Balickera Canal. It will require a number of the alternative roost sites to accommodate the Bent-winged Bats excluded from Balickera Tunnel, raising the risk of further harm, injury or death as bats fly further between alternative roosts to locate a roost with capacity.

- Southern Myotis more readily known to take up and breed in alternative habitat options in large numbers than Bent-winged Bats
- Ability to schedule works to partly avoid Southern Myotis breeding events.
- Allows remediation works to proceed quickly and reduces amount of time canal and tunnel are offline and unavailable to bats

# 7. Ameliorative measures

## 7.1 Measures to avoid

Ancillary infrastructure required for the tunnel remediation such as access tracks and site compounds has been designed to avoid impacts to native vegetation wherever possible by utilising existing access tracks and cleared areas.

The preferred strategy for minimising impacts to roosting bats as a result of tunnel remediation works relies upon a single, full bat exclusion of Balickera Tunnel. In this way risks of impacts to bats during works are avoided and instead reduced to a single event represented by the exclusion. If no bats are roosting within the tunnel during works, there will be no risk of injury or death to bats as a result of the proposal.

Careful scheduling and staging of the exclusion to coincide with the period of lowest occupancy over summer will avoid impacting bats during the peak period of occupancy over winter when all bats are less able to survive given limited availability of insect food resources. Although an exclusion conducted during April would also achieve this outcome it has been argued above that an April exclusion could potentially result in injury or death to a greater number of threatened bats because there are more Little Bent-winged Bats present during April and the population that uses the tunnel represents a greater proportion of the total population in Australia. It is acknowledged that an April exclusion would reduce the risk of injury and death to Southern Myotis and would not impact upon a breeding season

The tunnel will be available for habitation by bats once remediation works are completed.

The proposal will involve permanent changes to the structure of roosting habitat within the tunnel. A layer of shotcrete will be applied to the concrete lined sections including the vertical holes used as roosting and breeding habitat by Southern Myotis and as roosting habitat by Little and Large Bent-winged Bats. Some areas of Little and Large Bent-winged Bat roosting habitat located on the natural rock surfaces will also be permanently changed through the application of shotcrete and additional rock bolting.

The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts.

A microbat management plan (MMP) has been prepared and is included in Appendix J. The MMP details actions required to be implemented prior to, during and after completion of remediation works to minimise impacts to all bat species that roost within the Balickera Tunnel. The MMP includes the methods by which the exclusion will be undertaken and specifies the provisions for documenting the location and measurements (area, contouring) of roosting habitat within the tunnel that must be preserved or recreated, where impacts cannot be avoided.

## 7.2 Mitigation measures

### 7.2.1 General mitigation measures for biodiversity

Mitigation measures designed to minimise biodiversity impacts of the proposal are detailed in Table 7-1.

**Table 7-1: Biodiversity mitigation measures for the proposal**

| Potential Impacts | Safeguards/Mitigation Measures | Responsibility |
|---|---|---|
| General biodiversity measures | Implement all environmental controls outlined in the project Review of Environmental Factors (REF).<br>Prepare a Construction Environmental Management Plan (CEMP) prior to any construction works to address measures to be adopted to minimise impacts on the environment as a result of the construction works.<br>Pre-works briefing to be undertaken by Hunter Water environmental representative, advising of sensitive areas and relevant safeguards for these areas. | Project Manager<br>All Staff/Contractors |
| Microbats within tunnel | Implement Microbat Management Plan (Appendix J). | Project Manager<br>Project Ecologist<br>All Staff/Contractors |
| Damage to vegetation that is not proposed for removal | Extent of works for access track upgrades to be clearly demarcated prior to works to avoid damage to vegetation not proposed for removal<br>No-go zone to be fenced in potential *Pterostylis chaetophora* habitat near upstream portal (shown on Figure 7-1). | Project Manager<br>All Staff/Contractors |
| Impacts to wildlife<br>Injured or orphaned wildlife | The CEMP must include requirement for a qualified ecologist to be present for preclearance surveys of native vegetation for access track upgrades.<br>The CEMP must include instructions for dealing with orphaned or injured native animals and include the contact details for the NSW Wildlife Information, Rescue and Education Service Inc (WIRES). | Project Manager<br>Project Ecologist<br>All staff/Contractors |
| Spread of weeds / pathogens | Wash down all equipment and vehicles prior to entry and before leaving site, to manage the introduction and spread of weed propagules. | Project Manager<br>All Staff/Contractors |

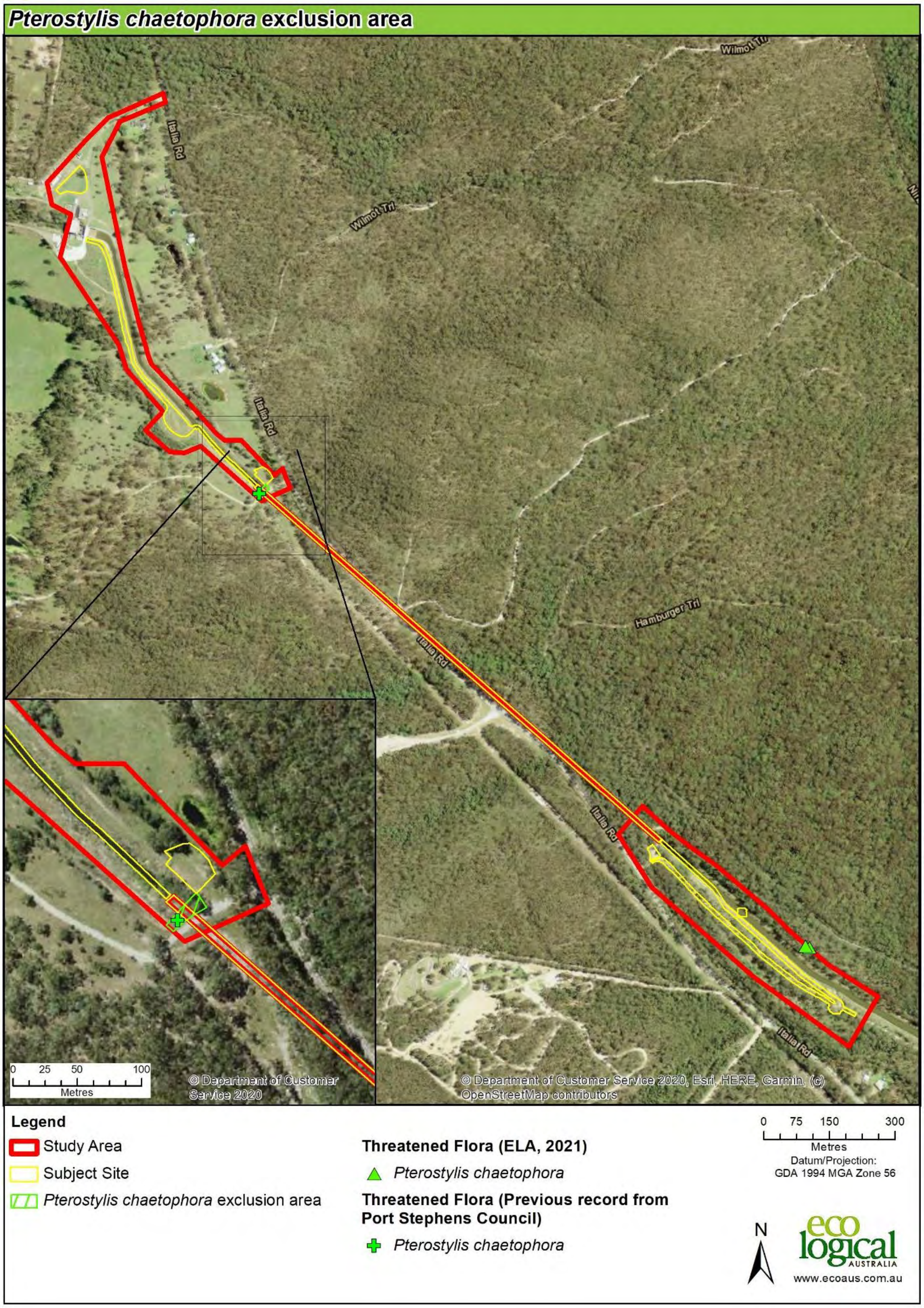



**Figure 7-1:** ***Pterostylis chaetophora*** **exclusion area**

### 7.2.2 Microbat specific mitigation measures

A microbat management plan (MMP) has been prepared which includes actions to be undertaken before, during and after completion of the remediation works (Appendix J) to ameliorate impacts to bats. It includes information on the provision of suitable alternative habitat in the form of bat boxes for Southern Myotis.

A comprehensive monitoring plan incorporating before, after, control and impact studies has been prepared and is included in the MMP in Appendix J. Monitoring of microbat species presence, activity levels, emergence behaviour, and the number of bats present at both the tunnel and alternative roost sites / control sites prior to, during and following completion of remediation works will assist in evaluating the success of the preferred strategy and MMP and may improve the options for protecting and conserving microbat habitat in the future.

Key aspects of the MMP include:

- installation of compensatory habitat for Southern Myotis prior to commencing works
- pre exclusion surveys of the tunnel, bat boxes and alternative roost sites / control sites
- timing of exclusion to reduce impacts to bats
- progressive and staged exclusion of each tunnel portal in conjunction with radio tracking of excluded bats and monitoring of the tunnel and alternative roost sites / control sites
- post exclusion release of bats from the tunnel prior to approval to commence works
- installation of double barrier system to keep bats out of the tunnel during works
- daily checks of the exclusion devices during works
- post exclusion monitoring throughout construction period of tunnel, bat boxes and alternative roost sites / control sites
- avoidance of impacts to main roost sites (two cluster sites on natural rock and 39 roost sites in vertical cylindrical 20 cm diameter holes in concrete lined sections), where possible
- where impacts to roost sites cannot be avoided, they will be recreated using shotcrete and signed off by the project ecologist
- availability of at least 75% of existing roosts in original form or as recreated habitat following completion of works
- post construction monitoring of the tunnel, bat boxes and alternative roost sites / control sites for a period of two years post construction
- ongoing operational monitoring of Balickera Tunnel, Brookfield Tunnel and Dungog WTP Tunnel every second year for eight years following completion two year post construction monitoring, reverting to every five years thereafter.

These aspects of the MMP are summarised in Table 7-2 below.

**Table 7-2. Summary of management actions from MMP**

| Management Measures | Details | Timing |
|---|---|---|
| **Pre exclusion** | | |
| Compensatory habitat | Install 10 x bat boxes for Southern Myotis | Spring and at least one month prior to commencing exclusion |
| Pre-exclusion survey – baseline alternative roosting habitat | Diurnal visual, emergence, thermal camera and ultrasonic surveys | Spring and summer prior to exclusion, once per season if works are delayed |
| Pre-exclusion survey – bat box inspection | Visual diurnal bat box inspection | Day prior to commencing exclusion |
| Pre-exclusion survey - tunnel | Emergence, thermal camera, ultrasonics and emergence survey at tunnel entrances | Night before commencing exclusion |
| Pre-exclusion survey – other sites | Ultrasonic monitoring of alternative roost sites and bat boxes | Conducted in parallel to exclusion stage 1 and stage 2 |
| **Exclusion** | | |
| Stage 1 exclusion (downstream portal) | Emergence survey, progressive installation of exclusion devices over nights 2 - 5 | 30 mins prior to sunset until activity reduces to pre-determined levels each night of exclusion then nightly progressive closure of curtains |
| Stage 1 exclusion – bat box inspection | Visual diurnal bat box inspection | Daily during exclusion |
| Stage 1 exclusion | Pre-dawn survey | Morning after final closure of exclusion device |
| Stage 2 exclusion (upstream portal) | Emergence survey, progressive installation of exclusion devices over nights 2 – 6 | 30 mins prior to sunset until activity reduces to pre-determined levels each night of exclusion then nightly progressive closure of curtains |
| Stage 2 exclusion – harp trapping and radio tracking | 1-2 nights of harp trapping to fit radio transmitters | When upstream portal is greater than 50% closed but not on the final closure night |
| Stage 2 exclusion – radio tracking of bats | Track bats for at least four hours following attachment of transmitters on first night, then daily roost search and nightly fixes for three hours post emergence | From night that transmitters are attached until battery fails |

| Management Measures | Details | Timing |
| --- | --- | --- |
| Stage 2 exclusion – bat box inspection | Visual diurnal bat box inspection | Daily during exclusion |
| Stage 2 exclusion | Pre-dawn survey at upstream portal and downloading of ultrasonic detector | Morning after final closure of exclusion device |
| **Post exclusion** | | |
| Post-exclusion surveys - other sites | Emergence surveys with thermal cameras at Brookfield, Pilchers, Dungog WTP, diurnal visual inspections of Twelve Mile Creek, Grahamstown Drain, Clarencetown Bridge or culverts | Day and evening after full exclusion and daily for 7 days or until radio tracking ceases, whichever is the longer |
| Post exclusion surveys – tunnel releases | Targeted partial opening of exclusion device at upstream portal to release any bats still roosting in tunnel and download ultrasonic detector, thermal camera recording | Between sunset and approx. 45 minutes after sunset, on evenings 1 – 5 in suitable weather following complete exclusion |
| Post exclusion surveys – bat box inspection | Visual diurnal bat box inspection | Daily during post exclusion period until no bats remain in tunnel |
| Post exclusion surveys – Tunnel Inspection Platform TIP) | Diurnal run of tunnel inspection platform to check for roosting bats | On the advice of the ecologist, proposed to be approx. one week after full exclusion of the tunnel |
| Post exclusion surveys – tunnel release and TIP | Repeat of the above three steps if bats are found roosting in the tunnel following the TIP run | Immediately following TIP run for up to five nights |
| **Pre-construction** | | |
| Annexe and double barrier install | Install annexe effecting a double barrier system prior to commencement of works | Once all bats have been cleared from the tunnel |
| **Construction** | | |
| Construction monitoring - tunnel | Inspect exclusion devices, monitor bat activity levels using ultrasonic detectors and email results to project manager | One week following declaration that the tunnel is bat free, during the first week of tunnel remediation works, monthly during tunnel remediation works, four nights ultrasonic recording |

| Management Measures | Details | Timing |
| --- | --- | --- |
| Construction monitoring – other sites | Ultrasonic monitoring of alternative roost sites and bat boxes | Conducted in parallel to tunnel monitoring, one week following bat free declaration, during the first week of construction then monthly throughout construction, four nights ultrasonic recording and single visual diurnal bat box inspection each monitoring event. |
| CONTINGENCY PLAN IF REQUIRED: Tunnel release of bats during construction | Targeted partial opening of exclusion device at upstream portal to release any bats still roosting in tunnel and download ultrasonic detector, thermal camera required | Between sunset and approx. 45 minutes after sunset, nightly in suitable weather conditions until all bats have left the tunnel. |
| Daily works inspection | Inspect exclusion devices twice daily and inform project ecologist if action required | Twice daily during works, early am and no later than 1 hour before sunset |
| Remove exclusion devices | Remove exclusion devices to allow access to bats | Immediately following demobilisation of site |
| **Post construction** | | |
| Post-construction monitoring | Monitor activity levels at tunnel, key alternative roost sites and in bat boxes after construction finishes as directed in MMP | Within one month after tunnel open to bats and then quarterly for two years |
| Ongoing operational monitoring | Biennial monitoring of the microbat colony in the tunnel, and at Brookfield and Dungog WTP Tunnels | Four nights ultrasonic recording at each tunnel portal each season, 1 night thermal camera recording at each tunnel portal each season, single diurnal bat box inspection each season, single night harp trapping at each tunnel portal during autumn, single paddle through / walk through / TIP during May or June and December or January |

# 8. Compensatory strategies

## 8.1 Proposed measures to offset residual impacts

### 8.1.1 Provision of alternative habitat for Southern Myotis

In order to provide alternative roosting habitat for Southern Myotis as close as possible to Balickera Tunnel it is proposed that ten x four chambered bat boxes, capable of housing up to 200 Southern Myotis be installed beneath the Pacific Highway Bridge over Balickera Canal, approximately 950 m downstream of the tunnel. During regional surveys for alternative habitat the bridge was inspected visually from below and did not contain suitable roosting habitat. Ultrasonic surveys of this site conducted in January 2021 recorded many Southern Myotis calls indicating that the canal is both a commuting route and foraging habitat for Southern Myotis moving between the tunnel and Grahamstown Dam. Guidelines for the installation, monitoring and maintenance of these boxes are included within the MMP in Appendix I.

### 8.1.2 Provision of funds to offset the loss of roosting habitat

Despite the suite of amelioration and mitigation measures proposed, the success of the temporary exclusion and post works habitation of the tunnel by Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis contains an element of risk. An exclusion of Little Bent-winged Bats or Large Bent-winged Bats on this scale has not been attempted before, although there are examples of smaller scale temporary exclusions of these species being conducted with positive results. Hunter Water have agreed to set aside funds to offset the loss of microbat roosting habitat, if it should eventuate that the bats do not return to the tunnel within a set period of time.

Under the current BC Act Biodiversity Offset Scheme, there is no provision for calculating the value of offsets for 'prescribed impacts' such as to threatened microbat roosting or breeding habitat within artificial structures like Balickera Tunnel. A suitable method for calculating the financial value of the offset will need to be agreed upon by Hunter Water, DPIE and the project ecologist. There is potential for offset funds to contribute to the management and conservation of maternity roost sites identified under the SoS program, or to direct funding into a research project that aims to address identified critical actions for the affected species.

### 8.1.3 Biodiversity Offsets Scheme

In accordance with Section 7.1.2 of the CERs, offsets required to compensate for the residual direct impacts of the proposal have been calculated in accordance with the Biodiversity Assessment Method (BAM). The residual impacts to native vegetation for the project have been calculated using the BAM Credit Calculator (BAM-C) using plot and transect data collected as part of the field studies for this SIS.

The required offset will be achieved by retiring all credits as calculated by the BAM-C in accordance with the Biodiversity Offsets Scheme under the BC Act. It is likely this will be achieved through payment into the Biodiversity Conservation Fund. The credit summary is provided in Section 8.1.4.

#### *8.1.3.1 Operation of the BAM Calculator*

Details of the inputs made into each section of the BAM-C are provided below. Landscape features are outlined in Table 8-1, native vegetation data is included in Table 8-2 to Table 8-6, and threatened species assessment is included in Table 8-7.

**Table 8-1: Landscape features assessment within the BAM-C for the subject site**

| Landscape feature | Data entered into BAM-C |
|---|---|
| IBRA bioregions and subregions | NSW North Coast, Karuah Manning |
| Mitchell Landscape | Newcastle Coastal Ramp |
| % Native vegetation cover in landscape | 90% (highest category) |
| Rivers and streams present | Balickera Canal |
| Linear Development | No |
| Method applied | Site based assessment |

**Table 8-2: Native vegetation assessment within the BAM-C for the subject site**

| Formation | Class | Plant Community Type | PCT % Cleared | Associated TEC |
|---|---|---|---|---|
| Dry Sclerophyll Forests (Shrub/grass sub-formation) | Hunter-Macleay Dry Sclerophyll Forests | 1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast | 56 | Not a TEC |

**Table 8-3: Plot locations and zones**

| Plot | PCT | Veg Zone | Patch size | Area (ha) | Zone | Easting | Northing | Bearing |
|---|---|---|---|---|---|---|---|---|
| Plot 1 | 1588 | 1588_Good | 101 | 0.05 | 56 | 388585 | 6383802 | 135 |

**Table 8-4: Plot composition and structure data**

| Data type | Tree | Shrub | Grass | Forb | Fern | Other |
|---|---|---|---|---|---|---|
| Composition score | 2 | 8 | 6 | 10 | 2 | 7 |
| Structure score | 35.2 | 0.9 | 2.5 | 1.2 | 1.1 | 0.7 |

**Table 8-5: Plot Function data**

| Plot | PCT | Large trees | Hollow-bearing trees | Litter Cover | Fallen Logs | Tree (5 - 10 cm) | Tree (10 - 20 cm) | Tree (20 - 30 cm) | Tree (30 - 50 cm) | Tree (50 - 80 cm) | Regen (dbh <5cm) | High threat exotic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot 1 | 1588 | 0 | 0 | 53 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 8.0 |

**Table 8-6: Vegetation integrity scores (current and future)**

| | Vegetation zone | Area (ha) | Composition | Structure | Function | VI Score | Change | Total Loss |
|---|---|---|---|---|---|---|---|---|
| Current VI Score | 1588_Good | 0.05 | 76.6 | 19.6 | 43.9 | 40.4 | | |
| Future VI Score | 1588_Good | 0.05 | 0 | 0 | 0 | 0 | -40.4 | -40.4 |

**Table 8-7: Threatened species assessment within the BAM-C for the subject site**

| Threatened species criteria | Data input into BAM-C |
|---|---|
| Habitat suitability: Predicted (Ecosystem Credits) | All affected species added to predicted species list |
| Habitat suitability: Candidate (Species Credits) | Barking Owl, Masked Owl and Powerful Owl removed due to absence of hollow-bearing trees from subject site.<br>Green-thighed Frog (*Litoria brevipalmata)* (habitat too degraded - no suitable habitat or records in locality) |
| Habitat survey | Surveys undertaken as per Section 4 of this SIS.<br>Results as per Section 5 of this SIS.<br>White-bellied Sea-Eagle: Yes (surveyed). Present due to pair duetting during breeding season.<br>Koala: Yes (assumed present). Present due to high number of records and suitable habitat.<br>Green and Golder Bell Frog: No (surveyed).<br>Little Bent-winged Bat (breeding): No (surveyed)<br>Large Bent-winged Bat (breeding): No (surveyed)<br>Southern Myotis: Yes (surveyed).<br>*Pterostylis chaetophora*: No (surveyed). Not present within subject site. |

### 8.1.4 Credit summary

The number of ecosystem credits required for the proposal are outlined in Table 8-8. The number of species credits required for the proposal are outlined in Table 8-9. A biodiversity credit report is included in Appendix G.

**Table 8-8: Ecosystem credits required**

| PCT ID | PCT Name | Vegetation Formation | Direct impact (ha) | Credits required |
|---|---|---|---|---|
| 1588 | Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast | Dry Sclerophyll Forests (Shrub/grass sub-formation) | 0.05 ha | 1 |

**Table 8-9: Species credit summary**

| Species | Common Name | Direct impact habitat (ha) | Credits required |
|---|---|---|---|
| *Myotis macropus* | Southern Myotis | 0.05 ha | 1 |
| *Haliaeetus leucogaster* | White-bellied Sea-Eagle | 0.05 ha | 1 |
| *Phascolarctos cinereus* | Koala | 0.05 ha | 1 |

## 8.2 Measurement of the adequacy of offsets

Operation of the BAM-C was undertaken by BAM Accredited Assessor Tom Schmidt (BAAS19034) in accordance with the relevant sections of the BAM (DPIE, 2020). The BAM was applied to the site in respect to calculation of the number of ecosystem and species credits required for the development in relation to direct impacts to native vegetation.

Adequacy of offsets for prescribed impacts to threatened microbat roosting or breeding habitat within artificial structures like Balickera Tunnel will be agreed upon by Hunter Water, DPIE and the project ecologist. There is potential for offset funds to contribute to the management and conservation of affected species as described in Section 8.1.2.

# 9. Conclusion and recommendations

The proposal involves remediation of the 1.2 km Balickera Tunnel in Balickera, NSW. The Balickera Tunnel is the main means to transfer water from the Williams River to Grahamstown Dam. Grahamstown Dam is the Lower Hunter Region's primary drinking water supply. The tunnel remediation works are required to ensure the Balickera Tunnel can continue operation and maintain drinking water supply. The Balickera Tunnel provides known roosting habitat for microchiropteran bats, including three threatened species:

- Little Bent-winged Bat
- Southern Myotis
- Large Bent-winged Bat.

The proposed restoration works were considered likely to have a significant impact on the threatened species known to utilise the tunnel.  In accordance with Section 7.8 (4) of the BC Act, the Hunter Water Principal elected to prepare an SIS to assess the likely significant impact on threatened species and requested CERs from OEH (now DPIE), which have guided this SIS.

Following targeted surveys and assessment of likelihood of occurrence of the initial subject species list, 12 threatened fauna species were determined as affected species for this SIS:

- Little Bent-winged Bat
- Large Bent-winged Bat
- Southern Myotis
- Eastern False Pipistrelle
- Eastern Coastal Free-tailed Bat
- Koala
- Grey-headed Flying-fox
- Little Lorikeet
- White-bellied Sea-Eagle
- Powerful Owl
- Grey-crowned Babbler (eastern subspecies)
- Masked Owl.

These species have been assessed further in this SIS which has found that there will be direct impacts (clearing) to 0.05 ha of native vegetation for modification of an existing access track and impacts to tunnel roosting microbats from roost habitat modification and temporary exclusion from the tunnel for up to 5 months. Tunnel roosting habitat will be available to microbats following completion of the remediation works.

Following consideration of alternative options, the preferred strategy for minimising impacts to roosting bats as a result of tunnel remediation works relies upon a single, full bat exclusion of Balickera Tunnel commencing during summer and persisting until autumn. This was selected as the preferred option for the following reasons:

- Least number of threatened bats potentially injured or killed as a result of the exclusion process.

- Minimum total number of bats present during this period, further reducing the risk of injury or harm to bats during the exclusion process.
- Active season for all bats with individuals more likely to survive disturbance / exclusion.
- A greater amount of alternative roosting habitat is available and can be made available for Southern Myotis than for either Bent-winged Bat species.
- Several of the suitable alternative roost sites within nightly flight range of the tunnel have capacity to accommodate the entire Southern Myotis colony (Grahamstown Drain, Clarencetown Bridge), as well as the newly created roost site using bat boxes beneath the Pacific Highway bridge over Balickera Canal. It will require a number of the alternative roost sites to accommodate the Bent-winged Bats excluded from Balickera Tunnel, raising the risk of further harm, injury or death as bats fly further between alternative roosts to locate a roost with capacity.
- Southern Myotis more readily known to take up and breed in alternative habitat options in large numbers than Bent-winged Bats
- Ability to schedule works to partly avoid Southern Myotis breeding events.
- Allows remediation works to proceed quickly and reduces amount of time canal and tunnel are offline and unavailable to bats

To reduce the impacts of the proposal, ameliorative measures will be undertaken including microbat exclusion, seasonal scheduling of works, retention of at least 75% of the roosting habitat within the tunnel (in original form and as recreated roosting habitat), installation of alternative roosting habitat and implementation of a detailed monitoring regime, all of which is detailed within the MMP.

A significant impact is likely if the recommended amelioration and mitigation measures (including exclusion of all bats from the tunnel) as set out in the MMP (Appendix J) are not implemented. Conducting tunnel remediation works without due consideration of the impacts to roosting bats can be expected to lead to reduced fitness, reduced survival, injury, illness and potentially death of a large number of Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis as a result of disturbance, exhaustion, starvation or predation.

Under the current work schedule and even following the MMP, with exclusion planned for December there is the potential for the failure of the Southern Myotis breeding events in October / November and January / February. This could equate to a loss of pups born in October (potentially up to 75 pups) if they are unable to fly at the time of exclusion, and abortion of pregnancies of a further 75 pups due to be born in January / February. This loss could be minimised by conducting the exclusion as late as possible in December and providing alternative roosting habitat for Southern Myotis as close as possible to the tunnel. It is not possible to avoid impacts to all species of bats inhabiting the tunnel as there are conflicting optimal time periods to conduct an exclusion for the different species of bat present.

Southern Myotis will readily inhabit and breed in bat boxes if installed in suitable locations. Bent-winged Bats are not known to inhabit bat boxes in large numbers. There are fewer Southern Myotis within the tunnel than the other two species. There are at least three Southern Myotis maternity roosts within nightly flight range of the tunnel that could provide additional alternative roosting habitat. The potential loss of approximately 155 Southern Myotis (including five adults, 75 pups from the first breeding event of the summer and 75 unborn pups from the second breeding event if stress causes mothers to abort), is considered to be more easily recovered from by local populations of Southern Myotis than would the loss of hundreds or more adult Bent-winged Bats if the exclusion is carried out at a time when a greater number of Bent-winged Bats were present.

The temporary unavailability of important roosting habitat for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis, as well as breeding habitat for Southern Myotis during the proposed period of microbat exclusion poses a residual, but reduced risk of death / injury to bats in comparison to the level of risk associated with the proposal being undertaken without microbat exclusion. Bats displaced from important roost sites must find alternative roost sites that are not already at capacity within nightly flight range of the excluded roost. Several alternative Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis roosts have been located within, or at the limit of the nightly flight range of these three bat species and it has been recommended that monitoring of these alternative roost sites occurs prior to, during and post exclusion of bats from the tunnel.

Despite the suite of amelioration and mitigation measures proposed, the success of the temporary exclusion and post works habitation of the tunnel by Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis contains an element of risk. As such, this SIS concludes, on the basis of the precautionary principle, that the proposal is likely to have a significant impact on the three threatened bat species known to utilise the tunnel. An exclusion of Little Bent-winged Bats or Large Bent-winged Bats on this scale has not been attempted before, although there are examples of smaller scale temporary exclusions of these species being conducted with positive results. Hunter Water have agreed to set aside funds to offset the loss of microbat roosting habitat, if it should eventuate that the bats do not return to the tunnel within a set period of time. Under the current BC Act Biodiversity Offset Scheme, there is no provision for calculating the value of offsets for ‘prescribed impacts’ such as to threatened microbat roosting or breeding habitat within artificial structures.

For the affected species which do not use tunnel habitat, the proposal would result in direct impacts to 0.05 ha of foraging habitat and potential indirect impacts from noise, dust and lighting during works. Due to the small impact area and large surrounding areas of similar habitat which will be retained, the proposal is considered unlikely to result in a significant impact to these species.

The BAM-C was operated to calculate an adequate offset which provides for sufficient habitat to compensate for impacts to threatened species associated with impacts to native vegetation. One ecosystem credit and three species credits are required. The offset will be secured in accordance with the requirements of the BC Act.

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# Appendix A Chief Executive's Requirements for Proposed Balickera Tunnel Stability Works Program

## ATTACHMENT A:

### CHIEF EXECUTIVE'S REQUIREMENTS FOR PROPOSED BALICKERA TUNNEL STABILITY WORKS PROGRAM

The purpose of a Species Impact Statement (SIS) is to:

- allow the applicant or proponent to identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the proposal
- assist consent and determining authorities in the assessment of a request for Part 5 approval under the *Environmental Planning and Assessment Act 1979* (EP&A Act)
- assist the Chief Executive of Office of Environment and Heritage (OEH) in deciding whether or not concurrence should be granted for the purposes of Part 5 of the EP&A Act
- assist the Chief Executive of OEH or the Minister for the Environment when consulted for the purposes of Part 5 of the EP&A Act

### DEFINITIONS

The definitions given below are relevant to these requirements:

- ***abundance*** means a quantification of the population of the species or community
- ***activity*** has the same meaning as in the EP&A Act
- ***affected species*** means subject species likely to be affected by the proposal
- ***conservation status*** is regarded as the degree of representation of a species or community in formal conservation reserves
- ***development*** has the same meaning as in the EP&A Act
- ***Chief Executive*** means the Chief Executive of the Office of Environment and Heritage
- ***DP*** means *Deposited Plan* which is the **plan** number given to a subdivision that is registered by the Land Property Information
- ***LGA*** means local government area
- ***locality*** means the area within a five (5) kilometre radius of the study area.
- ***significant species*** means species not listed in the *Biodiversity Conservation Act 2016* (BC Act) but considered to be of regional or local significance
- ***study area*** is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.
- ***subject site*** means the area which is proposed for development/activity
- ***subject species*** means those threatened and significant species and ecological communities which are known or considered likely to occur in the study area
- ***threatening process*** has the same meaning as that contained in the BC Act; the definition is not limited to key threatening processes.

All other definitions are the same as those contained in the BC Act.

### MATTERS TO BE ADDRESSED

The BC Act provides that the SIS must meet all the matters specified in section 7.20 of the Act and any additional requirements in the Biodiversity Conservation Regulation 2017 (BC Regulation). The requirements outlined in the BC Regulation have been repeated below (italics) along with the specific CERs for your proposal. Previous surveys and assessments that are relevant to the locality may be used to assist in addressing these requirements.

Section 7.21 (1) of the BC Act states that an applicant must comply with the CERs concerning the form and content of the SIS. Failure to fully comply with the CERs is therefore a potential breach of the legislation, and may result in OEH being unable to grant concurrence to a request by the consent authority to carry out the activity. Accordingly, the SIS must be formatted to follow the sections and subsections provided in the CERs.

# 1 FORM AND CONTENT OF THE SPECIES IMPACT STATEMENT

*1.1 A species impact statement for the purposes of this Part must be in writing signed by the principal author of the statement and by the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires). (s7.20(1))*

The applicant or proponent must sign the following declaration:

> "I… [insert name], of ...[address], being the applicant for the development…[insert Lot & DP numbers, street, suburb and LGA names] have read and understood this species impact statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the proposal".

# 2. CONTEXTUAL INFORMATION

## 2.1 Description of proposal, subject site and study area

*A species impact statement must include a full description of the proposed development or activity and the information as to matters relating to the impact on threatened species or ecological communities as is required by the regulations. (s7.20(2))*

### 2.1.1 Description of the proposal

A full description of the action includes a description of all associated actions, including, but not restricted to: - location of all lots / building envelopes, installation and maintenance of any proposed buildings / dwellings and associated structures, the proposed number and size of such lots, buildings / dwellings and associated structures, location of any associated facilities (including roads, amenities and other services), fire protection zones, access and egress routes, changes in surface water flows, impacts of noise disturbance and pollution, and any increases in people and road traffic. Actions that occur both on and off the subject land as a result of the proposal must be assessed; including actions conducted during any construction phase and any proposed action post-construction (e.g. proposed actions within a management plan).

### 2.1.2 Definition of SIS study area

The SIS study area must be defined. The study area will generally be larger than the development site as it includes any adjacent areas that will be directly or indirectly affected by the proposal. In defining the study area consideration shall be given to possible indirect effects of the proposed action on the area surrounding the subject site, for example habitat fragmentation, vegetation corridors, altered hydrology regimes, soil erosion, pollution, and increased human presence or associated impacts. These may include adjacent parcels of land containing suitable habitat for threatened species. It is therefore important to recognise that these parcels may need to be investigated along with the development site. The location, size and dimensions of the study area shall be provided. In describing the study area, the SIS must consider cumulative impacts, such as additional known or proposed development adjacent to the works subject to this proposal.

The study area should be established before the list of likely impacted threatened species and ecological communities (including their habitat) is determined so species etc. that are less obviously affected are also included. The study area must be clearly defined, marked on a geo-referenced map / aerial photograph (or equivalent), clearly showing the development site boundary and any additional areas facing indirect impact, and included in the final report.

Direct impacts are those that directly affect individuals or their habitat. Examples of direct impacts include:

- poisoning or removal of the organism itself
- removal of habitat
- clearing of native vegetation / habitat

If the proposal involves the clearing of vegetation and removal / damage to habitat the environmental assessment must clearly articulate the size of this impact, and where applicable delineate this based on vegetation / habitat type.

Indirect impacts occur when project-related activities affect species or ecological communities in a manner other than direct loss. Examples of indirect impacts include (but not limited to):

- sediment, pollutant or nutrient runoff into adjacent vegetation
- habitat fragmentation or isolation
- implementation of asset protection zones (*though these may also represent direct impact)
- loss of genetic diversity of threatened species or communities
- altered pollination syndromes that may adversely affect seed set
- soil erosion
- altered hydrology regimes (including downstream impacts)
- changes to the saline / freshwater balance in marine environments
- exposure to heat or predators, or loss of shade
- inhibition of nitrogen fixation
- weed invasion and feral animal incursion
- introduction and spread of pathogens, such as Dieback fungus (*Phytophthora*) and Myrtle Rust (*Uredo rangelii*)
- noise
- dust
- light pollution (i.e. increasing skyglow from uncontrolled urban uplight)
- fire (such as changes to intensity and frequency)
- fertilizer drift
- increased human activity (including litter) within or directly adjacent to sensitive habitat areas.

Indirect impacts should not be just limited to the terrestrial habitats. In instances where a development site adjoins marine, estuarine and riparian / riverine environs / habitat, impacts on these must be considered.

<u>Note</u>: Indirect impacts may lead to direct loss, and as such must be adequately quantified and assessed. Both impacts within the proposed development footprint and on adjacent / surrounding lands must be considered, and where appropriate adequately considered and addressed.

### <u>2.1.3 Description of SIS study area</u>

The description of the study area must include (but not limited to):

- The vegetation communities (Plant Community Types [PCTs]) and habitat types, including identification of the classification system used in the SIS. Details of the methodology adopted to delineate vegetation communities on site (e.g. random stratified sampling). Full floristic description of all vegetation communities present (including disturbed and undisturbed). A listing of the amount (in hectares) of each vegetation community in the study area. A geo-referenced map / aerial photograph (or equivalent) showing the location of the vegetation communities. A full floristic list in tabular format of all taxa (both native and exotic) recorded on the subject site, indicating which communities they occur in, their cover / abundance and frequency, conservation (including taxa of conservation significance) and comparisons to previous vegetation studies / mapping (if applicable);
- An examination of previous land uses and events, and the effect of these land uses and events on the study area. Examples of such land uses and events are clearing, timber felling, draining, recreational use and agricultural activities (including grazing);
- An examination of the fire history, or at least the time since the last fire, for the subject site is to be provided. Ideally, information on the frequency, season and intensity of fire events on the subject site will be provided. To adequately address this requirement, it may be necessary to consider fire events in the surrounding landscape;
- The local government land zoning and any proposed rezoning, and an examination of the degree of protection that current zoning and any proposed rezoning provides or will provide to native vegetation and threatened species and ecological communities on the subject site and in the study area and the locality;

- The land tenure and any proposed changes (e.g. acquisition by OEH as a nature reserve, national park, regional park etc.), and an examination of the degree of protection that current land tenures and any proposed land tenures provides or will provide to native vegetation and threatened species in the study area;
- Cumulative impacts of surrounding development, both known and proposed.
- State Environmental Planning Policies (e.g. State Environmental Planning Policy (Coastal Management) 2018, SEPP 44 Koala Habitat Protection) and an examination of the degree of protection these policies provide to native vegetation and threatened species on the subject site and in the study area; and
- Relevant Local Government planning instruments, including Local Environmental Plans and Development Control Plans.

### 2.2 Provision of relevant plans and maps

A plan of the subject area, including the scale of the plan should be provided. An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph. It should be geo-referenced and show the date of the photograph.

A geo-referenced topographic map or equivalent of the subject site and immediate surrounds at an appropriate scale should be provided. This map should detail the location of the proposal and location of works on site (including areas of indirect impact). Additionally, to provide an overview of the natural landscape in the general locality, the map should show or be overlain with details of vegetated (i.e. woody [e.g. forests, woodland, shrubland and heath] and non-woody native vegetation [e.g. grassland, sedgeland and saltmarsh]) vs. cleared areas, as well as indicating the current activities/usage of this land, such as rural, agricultural, industrial and residential. OEH expects a separate map will be provided to indicate what specific vegetation communities are on subject site (as detailed above in Section 2.1.3).

A map of the locality, showing any locally significant areas for threatened species such as parks and reserves, and areas of high human activity such as townships, regional centres and major roads should also be provided. The location, size and dimensions of the study area shall be provided.

Where any biodiversity offsets are proposed, the proponent must provide OEH with a proper survey plan, prepared by a registered surveyor that clearly shows the location and boundaries of any offset land. A printed copy of each survey plan must be provided to OEH at A1 or A0 scale. The survey plan must be of a form that is acceptable to OEH. Electronic copies should also be provided.

### 2.3 Land tenure information

Information about the land tenure across the study area. Any limitations to sampling across the study area (e.g. denied access to private land) shall be noted.

## 3 INITIAL ASSESSMENT

*A general description of the threatened species known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action (clause 7.6(2)(a)).*

### 3.1 Identifying subject species

<u>3.1.1 Assessment of available information</u>

In determining these species ('the subject species'), consideration shall be given to the habitat types present within the study area, recent and historic records of threatened species in the locality and the known distribution of threatened species.

Databases such as OEH's *BioNet Atlas* (www.bionet.nsw.gov.au), *Biodiversity Assessment Method* (BAM) *Calculator* (www.environment.nsw.gov.au/biobanking/calculator.htm), *Atlas of Living Australia* (www.ala.org.au), *Australian Museum* (http://ozcam.org.au), *Birdlife Australia* (http://birdsaustralia.ala.org.au/BDRS/home.htm), and the *Royal Botanic Gardens* (http://plantnet.rbgsyd.nsw.gov.au) should be consulted to assist in compiling the list. It should be noted that if the OEH BioNet Atlas is the only database that is referred to, due to data exchange agreements, the data provided by OEH will only include that for which OEH is a custodian. In many cases, this may only be a small subset of the data available. Other databases must also be consulted to create a comprehensive list of subject species.

The following species shall be considered for inclusion in the list of subject species, as they have either been recorded in the general area (approx. 10km radius), are within the species' known geographic limits or their broad habitat preferences may be present on site:

**Threatened Species**
(* indicates species that are listed on the *Environment Protection and Biodiversity Conservation Act 1999*).

**Flora (25 taxa):**

For targeted surveys please note the following known flowering / fruiting times for each species to time surveys appropriately. Surveying at these times is required for species that are not readily detectable (or are cryptic), where flowers or fruits are necessary for their positive identification. If targeted flora surveys for these species are conducted outside a species known phenology then justification must be provided as to why; if this is not provided or considered inappropriate, then all such species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided. For species which do not require flowers / fruits for positive identification (e.g. large trees / shrubs), then survey as appropriate (though appropriate justification on methods used is still required). It is recommended to utilise known reference sites to help delineate flowering patterns and sampling timeframes. OEH can provide advice on this for some species.

Targeted flora surveys must also adequately sample / cover all suitable habitat on the study area, and utilise suitable detection techniques (as per OEH 2016) such as belt transects (at appropriate widths to spot cryptic species) or random meanders (that sufficiently cover all known / potential habitat areas [i.e. not just the tracks or readily accessible areas]). If targeted flora surveys are poorly conducted or surveyed then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.

1. **Charmhaven apple (*Angophora inopina*)*** – flowers principally between mid-December and mid-January, and also sporadically at other times outside of this period (Bell 2001a); *Angophora inopina* has been confused and probably wrongly determined in many cases as *Angophora floribunda*, principally due to both species possessing rough, fibrous bark, and appearing superficially similar in flower and fruit morphology (Bell 2001a), vegetatively it may be distinguished by its broad, coriaceous leaves with short, broad petioles, whilst its fruit tend to be larger and cup-shaped to pyriform and not as prominently ribbed (Bell 2001a).
2. **Trailing woodruff (*Asperula asthenes)**** – flowers and fruits in spring (Thompson 2009); fruits are required to separate genera Asperula and Galium (Harden 1992); flowers predominantly Oct-Nov., although sometimes seen throughout the year (Mamott 2011); decumbent herb often trailing, typically found in-between other vegetation, its trailing / twining nature is a key taxonomic feature, forms mass clumps of stems, likely vegetatively spread (clonal-like); the flowers are white, tiny and fragrant (Harden 1992), up to 6 flowers per cyme/head.
3. **Small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*)*** – flowers from July to December (Benson & McDougall 2000, Makinson 2000, Harden 2002, Fairley 2004); in the Lower Hunter, Lake Macquarie / Newcastle area flowering normally occurs annually between late September and early December (Falding 2013).
4. **Small water-ribbons (*Maundia triglochinoides*)** – flowers November to January, in the warmer months (Harden 1993, Benson & McDougall 2002); without flowering material it may be confused with the more common genus *Triglochin* (i.e. 'individual fruit dehiscing but carpels remaining fused along their central axis for most of their length, ovule pendulous, attached at the apex of ovary in *Maundia*' cf. 'individual fruit separating into carpels, ovule erect, attached

at the base of the ovary in *Triglochin*' [Aston 1971, Harden 1993]), though *Maundia* tends to have spongy inflated leaves compared to linear, flattened or terete and strap-like in *Triglochin* (Aston 1971, Harden 1993).

5. ***Pterostylis chaetophora*** – Flowers from September to November. Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Fails to flower in dry seasons.
6. **Scrub turpentine (*Rhodamnia rubescens)***
7. **Native guava (*Rhodomyrtis psidioides)***
8. **Black-eyed Susan (*Tetratheca juncea*)*** – flowers predominantly November to February, though known to flower early from June onwards (Harden 1992, Driscoll 2003); noted infrequently all year under suitable conditions, recorded in late autumn to winter in some sub-coastal populations (e.g. Awabakal NR – S. Lewer pers. comm. 2013).

**Fauna (83 species):**

For fauna species please be aware of: (i) habitat preferences and known distribution for each of the species as an indication as to whether they may occur in the study area, and (ii) the best times of year these species may be detected if subject to surveys. If animals are captured with an uncertain taxonomy, species should be forwarded to the Australian Museum by a suitably qualified scientific licence holder.

**Amphibians (9 species):**
Green and golden bell frog (*Litoria aurea*)*

**Birds (49 species):**
Magpie goose (*Anseranas semipalmata*)
Regent honeyeater (*Anthochaera phrygia*)*
Dusky woodswallow (*Artamus cyanopterus cyanopterus*)
Australasian bittern (*Botaurus poiciloptilus*)*
Bush stone-curlew (*Burhinus grallarius*)
Glossy black cockatoo (*Calyptorhynchus lathami*)
Speckled warbler (*Chthonicola sagittata)*
Spotted harrier (*Circus assimilis*)
Brown treecreeper (*Climacteris picumnus* subsp. *victoriae*)
Varied sittella (*Daphoenositta chrysoptera*)
White-fronted chat (*Epthianura albifrons*)
Black-necked stork (*Ephipporhynchus asiaticus*)
Black falcon (*Falco subniger*)
Little lorikeet (*Glossopsitta pusilla*)
White-bellied sea-eagle (*Haliaeetus leucogaster*)
Pied oystercatcher (*Haematopus longirostris*)
Little eagle (*Hieraaetus morphnoides*)
Black bittern (*Ixobrychus flavicollis*)
Comb-crested jacana (*Irediparra gallinacea*)
Swift parrot (*Lathamus discolor*)*
Hooded robin (south-eastern form) (*Melanodryas cucullate)*
Black-chinned honeyeater (eastern subspecies) (*Melithreptus gularis* subsp. *gularis*)
Turquoise parrot (*Neophema pulchella*)
Barking owl (*Ninox connivens*)
Powerful owl (*Ninox strenua*)
Blue-billed duck (*Oxyura australis*)
Olive whistler (*Pachycephala olivacea)*
Scarlet robin (*Petroica boodang*)
Flame robin (*Petroica phoenicea*)
Grey-crowned babbler (eastern subspecies) (*Pomatostomus temporalis* subsp. *temporalis*)
Wompoo fruit-dove (*Ptilinopus magnificus*)
Rose-crowned fruit-dove (*Ptilinopus regina*)
Red-backed button-quail (*Turnix maculosa*)

Masked owl (*Tyto novaehollandiae*)

**Mammals (22 species):**
Eastern pygmy-possum (*Cercartetus nanus*)
Large-eared pied bat (*Chalinolobus dwyeri*)
Spotted-tailed quoll (*Dasyurus maculatus*) *
Eastern false pipistrelle (*Falsistrellus tasmaniensis*)
Golden-tipped Bat (*Kerivoula papuensis*)
Little bent-wing bat (*Miniopterus australis*)
Eastern bent-wing bat (*Miniopterus schreibersii* subsp. *oceanensis*)
Eastern freetail bat (*Mormopterus norfolkensis*)
Southern myotis (*Myotis macropus*)
Yellow-bellied glider (*Petaurus australis*)
Squirrel glider (*Petaurus norfolcensis*)
Brush-tailed phascogale *(Phascogale tapoatafa)*
Koala (*Phascolarctos cinereus*)* only combined populations of Queensland, New South Wales and the Australian Capital Territory are listed on EPBC Act.
Grey-headed flying-fox (*Pteropus poliocephalus*)*
Greater broad-nosed bat (*Scoteanax rueppellii*)
Eastern cave bat (*Vespadelus troughtoni*)

**Endangered ecological communities**

- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions
- Lower Hunter Spotted Gum-Ironbark Forest in the Sydney Basin Bioregion
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

The above lists are not necessarily exhaustive. The applicant must carry out their own process of determining the subject species. This process should incorporate consideration of:

- the vegetation communities present within the study area
- the presence, quantity, quality and degree of fragmentation of likely habitat for individual threatened species
- recent (within the last ten years) records of threatened species and ecological communities in the locality
- the known distribution of threatened species and ecological communities
- the known and predicted use of habitat for all potential species.

OEH's *BioNet Atlas*, *Australian Museum* and *Royal Botanic Gardens* databases, the *Birds Australia* and *NSW Bird Atlas* databases (for birds) and other relevant databases should be used to assist in compiling or assessing the list.

Threatened species and ecological communities on the above list may be excluded from further consideration as subject species only if a fully documented justification, robust to external examination, is provided. This documentation must address, as a minimum, the criteria for determining subject species that are listed above. In particular, threatened species that are cryptic, mobile or little surveyed (or possess combinations of these parameters (e.g. bats)), and for which the study area provides suitable habitat and falls within the species' range, must not be excluded solely on the basis of a lack of records in the locality. Furthermore, threatened species that occur in a range of habitats must not be excluded on the basis that their core habitat is not present in the study area or locality.

The proponent should be aware that additional species and ecological communities could be added to the schedules of the BC Act between the issue of these requirements and the granting of consent. If this occurs, these additional matters will need to be addressed in the SIS and considered by the determining or concurrence authority.

Preliminary Listed Species

OEH draws your attention to species that may have preliminary listing under the BC Act. They may be found on the website of the NSW Scientific Committee at www.environment.nsw.gov.au/committee/ListOfScientificCommitteeDeterminations.htm. Any preliminary-listed species may receive final determination under the Act during your SIS process and hence you would need to consider them.

Any 'final determination' to list a species, population or ecological community as 'critically endangered' or 'endangered' made after lodgement of a development application or activity proposal needs to be included in the consideration of impacts and the application of the test of significance. Vulnerable species listed after the principal author signs the SIS are not subject to impact assessment as long as the application is determined and commenced within 12 months of lodgement.

# 4 SURVEY

## 4.1 Requirement to survey

A fauna and flora survey must be conducted in the study area. Targeted surveys should be conducted for all subject species determined in accordance with Section 3.1. Recent (less than 5 years old) surveys and assessments may be used to assist in addressing this requirement. However, previous surveys will not be considered to have addressed this requirement if they have:

- been undertaken in seasons, weather conditions or following extensive disturbance events when the target subject species are unlikely to be detected or present (e.g. outside known flowering / fruiting periods, adverse drought conditions, flooding, bushfire [though some species are 'fire obligates' requiring fire to germinate], slashing and overgrazing etc.); or
- utilised methodologies, survey sampling intensities, timeframes or baits that are not the most appropriate ones for detecting the target subject species unless these differences can be clearly demonstrated to be likely to have had an insignificant impact upon the outcomes of the surveys.

Surveys must be undertaken by appropriately experienced and qualified persons. A recognised expert, from institutions such as the Australian Museum (Sydney), the National Herbarium of NSW at the Royal Botanic Gardens (Sydney) or the Queensland Herbarium (Brisbane), or who is otherwise considered acceptable by OEH, must be used to determine or confirm the identification of species that are unknown or which have been only provisionally identified.

Survey methods adopted must be those considered by experienced wildlife surveyors to be those most likely to detect the targeted subject species (more than one survey method must be utilized for those subject species for which complementary methods have the potential to result in a significant increase in detection). Survey effort (including intensity, repetition and coverage) must be at a level that can be reasonably expected to detect the subject species if present in the study area. Surveys must be undertaken at the time of year when the subject species are most likely to be detected (e.g. targeted threatened flora should be carried out when a species is flowering or fruiting, as these features are typically required to positively identify species) and, where possible, in appropriate weather conditions. OEH expects the weather conditions (e.g. minimum ambient air temperature, maximum ambient air temperature, amount of precipitation that occurs each 24 hour period, details about wind speed and direction and the amount of cloud cover) and the phase of the moon to be recorded for each day of survey (including dates) to be documented and included in the report.

Survey procedures and assessment of results should be consistent with those procedures and assessment approaches contained within the following OEH publications:

- '*Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities*' *(DEC – November 2004)'*. (*Note: Section 6.1 *Assessment of Significance* has been amended by OEH 2018)
- '*Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECC – April 2009a)'
- '*Threatened Species Test of Significance Guidelines'* (OEH, 2018).
- 'NSW Guide to Surveying Threatened Plants'. (OEH, 2016)

*Note that OEH has produced separate survey guidelines to cover Amphibians (frogs) and plants, which replace those sections in the DEC (2004) guidelines. However, the survey requirements for all other species of fauna are still found in the DEC (2004) guidelines.

The above documents can be located on OEH's website under the 'Threatened species survey and assessment guidelines' at:

- http://www.environment.nsw.gov.au/surveys/GuidelinesForCarryingOutASurvey.htm

If a proposed survey methodology is likely to vary significantly from widely accepted methods, the proponent should discuss the proposed methodology with OEH prior to undertaking the SIS, to determine whether OEH considers that it is appropriate.

In addition to the above guidelines, OEH has recently posted new information on OEH website to ensure appropriate surveys are completed, with particular reference to fauna surveying.

**False absences and imperfect detection**

While the presence of a target species can often be confirmed at a site relatively easily, it is generally impossible to confirm a species is absent. Unless a species has a 100% chance of being detected on a single visit (i.e. it has a probability detection of 1) non-detection does not necessarily mean the species is absent (MacKenzie *et al*. 2002). Very few species are so conspicuous that they are always detected in each survey (MacKenzie *et al*. 2002).

A species' detectability is influenced by several factors (Tyre *et al*. 2003). Such factors include:

- the species in question – fauna species with large home ranges are especially likely to go undetected in an area, as at any given time they may be in another part of their range
- climatic conditions (e.g. temperature, rainfall)
- experience of the surveyor/s
- the survey methodology used.

An observed absence may be due to an observer failing to detect a species that is actually resident at the site, for example, a bird that was elsewhere in its home range at the time of the survey or failed to call during a point count (MacKenzie 2005). False absences have serious consequences for habitat modelling and monitoring studies as well as impact assessments. When fauna surveys are conducted for the purpose of impact assessment, false absences may result in inadequate conservation measures and an increased risk of local extinction (Wintle *et al*. 2005).

Hence, the SIS should be conservative when determining whether a species, population or community (including their habitat) are potentially present (i.e. precautionary approach).

**Stratifying the site**

When designing a field survey, firstly stratify the study area (i.e. divide the area into relatively homogenous units – often referred to as 'environmental sampling units' or 'stratification units'). Stratified sampling provides a logical, objective and efficient method of undertaking surveys and ensures that the full range of potential habitats and vegetation types will be systematically sampled and mapped. For the mapping of vegetation and delineation of habitat types, the study area / subject site should be initially stratified on biophysical attributes (e.g. landform, geology, elevation, slope, soil type, aspect, climate, rainfall etc.) that best delineate likely vegetation changes across the landscape. Vegetation structure or type (as per the OEH Plant Community Type or other acknowledged vegetation mapping / classification), condition and disturbance history may be used to better define the boundaries of stratification units.

Once the stratification units have been identified, they should be recorded on a survey map. Remote sensing such as aerial or satellite photograph interpretation coupled with ground truthing will help better refine and determine the spatial vegetation patterns and habitat types across a study area.

For further information on stratification refer to the new information posted on OEH website, as detailed above.

**Visiting the site**

Conduct a preliminary site visit to refine the initial stratification units, determine the broad vegetation types (e.g. if using OEH BioNet Vegetation Classification database to determine Plant Community Types [PCTs]) present at the site, assess the vegetation condition and conduct a broad habitat assessment to help delineate specific features suitable for sampling.

Taking a copy of OEH's BioNet Vegetation Classification database (for PCTs) (http://www.environment.nsw.gov.au/research/Visclassification.htm) for the relevant former Catchment Management Authority (CMA), local government areas or equivalent (e.g. existing vegetation mapping) into the field during the preliminary site visit, may be useful in determining the likely vegetation types present. However, for some CMAs this should only be used as a guide as some vegetation types / communities have not been captured or delineated in the database.

**Survey Design**

Once the site has been stratified, an adequate survey design (e.g. stratified random sampling for vegetation / flora) should be developed which adequately samples all stratification units and habitat types. Vegetation survey sites should be selected randomly and be based on the variation inherent in the stratification, while fauna sites are likely to be selected on the basis of vegetation change and specific habitat types present (e.g. hollow bearing trees, feed trees, rock outcrop, presence of water etc.). Additional targeted surveying will be required for threatened species that are dependent on specific vegetation types or habitats or require specific sampling because of seasonality (e.g. flowering season for some plants, warmer months for fauna etc.).

To sample vegetation, for example, a standard plot should be adopted to ensure the structural and floristic character of all vegetation types on site is adequately captured (e.g. 0.04 ha [20m × 20m] quadrat).

<u>Targeted Surveys - Flora</u>

For targeted flora surveys please note the known flowering / fruiting times for each species to time surveys appropriately (as listed above for potential 'subject species'). Surveying at known flowering times is required for all potential species that are not readily detectable (or are cryptic), where flowers or fruits are necessary for their positive identification. If targeted flora surveys for potential species are conducted outside a specie's known phenology then justification must be provided as to why; if this is not provided or considered inappropriate, then all such species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided. For species which do not require flowers / fruits for positive identification (e.g. large trees / shrubs), then survey as appropriate (though appropriate justification on methods used is still required). It is recommended to utilise known reference sites to help delineate flowering patterns and sampling timeframes. OEH can provide advice on this for some species.

Targeted flora surveys must also adequately sample / cover all suitable habitat on the study area, and utilise suitable detection techniques such as belt transects (at appropriate widths to spot cryptic species) or random meanders (that sufficiently cover all known / potential habitat areas [i.e. not just the tracks or readily accessible areas]). OEH has produced a survey guideline which outlines preferred survey methodologies and techniques - 'NSW Guide to Surveying Threatened Plants'. (OEH, 2016). If targeted flora surveys are poorly conducted or surveyed then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.

Targeted Surveys – Fauna

When undertaking targeted fauna surveys, you must be aware of: (i) habitat preferences and known distribution for each of the species as an indication as to whether they may occur in the study area, (ii) the best times of year these species may be detected if subject to surveys, and (iii) suitable survey techniques to adequately detect a potential species. If targeted fauna surveys are poorly conducted, inappropriately surveyed or undertaken outside known detection periods, then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.

If animals are captured with an uncertain taxonomy, species should be forwarded to the Australian Museum by a suitably qualified scientific licence holder.

Habitat assessment

Habitat assessment is recommended for all sites and should be used to supplement surveying and survey design. In instances where intensive or species-specific surveys have not been carried out due to either timing or seasonality constraints, habitat assessment may be used as a surrogate for intensive surveys. However, in this instance threatened species should be assumed present if their habitat requirements are met. Ensure all impact assessments include a thorough habitat assessment.

Undertaking a habitat assessment of the study area will assist with predicting the occurrence of threatened species in the study area and will guide the location of targeted surveys. A comprehensive habitat assessment should be conducted across the whole site, identifying key habitat features for both flora and fauna.

You should be familiar with the habitat requirements of each threatened species identified as possibly occurring in the study area. This information can be obtained from OEH's recovery plans website (http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/recovery-plans), threatened species profiles and scientific literature. Threatened species profiles are available on OEH website:

- www.environment.nsw.gov.au/threatenedspecies/

The habitat assessment should include information on:

- landscape features in the study area (e.g. river banks, rocky outcrops, dry slopes, wetlands, undulating terrain)
- any other features that could provide habitat such as hollow-bearing trees or culverts
- the vegetation types present (such as OEH's BioNet Vegetation Classification database (for PCTs - http://www.environment.nsw.gov.au/research/Visclassification.htm) or appropriate vegetation mapping).

It is important to record all areas of native and introduced vegetation, as even weeds can potentially provide habitat for threatened fauna. As part of the habitat assessment, you should look for:

- hollow-bearing trees, including dead stags;
- bush rock and rocky outcrops;
- natural burrows, such as those of the Hastings River Mouse;
- large trees with basal cavities;
- logs;
- wetlands, streams, rivers, dams and other water bodies;
- nests and roosts;

- wombat burrows;
- dens used by yellow-bellied gliders, squirrel gliders and brush-tailed phascogales;
- yellow-bellied glider and squirrel glider sap feed trees;
- distinctive scats (e.g. those of the spotted-tailed quoll or koala);
- latrine and den sites of the spotted-tailed quoll;
- *Allocasuarina* spp.;
- flying-fox camps;
- Microchiropteran bat tree roosts;
- Microchiropteran bat subterranean roosts (caves, culverts, tunnels and disused mineshafts);
- swift parrot and regent honeyeater feed or nest trees;
- winter-flowering eucalypts;
- mistletoes;
- permanent soaks and seepages; and
- areas that can act as corridors for plant or animal species.

Another important factor to consider is the connectivity value of the site. If the proposal site forms an important corridor in the area, the development is likely to have an effect on threatened species in the region.

A geo-referenced map / aerial photograph (or equivalent), of the study area detailing key habitat features, including the vegetation types, must be included in the report.

*Flora / Vegetation Survey and Mapping*

Typically, a floristic quadrat / transect will be used for vegetation based surveying. This should record the vegetation structure and cover of all structural layers, all species present, including their cover and abundance, and general location (e.g. Global Positioning System (GPS) co-ordinates etc.) and physiographic details (e.g. condition, position in landscape, soils etc.). These techniques are described in the OEH guidelines and are generally the accepted national (NVIS – National Vegetation Inventory System) standard (www.environment.gov.au/topics/science-and-research/databases-and-maps/national-vegetation-information-system). Each stratification unit must be adequately sampled.

All quadrats / transects should be adequately assessed to determine a suitable vegetation classification which accurately reflects the site. This may be done manually, or through the aid of appropriate statistical software / numerical analysis, such as cluster analysis and ordination analysis computer packages (e.g. PATN (Belbin 1989)). The latter will be dependent on how detailed the survey was, the size of the area sampled, the inherent diversity / complexity of vegetation on site and the amount of plot data collected. Details of the classification and how it was determined must be supplied in the report.

To complement and better refine the vegetation classification, ground truthing and aerial photograph or satellite imagery interpretation should be used. This will be used to generate the vegetation map and enable greater definition / delineation of vegetation communities present, and ensure a more accurate map. Ground-truthing and Aerial Photograph Interpretation (API) should be conducted at a level which captures all the obvious vegetation changes / communities on the subject site (particularly those that are noticeable at the ground-level) and ensure that all vegetation communities are adequately delineated on a geo-referenced map (the 'vegetation map'). Floristic quadrats / transects and any associated analysis will help define and describe the communities shown on the vegetation map. Recognition and delineation of native vegetation patterns on aerial photography may be based on combinations of:

- texture (crown size and shape)
- vegetation height and density
- vegetation and background tone and colour
- landuse pattern (non-woody areas).

*Determining Biometric vegetation types / Plant Community Types*

The classification of native vegetation in NSW follows the system described by Dr David Keith in '*Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT*' (Keith 2004). This classification scheme divides native vegetation into 17 broad vegetation formations. Each formation consists of a number of vegetation classes. There are 99 vegetation classes.

The BioNet Vegetation Information System provides detailed information on the Plant Community Types (PCT) of NSW, such as structure, floristics, key characteristic species, distribution and conservation value (but not limited to this). Access to the information on PCTs and the VIS database is located at:
https://www.environment.nsw.gov.au/research/Vegetationinformationsystem.htm

If you are proposing to conduct a biodiversity assessment using the Biodiversity Assessment Method (BAM) under the Biodiversity Offsets Scheme to determine the offset requirements of the proposal, then it is advisable and advantageous that during the survey component of the SIS that you collect the relevant data in the appropriate format for the BAM Calculator (*Note: this may reduce duplication or further surveying at a later date). This process can provide details of the required ecosystem and species (threatened) credits that need to be retired to offset the impacts of the development. Under this scenario all vegetation types in the study area should be identified and matched to an OEH Plant Community Type.

If a Biodiversity assessment is conducted using the BAM Calculator then OEH requests that the proponent provide an explanation of how the local vegetation communities were assigned to Plant Community Types, copies of BAM Credit Reports, copies of all field data sheets and an explanation of the underlying assumptions used at every step of the BAM Calculator.

### 4.2 Documentation of survey effort and technique

4.2.1 Description of survey techniques and survey sites

Survey technique(s) must be described and a reference given, where available, outlining the survey technique employed. Specific subject species targeted by each survey technique should be listed.

Survey site(s) and stratification units must be identified on a geo-referenced map / aerial photograph (or equivalent), with a clear legend, at the same scale as previous maps where possible. The size, orientation and dimensions of a quadrat or a length of transect should be clearly noted for each type of survey technique undertaken. Full Australian Map Grid (AMG) grid (Geocentric Datum of Australia (GDA) compliant) references for the survey site(s) should be noted.

4.2.2 Documenting survey effort

The time invested in each survey technique applied must be summarised (preferably in tabular format) in the SIS (e.g. - number of person hours per transect / quadrat, duration of call playback, number of nights traps set etc.). It is not sufficient to aggregate all time spent on all survey techniques. Effort must be expressed for each separate survey technique and each separate vegetation community. Survey, quadrat and transect sites must be schematically shown on a geo-referenced map or photograph. Targeted surveys also need to specify method adopted (e.g. belt transects, random meander [Cropper 1993]), habitats searched (e.g. type / features), duration, effort, prevailing weather conditions and location. Environmental conditions during the survey should be noted at the commencement of each survey technique.

Personnel details including name of all surveyor(s) and contact phone number should be provided. The person who identified records (e.g. Anabat, hair tubes, motion-sensor camera, and scat analysis) should also be identified.

### 4.3 Survey results

4.3.1 Subject species survey results

The report should provide a full list of all flora and fauna recorded in the study area / subject site.

Subject species recorded in the study area shall be identified, and the vegetation community in which they were recorded noted. Information concerning all records of threatened species made during the survey is to be provided in an appendix to the SIS. This information is to be in a form consistent with *BioNet Atlas* data recording cards and include information for all fields listed on these cards.

The limitations of survey techniques employed (including survey intensity, detectability of species, seasonality, weather conditions and adverse disturbance conditions) must be considered and discussed with respect to the results of the survey, and additional subject species considered to potentially occur in the study area identified. This assessment must be robust to external evaluation.

4.3.2 General species survey results

The SIS must provide details of all the vegetation communities (including disturbed and undisturbed / modified), habitat types, and all fauna and flora recorded on the subject site and study area in general.

A full list of the protected fauna and native plant species (as defined by the BC Act) found during the course of surveys must be included. Such information is indicative of the habitat quality of the site. This list must indicate the significance of each species, whether the species is introduced, and the habitat in which each species was recorded.

### 4.4 Subject species habitat mapping

Areas identified as known or potential habitat in the study area are to be mapped on a geo-referenced map / aerial photograph (or equivalent) separately for each of the subject species. These maps should be at the same scale as previous maps where feasible, and are to include any point locality records of the relevant subject species recorded from the SIS survey in the study area. Note: Records obtained from the 'BioNet Atlas' database can be used in determining likely habitat, but they are not to be schematically mapped in the SIS, as this is considered a breach of licence conditions for such records.

While in some circumstances the task of identifying potential habitat can be problematic, the SIS should provide the best expert estimate of the habitat of each threatened species and ecological community known or considered likely to occur in the study area. This is necessary in order to clearly support conclusions concerning the quantitative significance of habitat loss associated with the proposal. Information which can be used in preparing these maps includes records of threatened species in the local area, maps of vegetation communities and broad habitat types in the study area, information on the habitat requirements of threatened species and site-specific knowledge gained through field survey and inspection during preparation of the SIS.

### 4.5 General report structure

In summary, the report must include details on the following (but not be limited to):

- a description of the subject site, study area and its regional context; including a geo-referenced map / aerial photograph (or equivalent) indicating their location;
- details of the survey methodology and design adopted, including:
    - the number and location of traps (e.g. cage, Elliott, hair sampling tubes etc.), call playback sites, diurnal searches, random meanders, quadrats and transects,
    - the number of repetitions (Note: – you will need to provide a justification if this differs from the recommendations in these guidelines),
    - details of all floristic plots and transects,
    - details of the stratification,
    - identification of the classification system used (e.g. Specht *et. al*. (1974), Walker & Hopkins (1998) [Note: the classification must have regard to both structural and floristic composition elements]),
    - timing of surveying, climatic (weather) conditions and phases of the moon during survey,

  - details of how the vegetation classification for the site was developed, including details and associated products (e.g. dendrograms / two-way tables) of any analyses used, if applicable,
  - copies of any analyses used (e.g. PATN or other statistical files) and all field data sheets, and
  - geo-referenced maps / aerial photographs (or equivalent) showing the location of all survey points, quadrats and transects, and stratification units.
- detailed description of all vegetation communities / types (both undisturbed and disturbed) on the site and study area (it is preferable to link them to, OEH's Plant Community Types / Biometric vegetation types – in which case a step by step summary of how the site vegetation was matched with available Biometric vegetation types should also be included), including a geo-referenced map / aerial photograph (or equivalent) showing their location. The descriptions should include: - a general description, characteristic features (e.g. lacks a mid-storey, restricted to a particular geomorphic / edaphic feature etc.), their distribution and size (e.g. hectares), their vegetation structure (including cover), their condition, key diagnostic species, relationship to other communities, species richness and any significant species present (e.g. threatened species, Rare or Threatened Australian Plants (ROTAP: Briggs & Leigh 1996), regionally significant taxa);
- details of all habitat features / types should be included and mapped (where appropriate), such as frequency and location of stags, hollow bearing trees (including size), mature / old growth trees, culverts, rock shelters, rock outcrops, presence of feed tree / shrub / groundcover species (e.g. winter-flowering eucalypts, *Acacia* and *Banksia* trees, *Casuarina* / *Allocasuarina* and areas of native grasses], crevices, caves, drainage lines, soaks etc.;
- if a BAM calculator assessment is conducted for the development site and any offset sites then the proponent must provide:
  (a) copies of any BAM Calculator Credit Reports generated,
  (b) copies of all field data sheets, and
  (c) copies of a checklist that includes the data and underlying assumptions used at every step of the BAM Calculator.
- a list of all flora and fauna detected on the study area / subject site during the surveys, including threatened species. All threatened species and ecological communities must be clearly marked on geo-referenced map / aerial photograph (or equivalent);
- details of how the proposal will impact (both direct and indirect) and affect known and potential threatened species and ecological communities (including their habitat). This is likely to include a revised test of significance;
- details of the habitat assessment;
- details of how the proposal may impact on corridors, connective links and fragmentation;
- details of how the proposal will impact (both directly and indirectly) on adjacent or nearby OEH conservation estate or if applicable, other internationally / nationally important areas, (e.g. Ramsar wetlands, wetlands listed in the Directory of Important Wetlands, State Environmental Planning Policy (Coastal Management) 2018 areas and Forestry flora reserves);
- details of any impacts on or relevance of other environmental policies or guidelines (as outlined in Section 2.1.3);
- details of mitigation and offset / compensatory habitat measures;
- details of any other approvals required under any other State or Federal legislation;
- names, qualifications and experience of all personnel involved in the field surveys, analysis of results and report writing;
- paper copies of any maps of proposed biodiversity offset areas at A0 or A1 scale that clearly show the location and boundaries of any proposed offset area. These maps must be prepared by a registered surveyor and be proper survey plans that are acceptable to local Councils;
- an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the *Protection of the Environment Administration Act 1991*;
- a discussion of the likely social and economic consequences of granting or of not granting concurrence; and
- any other information outlined elsewhere in these guidelines, such as background and comparisons to previous studies (e.g. vegetation mapping reports), mitigation and offset measures etc. that should be included in the report.

## 5 ASSESSMENT OF LIKELY IMPACTS ON THREATENED SPECIES

Section 5 need only be addressed if threatened species are likely to be affected.

Assessment of impacts must include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts must also include an assessment of impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free or fuel reduced zones in retained bushland, the impacts of this on any threatened species must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in '*Planning for Bushfire Protection*' (NSW Rural Fire Service 2006) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

### 5.1 Assessment of species likely to be affected

> *An assessment of which threatened species known or likely to be present in the area are likely to be affected by the action (clause 7.6(2)(b))*.

This requirement is asking you to refine your list of subject species (given the outcome of survey and analysis of likely impacts) in order to identify which threatened species may be affected and the nature of the impact.

The remaining requirements in this section need only be addressed for those species that are likely to be affected by the proposal.

### 5.2 Discussion of conservation status

> *For each species likely to be affected-details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it and its habitat requirements* (*clause 7.6(2)(c)).*
>
> *An assessment of whether those species are adequately represented in conservation reserves (or other similar protected areas) in the region (clause 7.6(2)(e)).*
>
> *An assessment of whether any of those species is at the limit of its known distribution (clause 7.6(2)(f)).*

Assessment should include reference to the threatening processes that are generally accepted by the scientific community as affecting the species and are likely to be caused or exacerbated by the proposal. Assessment should also include reference to any approved or draft recovery plans which may be relevant to the proposal; including those prepared by other state Governments or the Commonwealth Government.

### 5.3 Discussion of local and regional abundance

> *An estimate of the local and regional abundance of those species (clause 7.6(2)(d)).*

<u>5.3.1 Discussion of other known local populations</u>

A discussion of other known populations in the locality shall be provided, along with an assessment of their regional significance. The long-term security of other habitats shall be examined as part of this discussion. The relative significance of the subject site for threatened species or endangered population in the locality shall be discussed.

5.3.2 Discussion of habitat utilisation

An estimate of the numbers of individuals utilising the area and how these individuals use the area (e.g. residents, transients, adults, juveniles, nesting, foraging). This should include discussion of the significance of these individuals to the viability of the threatened species or endangered population in the locality.

5.3.3 Description of vegetation

The vegetation present within the study area and the area covered by each vegetation community should be mapped and described, as previously stated in Section 4.3.2.

## 5.4 Assessment of habitat

*A full description of the type, location, size and condition of the habitat of those species and details of the distribution and condition of similar habitats in the region (clause 7.6(2)(g))*

5.4.1 Description of habitat values

Specific habitat features shall be described, such as frequency and location of stags, hollow bearing trees (including size), mature / old growth trees, culverts, rock shelters, rock outcrops, presence of feed tree / shrub / groundcover species (e.g. winter-flowering eucalypts, Acacia and Banksia trees, *Casuarina* / *Allocasuarina*, Mistletoes and areas of native grasses), crevices, caves, drainage lines, soaks etc.), and density of understorey vegetation / groundcover.

The condition of the habitat within the study area shall be discussed, including the prevalence of introduced species, species of weeds present and an estimate of the total weed cover as a percentage of each vegetation community, whether trampling or grazing is apparent, effects of erosion, prevalence of rubbish dumping, history of resource extraction or logging and proximity to roads, and assessment of the potential for native seed bank resilience in disturbed areas.

Details of the fire history of the subject site (e.g. frequency, time since last fire, intensity) and the source of fire history (e.g. observation, local records) shall be provided.

5.4.2 Extent of habitat removal

The location, nature and extent of habitat removal or modification (e.g. including impacts of Asset Protection Zones (APZs)) which may result from the proposed action including the cumulative loss and fragmentation (isolation) of habitat from the study area (including all Development Applications and those areas in the subject area already with development consent or identified for development) and the impacts of this on the viability of the threatened species or endangered population in the locality.

This shall include an assessment of the proportion of the habitat of the affected species to be affected by the proposal, in relation to the total extent of the habitat in the study area and subject site, and the impact of this on the viability of the affected species in the locality.

5.4.3 Consideration of corridors

Areas within the subject site which may act as local or regional corridors (or part thereof) for affected species must be identified and described. A geo-referenced map showing identified corridors must be provided, and the impact of the proposal on these areas shall be discussed. If relevant, this section should include consideration of ‘Key Habitats and Corridors for Forest Fauna’ (NPWS Occasional Paper 32: Scotts 2003) and regional linkages, as identified within ‘Regional Conservation Assessment, Lower Hunter and Central Coast Region’ (Morison & House 2004), or other appropriate studies (e.g. Council specific LES, LEP documents and structure plans).

5.4.4 Impacts on Threatened Species in OEH Estate

This section only needs to be addressed when threatened species in OEH estate (e.g. National Parks, Nature Reserves) are likely to be either directly or indirectly impacted upon.

The SIS must assess the potential impacts on any threatened species which may likely be directly or indirectly impacted upon that reside with OEH estate, including but not limited to fragmentation or loss of connective linkages, edge effects (e.g. increased boundary to area ratio), increased predation potential, weed invasion, loss or impacts on pollination vectors, changes to hydrology, nutrient increases, pollution, anthropogenic impacts (e.g. increased visitation, refuse) etc.

### 5.5 Assessment of the effect of the action on threatened species

*A full assessment of the likely effect of the action on those species, including, if possible, the quantitative effect of local populations in the cumulative effect in the region (clause 7.6(2)(h)*

This section should include a full assessment of the impacts of the action on threatened species, including assessment of cumulative impacts in the region.

### 5.6 Description of feasible alternatives

*A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (clause 7.6(2)(i)).*

Where a Review of Environmental Factors (REF) deals with these matters, the SIS may refer to the relevant section of the REF.

This section must include details of the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

## 6 ASSESSMENT OF LIKELY IMPACTS ON ECOLOGICAL COMMUNITIES

Section 6 need only be addressed when ecological communities are likely to be affected.

Assessment of impacts must include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts must also include an assessment of impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free or fuel reduced zones in retained bushland, the impacts of this on any threatened ecological communities must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in ‘Planning for Bushfire Protection’ (NSW Rural Fire Service 2006) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

### 6.1 Assessment of ecological communities likely to be affected

*A general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action (clause 7.6(3)(a))*

This must include reference to the ecological community as described by the NSW Scientific Committee, including maps of the extent and condition of the community with particular reference to those parts of the community that may only be represented by soil stored seed with no above ground components of the community present.

## 6.2 Discussion of conservation status

*For each ecological community present-details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it and its habitat requirements (clause 7.6(3)(b)).*

*An assessment of whether those ecological communities are adequately represented in conservation reserves (or other similar protected areas) in the region (clause 7.6(3)(c))*

*An assessment of whether any of those ecological communities is at the limit of its known distribution (clause 7.6(3)(d))*

Assessment should include reference to the threatening processes that are generally accepted by the scientific community as affecting the ecological community and are likely to be caused or exacerbated by the proposal. The assessment should also include reference to any approved or draft recovery plans which may be relevant to the proposal.

<u>6.2.1 Significance within a local context</u>

An assessment of the community on the subject site in relation to other sites in the study area and in the locality. The tenure and long term security of other localities shall be examined as part of this discussion.

The relative significance of the subject site for the ecological community shall be discussed. The assessment of the community should be considered in terms of the following features including, the size of the remnant, the quality of the habitat and the level of disturbance on this site in comparison to other sites in the locality.

<u>6.2.2 Discussion of corridor values</u>

The potential of the proposal to increase fragmentation of the community and increase edge effects.

If corridors that allow connectivity between localities of ecological communities are present within the subject site, the impact of the proposal on these areas shall also be discussed.

<u>6.2.3 Discussion of regional significance</u>

The significance of the locality for the community from a regional perspective shall be noted and discussed.

<u>6.2.4 Impacts on Ecological Communities in OEH Estate</u>

This section only needs to be addressed when threatened ecological communities in OEH estate are likely to be either directly or indirectly impacted upon.

The SIS must assess the potential impacts on any threatened ecological communities which may be directly or indirectly impacted upon that reside within OEH estate.

## 6.3 Assessment of habitat

*A full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region (clause 7.6(3)(e))*

<u>6.3.1 Description of disturbance history</u>

If the site shows signs of disturbance, details should be provided of the site's disturbance history and an assessment should be made of the ability of the ecological community to recover to a pre-disturbance condition.

6.3.2 Extent of habitat removal

The location, nature and extent of habitat removal or modification which may result from the proposed action including the cumulative loss of habitat from the study area (including all proposed DAs and those areas in the subject area already with development consent or identified for development) and the impacts of this on the viability of the ecological community in the locality.

This shall include an assessment of the proportion of the ecological community to be affected by the proposal, in relation to the total extent of the ecological community, and the impact of this on the viability of the ecological community in the locality.

### 6.4 Assessment of effect of the action

*A full assessment of the likely effect of the action on the ecological community, including, if possible, the quantitative effect of local populations in the cumulative effect in the region (clause 7.6(3)(f)*

This section should include a full assessment of the impacts of the action on threatened ecological communities, including assessment of cumulative impacts in the region.

### 6.5 Description of feasible alternatives

*A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (clause 7.6(3)(g))*

Where a Review of Environmental Factors (REF) deals with these matters, the SIS may refer to the relevant section of the REF.

In the discussion of feasible alternatives to the proposed development with regards to biophysical, economic and social considerations, and the principles of ecologically sustainable development, the SIS must also include details on the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

## 7 AMELIORATIVE MEASURES

### 7.1 Description of ameliorative measures

*A full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and ecological community including a compilation (in a single section of the statement) of those measures (clause 7.6(2)(j)) and clause 7.6(3)(h))*

7.1.1 Long-term management strategies

Consideration shall be given to developing long-term management strategies to protect areas within the study area which are of particular importance for the threatened species or ecological communities likely to be affected. This may include proposals to restore, improve or provide long term protection for habitat on site where possible. Any such proposal is to be accompanied by a plan of management identifying the specific areas to be restored, improved or protected, the threatened species / ecological community values of those areas, and detailing the management actions to be implemented to maintain and protect those values, including corrective actions to be taken in the event that monitoring indicates that management does not achieve specified objectives.

7.1.2 Compensatory strategies

OEH notes that its 'offset provision' principles (Appendix 1) state that impacts must be avoided first by using prevention and mitigation measures (DECC 2007a). Where significant modification of the proposal to minimise impacts on threatened species or ecological communities is not possible then compensatory strategies should be considered. These should include offsite or local area proposals that contribute to long term conservation of affected threatened species or ecological communities. If on or off-site compensatory habitat is not considered appropriate, justification must be provided. OEH is of the opinion that where a proposal which involves the clearing of threatened species habitat (i.e. native vegetation) that cannot be avoided or mitigated against, then appropriate offsets which compensate for the clearing of the habitat must be provided. The proponent must provide proper survey plans of any biodiversity offsets with the SIS, as described in sections 2.2 and 4.5 above.

Compensatory benefits likely to result from such measures proposed for alternative sites are to be discussed and evaluated along with a discussion of mechanisms of how they might best occur.

The tenure of lands, land use and the future use of lands proposed to support compensatory habitat must be considered.

Justification for any area(s) proposed as compensatory habitat / offsets is to include an assessment of the threatened species / biodiversity values impacted on by the proposed works (i.e. those of the subject site) and a comparison of whether the proposed offset area(s) provides equivalent or greater values.

To determine the adequate biodiversity offset required to compensate the loss of threatened species or ecological communities and their habitat (e.g. vegetation communities) either one of the following methodologies are to be used:

- OEH's 'offsetting principles' (OEH 2014a), as outlined on OEH's website: *Principles for the use of biodiversity offsets in NSW* (OEH's website - www.environment.nsw.gov.au/biodivoffsets/index.htm) can be used as general guide for offsetting and compensatory habitat requirements
- a biodiversity assessment using the BAM under the Biodiversity Offsets Scheme. This would provide details of the required ecosystem and species (threatened) credits that need to be retired to offset the impacts of the development.

OEH is of the opinion that a biodiversity assessment using the BAM calculator provides a transparent framework and a quantitative alternative to the principles-based approach (i.e. 'offset provision' principles as outlined in the biodiversity accreditation guideline - OEH 2014a – Appendix 1).

OEH acknowledges that in this instance BAM is a voluntary process and not a requirement under the SIS CERs, but believes it provides a valuable insight and quantitative appraisal into what would be an acceptable offset package to compensate the likely impacts of the development. OEH notes that under the *Principles for the use of biodiversity offsets in NSW* – Principle 9 states that '*offsets must be quantifiable – the impacts and benefits must be reliably estimated*', in that offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. OEH is of the opinion that the BAM represents a methodology that ensures offsets are quantifiable. Please note, if a BAM assessment is not used then OEH would expect an alternative quantitative methodology is adopted that clearly indicates that the biodiversity values of an offset site is commensurate with those found at the impact site, whether it be with respect to size and scale, or as a measure of biodiversity credits. Under this scenario, it is likely OEH would undertake a desk-top (as a minimum) BAM assessment to assess the veracity of any alternative methods used. Please note - If the BAM Calculator is used then all appropriate data, including credit reports, figures (e.g. GIS) and data sheets need to be provided with the SIS when it is lodged.

The following principles are relevant to areas without an existing biodiversity offsets program. Offsets will require the proponent to consider adequate conservation in perpetuity, appropriate management regimes (including other habitat enhancement or mitigation measures) and financial security with respect to ongoing management. OEH would typically consider suitable measures to ensure conservation in perpetuity, such as:

- the establishment of Biodiversity Stewardship Sites under the BC Act
- the retirement of biodiversity credits (where appropriate credits are available)
- the dedication of land as a public reserve under the *National Parks and Wildlife* (NPW) *Act 1974*
- a Conservation Agreement in-perpetuity registered on title under Division 12 of the NPW Act
- a Planning Agreement under Division 7.1, Subdivision 2 of Part 7 of the EP&A Act.

**Note**:
- OEH preferred method of securing an offset is under the Biodiversity Stewardship provisions of the *Biodiversity Conservation Act 2016* (i.e. a registered Biodiversity Stewardship Site).
- OEH no longer supports public positive covenant under s88E of the *Conveyancing Act 1919* as an appropriate conservation mechanism to secure and manage biodiversity offsets.
- Although OEH supports the use of conservation agreements under the NPW Act as one of the acceptable offsetting mechanisms, we are reviewing this approach and it is advisable that if you are considering this mechanism you contact the Biodiversity Conservation Trust) about its applicability.

To appropriately manage any proposed compensatory offsets, any retained habitat enhancement features within the development footprint and impact mitigation measures (including proposed rehabilitation and monitoring programs), OEH would require that an appropriate Management Plan (such as vegetation or habitat) be developed as a key amelioration measure. OEH acknowledges that where a proponent choses a Biodiversity Stewardship Agreement, Conservation Agreement or similar that a Management Plan will be specifically developed as part of their establishment process.

Management plans should be prepared prior to any potential approval of the development. Management Plans should clearly document how any retained vegetated areas or habitat features will be managed with respect to long-term conservation and viability, including clear details on how they will be funded. They should cover (where applicable), but not be limited to, the following issues:

- weed management (both control and suppression) and monitoring
- management of retained native vegetation and habitat (including buffer zones)
- feral animal control
- fire management (including asset protection zones [APZs])
- public access (including restriction of, increased traffic, and associated impacts, such as increased refuse and pets)
- size and management of buffer zones
- minimisation of edge effects and fragmentation
- stormwater control and changes to hydrology (including stormwater / runoff control and sediment / erosion control measures)
- management of specific habitat enhancement measures (e.g. hollow / habitat trees, animal fencing to facilitate movement, artificial hollows and nest boxes etc.)
- fauna displacement and if appropriate translocation (including any licence requirements)
- proposed surveys, such as pre-extraction baseline, pre-clearance and rehabilitation surveys
- details of long-term monitoring (including proposed timing)
- details of any rehabilitation program, including details of timing (including proposed staging details), rehabilitation measures (including details of proposed revegetation and species mix), and post-rehabilitation monitoring
- measures to ensure conservation in perpetuity (e.g. transfer to OEH [NPWS] estate, conservation agreements or covenants)
- funding details of long-term financial commitment to any proposed conservation measures, including any mechanisms to be implemented to achieve this.

<u>7.1.3 Ongoing monitoring</u>

Any proposed pre-construction flora, fauna or vegetation monitoring plans or on-going monitoring of the effectiveness of the mitigation measures shall be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency. Generally, ameliorative strategies which have not previously been proved effective should be undertaken under experimental design conditions, appropriately monitored and appropriately analyzed. Data analysis could include an 'Analysis of similarities' (ANOSIM) assessment of changes in foliage cover of plant species recorded in fixed quadrats or transects between sampling periods (Clarke 1993). Objectives of any monitoring plans are to include identifying any modifications needed to improve the effectiveness of ameliorative measures. These aspects should also be covered in any relevant management plans. Additionally a review of management plans should be undertaken at regular intervals (e.g. 5 years) to ensure adaptive management, where required, is undertaken.

## 8 TEST OF SIGNIFICANCE OF LIKELY EFFECT OF PROPOSED ACTION

A 'Test of Significance' (s. 7.3 BC Act) is to be provided for each of the affected species (threatened species or ecological communities) identified in the SIS, incorporating relevant information from sections 5.1 to 7 of the SIS. On the basis of these assessments a conclusion is to be provided concerning whether, based on more detailed assessment through the SIS process and consideration of alternatives and ameliorative measures proposed in the SIS, the proposal is still considered likely to have a significant effect on threatened species or ecological communities or their habitats.

The threatened species 'Test of significance' should be consistent with those procedures and assessment approaches contained within OEH publication:

- '*Threatened Species Test of Significance Guidelines'* (OEH, 2018). This document is available from OEH's website: https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/assessment-of-significance

## 9 ADDITIONAL INFORMATION

### 9.1 Qualifications and experience

*A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement (Section 7.20(3)).*

You should have extensive experience in conducting field surveys and should be able to identify threatened species and their habitats relevant to the study area, as well as any similar species that may be confused with them. You should familiarise yourself with herbarium or museum specimens of any threatened species you are not already familiar with, before you conduct field surveys.

### 9.2 Other approvals required for the development or activity

*A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or ecological community (Clause 7.6(2)(k) and Clause 7.6(3)(i)).*

In providing a list of other approvals the following shall be included:

- Where an approval(s) is required under Part 5 of the *Environmental Planning and Assessment Act 1979*, the name of the determining authority or authorities, the basis for the approval and when these approvals are proposed to be obtained should be included; or

<u>*Environment Protection and Biodiversity Conservation Act 1999*</u>

An action will require the approval of the Federal Minister for the Environment (in addition to any State or Local Government approval or determination) if that action will have, or is likely to have, a significant impact on a matter of national environmental significance. Threatened species and communities listed in the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are considered to be a matter of national environmental significance.

Many of the species and ecological communities listed in the BC Act are also listed in the EPBC Act. Further information regarding the operation of the EPBC Act, including listed threatened species and communities, may be obtained by contacting the Australian Government Department of the Environment and Energy on 1800 803 772 or at the Department's website www.environment.gov.au/biodiversity/threatened/index.html.

### 9.3 Licensing matters relating to the survey

Persons conducting flora and fauna surveys must have appropriate licences or approvals under relevant legislation. The relevant legislation and associated licences and approvals that may be required are listed below:

*Biodiversity Conservation Act 2016:*
Biodiversity Conservation Licence (Section 2.11)

*Animal Research Act 1985:*

- Animal Research Authority to undertake fauna surveys.

Typically you will require a licence under section 2.11 of the BC Act to undertake an activity (e.g. survey) for scientific, educational or conservation purposes that is likely to result in one or more of the following:

- harm to any protected fauna, or to an animal that is a threatened species or is part of a threatened ecological community
- harm to any protected native plant, or any plant that is a threatened species or is part of a threatened ecological community. You will need a licence if you plan to collect voucher specimens for identification purposes, pick cuttings or whole plants, or collect seed
- damage to a habitat of a threatened species or a threatened ecological community.

Information pertaining to section 2.11 licences can be obtained from the following website:
https://www.environment.nsw.gov.au/licences-and-permits/scientific-licences

It is a condition of all licences that you submit a report of the work carried out under the licence, including any results and specific details / locations of all flora and fauna, to OEH within two months of the expiry of the licence.

Also, be aware of the requirements relating to animal care and ethics when conducting wildlife surveys. The handling and capture of animals is regulated by the *Animal Research Act 1985* and the *Animal Research Regulation 1995*, which are administered by Department of Primary Industries. The Act requires that every person undertaking animal research must hold an Animal Research Authority. Under the Act, animal research includes the 'use' (e.g. handling, trapping etc.) of animals in field surveys. Details on animal ethics can be obtained from the following website:

- www.animalethics.org.au/home

All surveys must be carried out in accordance with the NSW Department of Primary Industries Guidelines for wildlife surveys located at:

- www.animalethics.org.au/policies-and-guidelines/wildlife-research/wildlife-surveys

### 9.4 Section 7.20(4) reports

Section 7.20(4) of the BC Act has the effect of requiring OEH to provide that information regarding the State-wide conservation status of the subject species that it has available. These documents are available on the internet at:

https://www.environment.nsw.gov.au/threatenedspeciesapp/

This website provides basic profiles for the majority of species listed as threatened, as well as links to the Scientific Committee determinations, more detailed profiles, environmental impact assessment guidelines and recovery plans, where these documents are available. OEH is unable to provide any further information for section 7.20(4) reports.

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## Appendix 1:

### Principles for the use of biodiversity offsets in NSW (OEH 2014)

Located at: www.environment.nsw.gov.au/biodivoffsets/oehoffsetprincip.htm

These principles have been developed by the Office of Environment and Heritage (OEH) to provide a useful framework when considering biodiversity impacts and appropriate offset requirements.

They are intended to be used for proposals other than those for state significant development (SSD) or state significant infrastructure (SSI). A Biodiversity Offsets Policy for Major Projects has been developed to deal with proposals for SSD and SSI.

**1. Impacts must be avoided first by using prevention and mitigation measures.**
Offsets are then used to address the remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

**2. All regulatory requirements must be met.**
Offsets cannot be used to satisfy approvals or assessments under other legislation, such as assessment requirements for Aboriginal heritage sites and for pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

**3. Offsets must never reward ongoing poor performance.**
Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

**4. Offsets will complement other government programs.**
A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks, and incentives for private landholders.

**5. Offsets must be underpinned by sound ecological principles.**
They must:

- include the conservation of structure, function and compositional elements of biodiversity, including threatened species
- enhance biodiversity at a range of scales
- consider the conservation status of ecological communities
- ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

**6. Offsets should aim to result in a net improvement in biodiversity over time.**
Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.
Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.
Offsets may include:

- enhancing habitat
- reconstructing habitat in strategic areas to link areas of conservation value
- increasing buffer zones around areas of conservation value

- removing threats by conservation agreements or reservation.

**7. Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.**
As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

**8. Offsets should be agreed prior to the impact occurring.**
Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

**9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated.**
Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- the area of impact
- the types of ecological communities and habitat or species affected
- connectivity with other areas of habitat or corridors
- the condition of habitat
- the conservation status and/or scarcity or rarity of ecological communities
- management actions
- level of security afforded to the offset site.

The best available information or data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:

- they protect land with high conservation significance
- management actions have greater benefits for biodiversity
- the offset areas are not isolated or fragmented
- the management for biodiversity is in perpetuity, such as secured through a conservation agreement.

Management actions must be deliverable and enforceable.

**10. Offsets must be targeted.**
They must offset impacts on the basis of like-for-like or better conservation outcomes. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats.

Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

**11. Offsets must be located appropriately.**
Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

**12. Offsets must be supplementary.**
They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space, cannot be used as offsets.

**13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or contracts.**
Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

*Page last updated: 8 September 2014*

## ATTACHMENT B:

### PROJECT-SPECIFIC CHIEF EXECUTIVE'S REQUIREMENTS FOR PROPOSED BALICKERA TUNNEL STABILITY WORKS PROGRAM

The species impact statement (SIS) must include the following information:

1. Personnel
    - The proponent must engage a recognised microbat expert in preparation of the SIS. It is recommended that consultation with OEH be undertaken prior to preparation of the SIS to ensure that OEH is satisfied with the qualifications and experience of the appointed expert.

2. Species details
    - Details of all threatened species present within the tunnel and the number of individuals utilising the tunnel across different times of the year.
    - Analysis of habitat features within the tunnel, including detailed figures showing all possible habitat within the full length of the tunnel.
    - Details on locations within the tunnel that bats are currently utilising, including figures showing roosting and breeding locations of each species of bat.
    - Analysis on the importance of the bat populations utilising the tunnel within the locality (percentage of the local population, the importance of the little bent-wing bat roosting site as the most southerly known location, breeding populations of southern myotis within the locality, other over-wintering sites for eastern bent-wing bat).
    - Analysis on the lifecycle of each species of bat within the tunnel and how each species is utilising the tunnel (e.g. pregnancy, breeding times, over-wintering etc.).
    - Analysis on whether the tunnel represents breeding habitat for the little bent-wing and eastern bent-wing bats and possible locations of alternative maternity sites being utilised within the locality.
    - Details on alternative roosting sites within the locality for all three species.
    - Details on alternative breeding sites for southern myotis within the locality.

3. Construction details
    - Details on the works proposed to be undertaken and the location of these works, including figures showing the location of works with reference to the location of bat habitat and currently utilised areas within the tunnel.
    - Description of feasible alternatives that may have less impact on the species.
    - Specific details on the stabilisation methods proposed within the tunnel, where each method will be utilised (e.g. rock bolting, shotcrete) and possible alternatives to these methods, with reference to the proximity of bat habitat and currently utilised areas.
    - Details on timing for the works that will reduce impacts on bats (time of year and time of day) – and analysis and justification for the proposed timing.
    - Details on general construction methods (e.g. access, machinery, personnel).
    - Details on dewatering of the tunnel and possible impacts on bats.
    - Details of vegetation to be cleared/disturbed.

4. Impacts
    - Outline of all impacts associated with the proposal with reference to key threats to the species
    - Details on noise, light, dust, vibration and contaminants likely to be produced during construction and analysis of the likely sensitivity of bats to these impacts.
    - Details on any removal of habitat proposed within the tunnel (e.g. shotcreting over sections of habitat, filling of cracks currently utilised).
    - Details of the final habitat value of the tunnel for each of the bat species following stabilisation works.
    - Analysis on the impact of habitat removal on the local population.
    - Analysis on the impact on the local population if bats disperse and do not return to the tunnel.

- Analysis on the cumulative impacts on the species at a local and regional scale.

5. Mitigation measures
    - Details of a bat management plan to be prepared.
    - Details of staging of works to minimise impacts on bats present.
    - Details of any exclusionary measures proposed for bats during construction.
    - Details on how existing habitat features will be maintained (e.g. limiting use of shotcrete).
    - Details on mitigation measures to minimise and reduce the impact of noise, light, dust, vibration and contamination on the bats.
    - Details of a monitoring plan to be implemented before, during and after construction.
    - Outline of triggers and responses during construction to minimise impacts
    - Details of reporting to be undertaken.
    - Details on bat handling protocols.
    - Details on any proposed artificial habitat features to be installed/constructed.
    - Details on rehabilitation of disturbed vegetation at entrances.
    - Details on the ongoing management of the habitat within the tunnel.

## ATTACHMENT C:

**Checklist for determining if an SIS has met the requirements of the Chief Executive of the Office of Environment and Heritage**

Under Part 5 of the *Environmental Planning and Assessment Act 1979*, if the activity is likely to have a significant impact, or will be carried out in a declared area of outstanding biodiversity value, the proponent must either apply the Biodiversity Offsets Scheme or prepare a species impact statement (SIS).

Before deciding to issue approval and consequently requesting the concurrence of the Chief Executive of OEH, it is required of the determining authority to determine whether the SIS meets the Chief Executive's requirements (CERs).

This checklist has been drawn up to assist determining authorities in this matter. A comments column has been included to allow authorities to provide, among other things, reasons for their decisions or comments on whether an omission is significant.

Note that this is a generic checklist and some items may not be relevant to the application being reviewed or the CERs issued. If the requirements do not specify one of the matters below, then it is recommended that this be noted in the comments column. Consultants preparing an SIS may also use this checklist as a brief guide to preparing the SIS.

| Matter | Yes/No | Comments |
|---|---|---|
| Has the SIS been signed by both its author and the applicant for consent/approval? | | |
| Has the description of the proposal included all associated activities and works, such as hazard reduction zones, access roads and road upgrades, utilities, etc? | | |
| Have all requested plans, maps and aerial photographs been provided? This includes any A1 or A0 sized proper survey plans prepared by a registered surveyor that clearly show the location and boundaries of any proposed offsets. | | |
| Has the SIS determined the subject species by reviewing the suggested list in the CERs, other available information and survey results and assessing which species and ecological communities are to be impacted by the development? | | |
| Has the survey undertaken provided sufficient information to determine the likely impacts of the proposal on threatened species and ecological communities? | | |
| Have surveys been undertaken during the appropriate season(s) for the detection of the species that may possibly occur on site? | | |
| Have surveys been undertaken during appropriate weather conditions? | | |
| Have climatic conditions preceding the surveys (e.g. drought c.f. wet) affected the possibility of subject species being detected? | | |

| Matter | Yes/No | Comments |
|---|---|---|
| Have all specific survey methods, techniques and intensities requested in the CERs been followed completely? | | |
| Has the documentation of survey effort, locations and techniques provided sufficient information to determine the above? | | |
| Has the assessment of impacts included the impacts of ALL activities associated with the development, including fire hazard reduction requirements, access road upgrades, downstream and downslope impacts, detention basins, severing of fauna movement corridors, etc. | | |
| Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species' in the locality (locality is defined in the CERs)? | | |
| Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the locality? | | |
| Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species in the region. | | |
| Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the region? | | |
| Have alternatives to the proposal been discussed? Alternatives may include relocation of infrastructure or, for example, reducing minimum lot size so that a similar number of lots may be realised whilst retaining a larger conservation lot within a subdivision, or changing mining techniques. | | |
| Has the discussion of alternatives included assessment of the social and economic (not merely financial) aspects of these alternatives (particularly, of not proceeding)? | | |
| Has the discussion included an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the *Protection of the Environment Administration Act 1991*? | | |
| Have all proposals for compensatory actions (e.g. purchase of similar vegetation / habitat or revegetation of habitat, where appropriate) been discussed with the relevant landowners/manager? | | |
| Is there documented agreement for sale or revegetation activities? | | |
| Is there agreement to change zoning or enter into a covenant on title in order to secure the conservation of the properties being purchased or revegetated? | | |
| If translocation is proposed, has the impact of the translocation on the recipient site(s) been assessed? | | |

| Matter | Yes/No | Comments |
|---|---|---|
| Is there a 'Plan of Management' or similar titled document? | | |
| Has the SIS utilised relevant information from published draft and final recovery plans? If no plan has been published, but it is known that one is being prepared, has the SIS utilised advice from the NPWS as to the likely contents of that recovery plan (liaison to obtain this advice may have been specified in the CERs)? For example, would the proposal result in the loss of a local population or remnant that a recovery plan describes as being of particular importance to the conservation of the species, population or ecological community? | | |
| If a BAM Calculator assessment has been done for the proposal have the following been provided: copies of Credit reports, copies of field datasheets, and copies of a checklist that includes all data used in the credit calculator and the underlying assumptions, such as how local vegetation communities were assigned to Plant Community Types? | | |
| Has the SIS discussed the relationship of the proposal to any listed Key Threatening Processes (e.g. does the proposal result in the need for High Frequency Fire as a fire hazard reduction measure, or does it result in the Clearing of Native Vegetation)? | | |
| Has the SIS discussed the relationship of the proposal to any published Threat Abatement Plan (e.g. does the proposal result in an increased threat in a manner that is specifically at odds with a published plan)? | | |
| Has a revised test of significance been included? | | |
| Has the 'Additional Information' specified in section 9 of the CERs been provided? | | |
| Have the qualifications and experience of those involved in the surveys been included? | | |
| Have other approvals which are required for the development or activity been documented? | | |
| Any licensing requirements (e.g. s.2.11 under BC Act). | | |

# Appendix B Likelihood of Occurrence Assessment

Five terms for the likelihood of occurrence of species are used in this report, as defined below:

- “yes” = the species was or has been observed on the site;
- “likely” = a medium to high probability that a species uses the site;
- “potential” = suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely, or unlikely to occur;
- “unlikely” = a very low to low probability that a species uses the site; and
- “no” = habitat on site and in the vicinity is unsuitable for the species.

**Table B-1: Likelihood of occurrence for Threatened Ecological Communities**

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions | E | CE | Typically forms a woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark), *Brachychiton populneus subsp. populneus* (Kurrajong) and *Eucalyptus moluccana* (Grey Box). Other tree species such as *Angophora floribunda* (Rough-barked Apple) and *Callitris endlicheri* (Black Cypress Pine) may be present and occasionally dominate or co-dominate. A shrub layer is often present. Subshrubs may also be common. Ground cover can be moderately dense to dense and consist of numerous forbs and grass species as well as a small number of ferns, sedges and twiners. | Central Hunter Valley between about Singleton and Muswellbrook. It is known to occur in the Cessnock, Singleton and Muswellbrook LGAs but may occur elsewhere within the Sydney Basin Bioregion. | Associated mostly with Permian lithology, and is situated on gently undulating hills, slopes and valleys, or occasionally on rocky knolls. | No. Study area is not on Permian sediments. | No. Community not present. | No |
| Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions | E | CE | Typically forms an open forest or woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark), *Corymbia maculata* (Spotted Gum) and *Eucalyptus moluccana* (Grey Box). Other tree species such as *Eucalyptus fibrosa* (Red Ironbark) and *Eucalyptus tereticornis* (Forest Red Gum) may be present, and occasionally dominate or co-dominate. A sparse layer of small trees including *Allocasuarina luehmannii* (Buloke) or *Acacia parvipinnula* (Silver-stemmed Wattle) may be present in some areas. The shrub layer varies from sparse to moderately dense. Ground cover can be sparse to moderately dense and consists of numerous | Central Hunter Valley mainly between Maitland and Muswellbrook. It has been recorded from Singleton, Cessnock and Muswellbrook LGAs but may occur elsewhere within the North Coast and Sydney Basin Bioregions. | Undulating country including low rises and slopes. It may also occur on alluvial and colluvial soils in valleys. Occurs on clayey soils found on Permian sediments. | No. Study area is not on Permian sediments. | No. Community not present. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | forbs, a few grass species and occasional ferns and sedges. | | | | | |
| Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | V | Characteristic plants include *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* (Sea Rush), *Sarcocornia quinqueflora* subsp. *quinqueflora* (Samphire), *Sporobolus virginicus* (Marine Couch), *Triglochin striata* (Streaked Arrowgrass), *Ficinia nodosa* (Knobby Club-rush), *Samolus repens* (Creeping Brookweed), *Selliera radicans* (Swamp Weed), *Suaeda australis* (Seablite) and *Zoysia macrantha* (Prickly Couch). | Occurs in the intertidal zone along the NSW coast. | The intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. Frequently found as a zone on the landward side of mangrove stands. | No. No intertidal habitat present. | No. Community not present. | No |
| Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | | Dominated by herbaceous plants and have very few woody species. Areas that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 m tall and dominated by amphibious plants. Where they are subject to regular inundation and drying the vegetation may include large emergent sedges over 1 m tall, as well as emergent or floating herbs. As standing water becomes deeper or more permanent, floating and submerged aquatic herbs become more abundant. | Known from along the majority of the NSW coast. | Coastal areas subject to periodic flooding and in which standing fresh water persists for at least part of the year. Typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes. | Potential. | No. Community not present. Balickera Canal is constructed, and aquatic vegetation is generally absent. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions | E | | Generally forms a tall to very tall (18-35 m) woodland. Stands on major floodplains are generally dominated by *Eucalyptus camaldulensis* (River Red Gum) in combinations with *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus melliodora* (Yellow Box) and *Angophora floribunda* (Rough-barked Apple). Stands of *Casuarina cunninghamiana subsp. cunninghamiana* (River Oak) and *Casuarina glauca* (Swamp Oak) can form a part of this community. | Along the Hunter River and tributaries in the local government areas of Maitland, Mid-Western, Muswellbrook, Singleton, and Upper Hunter but may occur elsewhere within the NSW North Coast and Sydney Basin Bioregions. | Floodplains and associated rises. | No. Combination of characteristic species, landform and location not present. | No. Community not present. | No |
| Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions | E | | Open forest where the most common canopy tree species are *Eucalyptus tereticornis* (Forest Red Gum) and *E. punctata* (Grey Gum). Other frequently occurring canopy species are Angophora floribunda (Rough-barked Apple), *E. crebra* (Narrow-leaved Ironbark), *E. moluccana* (Grey Box) and *Corymbia maculata* (Spotted Gum). The shrub layer is open and common shrub species include *Breynia oblongifolia* (Coffee Bush), *Leucopogon juniperinus* (Prickly Beard-heath), *Daviesia ulicifolia* (Gorse Bitter Pea) and *Jacksonia scoparia* (Dogwood). The ground cover typically comprises grasses and herbs. | Between Muswellbrook, Beresfield, Mulbring and Cessnock in the Lower Hunter in the Sydney Basin and North Coast bioregions. | Gentle slopes of depressions and drainage flats on the Permian sediments of the Hunter Valley floor. | No. Study area is not on Permian sediments. | No. Community not present. | No |
| Hunter Valley Vine Thicket in the NSW North Coast and Sydney Basin Bioregions | E | | Typically forms a low forest, usually less than 10 m tall, with a closed canopy dominated by small rainforest trees. Emergent eucalypts are common. A shrub stratum is usually present. | Highly restricted geographic distribution in the central Hunter Valley. The largest occurrence is at Brushy | Mainly occurs on rocky slopes on Carboniferous sediments and volcanics, | No. No rocky slopes or vine thickets present. | No. Community not present. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | Vines are common and ground cover is generally sparse. | Hill adjacent to Glenbawn Dam, north east of Scone. | occasionally with limestone. | | | |
| Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | CE | Littoral Rainforest is generally a closed forest, the structure and composition of which is strongly influenced by its proximity to the ocean. The plant species of this community are predominantly rainforest species. While the canopy is dominated by rainforest species, scattered emergent individuals of sclerophyll species, such as *Angophora costata, Banksia integrifolia, Eucalyptus botryoides* and *Eucalyptus tereticornis* occur in many stands. There is considerable floristic variation between stands. | Occurs only on the coast, mostly within 2 k of the sea though occasionally further inland. Found at locations in the NSW North Coast Bioregion, Sydney Basin Bioregion and South East Corner Bioregion. | Occurs on sand dunes and on soil derived from underlying rocks. | No. No littoral rainforest vegetation present. | No. Community not present. | No |
| Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions | E | | This community is dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus fibrosa* (Broad-leaved Ironbark), while *E. punctata* (Grey Gum) and *E. crebra* (Grey Ironbark) occur occasionally. A number of other eucalypt species occur at low frequency, but may be locally common in the community. The understorey is marked by *Acacia parvipinnula, Daviesia ulicifolia, Bursaria spinosa, Melaleuca nodosa* and *Lissanthe strigosa.* In an undisturbed condition the structure of the community is typically open forest. | Restricted to a range of approximately 65 km by 35 km centred on the Cessnock - Beresfield area in the Central and Lower Hunter Valley. Outliers are also present on the eastern escarpment of Pokolbin and Corrabare State Forests. | Occurs principally on Permian geology in the central to lower Hunter Valley; also on Narrabeen Sandstone. | Potential. | No.<br>Community not present.<br>Study area not on Permian sediments, characteristic species *Eucalyptus fibrosa* not present, and community in study area contains high | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | abundance and diversity of other Eucalypt species. | |
| Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions | V | | Lower Hunter Valley Dry Rainforest typically has a canopy of 15-25 m high with 40-80% cover. The most common canopy trees include *Elaeocarpus obovatus* (Hard Quandong), *Baloghia inophylla* (Brush Bloodwood), *Streblus brunonianus* (Whalebone Tree), *Mallotus philippensis* (Red Kamala), *Capparis arborea* (Brush Caper Berry), *Olea paniculata* (Native Olive) and *Dendrocnide excelsa* (Giant Stinging Tree). Emergent trees 20 to 30 m tall are often present. The shrub layer is dense and vines are abundant. The ground cover is variable and is comprised of forbs, grasses and ferns. | This community mainly occurs on the Barrington footslopes along the northern rim of the Hunter Valley Floor, where it occupies gullies and steep hillslopes with south facing aspects. | Typically occurs on Carboniferous sediments in gullies and on steep hillslopes with south facing aspects. It is generally found at elevations less than 300 m a.s.l. with a mean rainfall less than 900 mm. | No.<br>No dry rainforest vegetation communities present. | No.<br>Community not present. | No |
| Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions | E | CE | In a relatively undisturbed state, the community has a closed canopy, characterised by a high diversity of trees whose leaves may be mesophyllous and encompass a wide variety of shapes and sizes. Typically, the trees form three major strata: emergents, canopy and sub-canopy which, combined with variations in crown shapes and sizes results in an irregular canopy appearance. The trees are taxonomically diverse at the genus and family levels, and some may have buttressed roots. A range of | From the NSW north coast south to the Hawkesbury River. | Associated with a range of high-nutrient geological substrates, notably basalts and fine-grained sedimentary rocks, on coastal plains and plateaux, footslopes and foothills. | No.<br>No rainforest vegetation communities present. | No.<br>Community not present. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | plant growth forms are present, including palms, vines and vascular epiphytes. | | | | | |
| Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion | E | CE | Larger stands of the community typically have a dense canopy, which blocks most light from reaching the ground, creating cool, moist conditions within. Typical tree species in the community include figs (*Ficus macrophylla, F. obliqua and F. watkinsiana*), palms (*Archontophoenix cunninghamiana* and *Livistona australis*), *Grevillea robusta* (Silky Oak), *Castanospermum australe* (Black Bean) and *Syzygium australe* (Brush Cherry). | Small remnants in scattered localities on floodplains of the NSW north coast. | Generally occupies riverine corridors and alluvial flats with rich, moist silts often in subcatchments dominated by basic volcanic substrates. | No.<br>No rainforest vegetation communities present. | No.<br>Community not present. | No |
| River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | CE | The structure of the community may vary from tall open forests (>40 m) to woodlands. The most widespread and abundant dominant trees include *Eucalyptus tereticornis* (Forest Red Gum), *E. amplifolia* (Cabbage Gum), *Angophora floribunda* (Rough-barked Apple). A layer of small trees and scattered shrubs may be present. The groundcover is composed of abundant forbs, scramblers and grasses. | Coastal floodplains of NSW. | Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. | Yes. Suitable habitat and species present. | No.<br>Community present in study area. The community is outside of the subject site and no impacts to the community will occur. | No |
| Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion | E | | The composition of the tree stratum (which may exceed 40 m in height) varies considerably, but the most widespread and abundant dominant trees include *Eucalyptus tereticornis* (forest red gum), *E. siderophloia* | Coastal floodplains of the North Coast of NSW. | Associated with clay-loams and sandy loams, on periodically inundated alluvial | No.<br>Combination of characteristic species, | No.<br>Community not present. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | (grey ironbark), *Corymbia intermedia* (pink bloodwood) and, north of the Macleay floodplain, *Lophostemon suaveolens* (swamp turpentine). A layer of small trees and scattered shrubs may be present. The groundcover is composed of abundant forbs, scramblers and grasses. | | flats, drainage lines and river terraces associated with coastal floodplains. | landform and location not present. | | |
| Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | E | The structure of the community may vary from open forests to low woodlands, scrubs or reedlands with scattered trees. It has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species. Other trees including *Acmena smithii* (Lilly Pilly), *Glochidion spp.* (Cheese Tree) and *Melaleuca spp.* (paperbarks) may be present as subordinate species. The understorey is characterised by frequent occurrences of vines, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter.The composition of the ground stratum varies depending on levels of salinity in the groundwater. | Coastal floodplains of NSW. | Associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. Generally occurs below 20 m elevation. | Yes. Suitable habitat and species present. | No. Community present in study area. The community is outside of the subject site and no impacts to the community will occur. | No |
| Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions | E | | The most widespread and abundant dominant trees include *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenervia* (Paperbark) and, south from Sydney, *Eucalyptus botryoides* (Bangalay) and *Eucalyptus longifolia* (Woollybutt). Shrubs and occasional vines may be present. The | Coastal floodplains of NSW. | Associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage | No. Characteristic species not present. | No. Community not present. | No |

| Community Name | BC Act Status | EPBC Act Status | Description | Distribution | Habitat | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|
| | | | groundcover is composed of abundant sedges, ferns, forbs, and grasses. | | lines associated with coastal floodplains. | | | |
| Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions | E | | In this community *Themeda australis* may have a distinctive appearance, being prostrate and having glaucous leaves. *Banksia integrifolia subsp. integrifolia, Westringia fruticosa* and *Acacia sophorae* occurs as an emergent shrub or as a dense cover where they have recruited over grasslands. Smaller shrubs occur often as prostrate to dwarf forms. | Widely scattered patches in the NSW North Coast, Sydney Basin and South East Corner bioregions. | Found on a range of substrates, although infrequently on sandstone. | No. Study area not on coast. | No. Community not present. | No |
| 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 | CE | CE | Characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs, and the dominance, or prior dominance, of *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) and *E. blakelyi* (Blakely's Red Gum). In the Nandewar Bioregion, *Eucalyptus microcarpa* or *E. moluccana* (Grey Box) may also be dominant or co-dominant. The tree-cover is generally discontinuous and consists of widely-spaced trees of medium height in which the canopies are clearly separated. | Occurs in an arc along the western slopes and tablelands of the Great Dividing Range from Southern Queensland through NSW to central Victoria. | Areas where rainfall is between 400 and 1200 mm per annum, on moderate to highly fertile soils at altitudes of 170 m to 1200 m. | No. Characteristic species not present. | No. Community not present. | No |

**Table B-2: Likelihood of occurrence of threatened flora species**

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Angophora inopina* | Charmhaven Apple | V | V | Endemic to the Central Coast region of NSW. Populations occur around Karuah, and from Toronto to Charmhaven. There is an unconfirmed record of the species near Bulahdelah. | In open woodland with a dense shrub understorey on deep white sandy soils over sandstone. | 14 | Unlikely. No sandy soils present in study area. | No. This species was not recorded during targeted surveys.<br>No suitable habitat would be affected. | No |
| *Arthraxon hispidus* | Hairy Jointgrass | V | V | In NSW, found on the northern tablelands and north coast. | Edges of rainforest and in wet eucalypt forest, often near creeks or swamps. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Asperula asthenes* | Trailing Woodruff | V | V | Only in NSW, in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens/Wallis Lakes area | Damp sites, often along river banks. | 1 | Potential. Marginal habitat only and one record from locality. | No. This species was not recorded during targeted surveys. | No |
| *Caladenia tessellata* | Thick Lip Spider Orchid | E | V | Currently known from two disjunct areas; one population near Braidwood on the Southern Tablelands and three populations in the Wyong area on the Central Coast. | Grassy sclerophyll woodland on clay loam or sandy soils, or low woodland with stony soil. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Callistemon linearifolius* | Netted Bottle Brush | V | | Georges River to Hawkesbury River in the Sydney area (limited to the Hornsby Plateau area), and north to the Nelson Bay | Dry sclerophyll forest. | 4 | Potential. Dry sclerophyll forest in study area. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | area of NSW. Also, Coalcliff in the northern Illawarra. | | | | | |
| *Commersonia prostrata* | Dwarf Kerrawang | E | E | In NSW, found in the Southern Highlands and Southern Tablelands (Penrose State Forest, Tallong, near the Corang, and Rowes Lagoon), the Thirlmere Lakes area and on the North Coast (Tomago sandbeds north of Newcastle). | Occurs on sandy, sometimes peaty soils in a wide variety of habitats. | 0 | Unlikely. No sandy or peaty soils and no records within 10 km. | No. No suitable habitat would be affected. | No |
| *Corybas dowlingii* | Red Helmet Orchid | E | | Restricted to the central coast and Hunter regions of NSW, in the Port Stephens, Bulahdelah, Lake Macquarie and Freemans Waterhole areas. | Gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200 m. | 3 | Unlikely. No gullies or southerly slopes on gravelly soils within subject site. Only three records within locality from the Medowie area. recommended for delisting. | No. No suitable habitat would be affected. Also note that a recent genetic study (Wagner et al 2020) has revised the taxonomic status of *C. dowlingii*, and it is no longer considered a distinct species. | No |
| *Cryptostylis hunteriana* | Leafless Tongue Orchid | V | V | In NSW, recorded mainly on coastal and near coastal ranges north from Victoria to near Forster, with two isolated occurrences inland north-west of Grafton. | Coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest. | 0 | Unlikely. No records within locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Cynanchum elegans* | White-flowered Wax Plant | E | E | Restricted to eastern NSW, from Brunswick Heads on the north coast to Gerroa in the Illawarra region, and as far west as Merriwa in the upper Hunter River valley. | Dry rainforest; littoral rainforest; Coastal Tea-tree– Coastal Banksia) coastal scrub; Forest Red Gum or Spotted Gum open forest and woodland; and Bracelet Honeymyrtle scrub. | 0 | Unlikely. No suitable rainforest habitat. Marginal forest habitat. No records within locality. | No. This species was not recorded during targeted surveys. | No |
| *Dichanthium setosum* | Bluegrass | V | V | In NSW, found on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes. | Cleared woodland, grassy roadside remnants and highly disturbed pasture, on heavy basaltic black soils and red-brown loams with clay subsoil. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Diuris praecox* | Rough Doubletail | V | V | Between Bateau Bay and Smiths Lake, in hills and slopes of near-coastal districts. | On hills and slopes in open forests with a grassy to fairly dense understorey. | 0 | Unlikely. Subject site on not on hills and slopes. No records within locality. | No. No suitable habitat would be affected. | No |
| *Eucalyptus camfieldii* | Camfield's Stringybark | V | V | Narrow band from the Raymond Terrace area south to Waterfall. | Coastal heath on shallow sandy soils overlying Hawkesbury sandstone, mostly on exposed sandy ridges. | 0 | No. No coastal heath on sandy soils present within study area. No records within locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Eucalyptus glaucina* | Slaty Red Gum | V | V | Only on the north coast of NSW. Found near Casino and farther south, from Taree to Broke, west of Maitland. | Grassy woodland and dry eucalypt forest on deep, moderately fertile and well-watered soils. | 3 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Eucalyptus parramattensis* subsp. *decadens* | | V | V | Two separate meta-populations: one bordered by Cessnock—Kurri Kurri in the north and Mulbring—Aberdare in the south, and the other bounded by Salt Ash and Tanilba Bay in the north and Williamtown and Tomago in the south. | Dry sclerophyll woodland, wet or dry heath on deep, low-nutrient sands, often subject to periodic inundation or where water tables are relatively high. | 0 | No. No suitable habitat containing low nutrient sands subject to periodic inundation. No records in locality. | No. No suitable habitat would be affected. | No |
| *Euphrasia arguta* | | E | CE | In NSW, recently recorded only from Nundle area of the north western slopes and tablelands, from near the Hastings River and from the Barrington Tops. | Eucalypt forest with a mixed grass and shrub understorey, disturbed areas, along roadsides. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Grevillea parviflora* subsp. *parviflora* | Small-flower Grevillea | V | V | Sporadically distributed throughout the Sydney Basin and in the Hunter in the Cessnock - Kurri Kurri area. Also known from Putty to Wyong and Lake Macquarie on the Central Coast. | Heath and shrubby woodland to open forest on sandy or light clay soils usually over thin shales. | 10 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Maundia triglochinoides* | | V | | Coastal NSW north from Wyong and extending into southern Qld. | Swamps, lagoons, dams, channels, creeks or shallow freshwater | 5 | Potential. Channel presents marginal habitat. Five | No. This species was not recorded | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 30 - 60 cm deep on heavy clay. | | records from within 10 km, no records within locality. | during targeted surveys. | |
| *Melaleuca biconvexa* | Biconvex Paperbark | V | V | Only found in NSW, populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. | Damp places, often near streams or low-lying areas on alluvial soils. | 0 | Unlikely. No suitable habitat and no records within locality. | No. No suitable habitat would be affected. | No |
| *Persicaria elatior* | Tall Knotweed | V | V | In south-eastern NSW recorded from Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). | Beside streams and lakes, swamp forest or disturbed areas. | 1 | Potential. Disturbed canal provides marginal habitat. Only one record from within 10 km. | No. This species was not recorded during targeted surveys. | No |
| *Phaius australis* | Southern Swamp Orchid | E | E | Qld and north-east NSW as far south as Coffs Harbour. | Swampy grassland or swampy forest including rainforest, eucalypt or paperbark forest, mostly in coastal areas. | 0 | No. No swamp or swamp forest habitat in study area. | No. No suitable habitat would be affected. | No |
| *Prasophyllum* sp. *Wybong* | | | CE | Endemic to NSW, it is known from near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell, Tenterfield, Currabubula and the Pilliga area. Most populations are small, | Known to occur in open eucalypt woodland and grassland | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | although the Wybong population contains by far the largest number of individuals. | | | | | |
| *Pterostylis chaetophora* | | V | | In NSW, currently known from 18 scattered locations between Taree and Kurri Kurri, extending to the south-east towards Tea Gardens and west into the Upper Hunter, with additional records near Denman and Wingen. There are also a few records from the Sydney region, but it is unclear if any of these populations still exist. | Seasonally moist dry sclerophyll forest. | 543 | Yes. Recorded in study area. | No. Species determined not to be present within subject site based on surveys. | No |
| *Rhizanthella slateri* | Eastern Australian Underground Orchid | V | E | In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. | Sclerophyll forest in shallow to deep loams. | 0 | Unlikely. No records within locality. | No. No suitable habitat would be affected. | No |
| *Rhodamnia rubescens* | Scrub Turpentine | CE | CE | Occurs in coastal districts north from Batemans Bay in New South Wales, approximately 280 km south of Sydney, to areas inland of Bundaberg in Queensland. Typically occur in coastal regions and occasionally extend inland onto escarpments | Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils. | 2 | Potential. Marginal habitat. Rainforest and wet forest not present in study area. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | up to 600 m a.s.l. in areas with rainfall of 1,000-1,600 mm. | | | | | |
| *Rhodomyrtus psidioides* | Native Guava | CE | CE | In New South Wales (NSW), *Rhodomyrtus psidioides* is currently known to occur from Broken Bay, approximately 30 km north of Sydney, to the Queensland (Qld) border. Populations of the species extend north to Gympie, Qld. NSW populations are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120 km inland in the Hunter and Clarence River catchments and along the Border Ranges. | In NSW, suitable habitat for *R. psidioides* is likely to occur in the following vegetation classes: Subtropical Rainforests, Northern Warm Temperate Rainforests, Littoral Rainforests, North Coast Wet Sclerophyll Forests and possibly (especially at margins with rainforest types), Northern Hinterland Wet Sclerophyll Forests | 1 | Unlikely. Rainforest and wet forest not present in study area. | No. This species was not recorded during targeted surveys. | No |
| *Syzygium paniculatum* | Magenta Lilly Pilly | E | V | Only in NSW, in a narrow, linear coastal strip from Upper Lansdowne to Conjola State Forest. | Subtropical and littoral rainforest on gravels, sands, silts and clays. | 0 | No. No rainforest habitat present in study area. | No. No suitable habitat would be affected. | No |
| *Tetratheca juncea* | Black-eyed Susan | V | V | Confined to the northern Sydney Basin bioregion and the southern North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. | Low open forest/woodland, heathland and moist forest, mainly on low nutrient soils associated with the Awaba Soil Landscape. | 3 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Thesium australe* | Austral Toadflax | V | V | In eastern NSW it is found in very small populations scattered along the coast, and from the Northern to Southern Tablelands. | Grassland on coastal headlands or grassland and grassy woodland away from the coast. | 0 | No. No native grassland or grassy woodland habitat in study area. No records within locality. | No. No suitable habitat would be affected. | No. |

**Table B-3: Likelihood of occurrence for threatened fauna species and populations**

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Heleioporus australiacus* | Giant Burrowing Frog | V | V | South eastern NSW and Victoria, in two distinct populations: a northern population in the sandstone geology of the Sydney Basin as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. | Heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. | 0 | No. No suitable habitat in the study area. No records within 10 km. | No. No suitable habitat would be affected. | No |
| *Litoria aurea* | Green and Golden Bell Frog | E | V | Since 1990, recorded from ~50 scattered sites within its former range in NSW, from the north coast near Brunswick Heads, south along the coast to Victoria. Records exist west to Bathurst, Tumut and the ACT region. | Marshes, dams and stream-sides, particularly those containing *Typha* spp. or *Eleocharis* spp. Some populations occur in highly disturbed areas. | 1 | Unlikely. Very marginal habitat present. Only one record from within 10 km from 1985. | No. Species not recorded in targeted survey. No habitat would be affected. | No |
| *Litoria brevipalmata* | Green-thighed Frog | V | | Isolated localities along the coast and ranges from just north of Wollongong to south-east Queensland. | Occurs in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. It prefers wetter forests in the south of its range but extends into drier forests in northern NSW and southern Queensland. | 0 | No. No suitable habitat with pooling rainwaters in forest in the study area. No records within 10 km. | No. No suitable habitat would be affected. | No |
| *Mixophyes balbus* | Stuttering Frog | E | V | Along the east coast of Australia from southern Qld to north-eastern Victoria. | Rainforest and wet, tall open forest in the foothills and | 0 | No. No suitable rainforest or wet forest | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | escarpment on the eastern side of the Great Dividing Range. | | habitat in the study area. No records within 10 km. | | |
| *Mixophyes iteratus* | Giant Barred Frog | E | E | Coast and ranges from Eumundi in south-east Qld to Warrimoo in the Blue Mountains. | Freshwater permanent/semi-permanent streams, generally at lower elevation. Riparian rainforest or wet sclerophyll forest is favoured. | 0 | No. No suitable rainforest or wet forest habitat in the study area. No records within 10 km. | No. No suitable habitat would be affected. | No |
| *Actitis hypoleucos* | Common Sandpiper | | M | Summer migrant. In NSW, widespread along coastline and also occurs in many areas inland. | Coastal wetlands and some inland wetlands, especially muddy margins or rocky shores. Also, estuaries and deltas, lakes, pools, billabongs, reservoirs, dams and claypans, mangroves. | 0 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |
| *Anous stolidus* | Common Noddy | | M | Casual visitor to coastal NSW. | Marine. | 0 | No. Marine species. | No. No suitable habitat would be affected. | No |
| *Anseranas semipalmata* | Magpie Goose | V | | In NSW, found in central and northern parts of the state, with vagrants as far as south-eastern NSW. | Shallow wetlands, floodplains, grasslands, pastures, dams and crops. | 13 | No. No suitable habitat in the study area. | No. No suitable habitat would be affected. | No |
| *Anthochaera phrygia* | Regent Honeyeater | CE | CE | Inland slopes of south-east Australia, and less frequently in coastal areas. In NSW, most records are from the North-West Plains, North-West and South- | Eucalypt woodland and open forest, wooded farmland and urban areas with mature eucalypts, and riparian forests of | 2 | Potential. Eucalypt forest in study area. Only two | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | West Slopes, Northern Tablelands, Central Tablelands and Southern Tablelands regions; also recorded in the Central Coast and Hunter Valley regions. | *Casuarina cunninghamiana* (River Oak). | | records within 10 km. | Unlikely to breed or forage regularly in the study area. Study area not mapped important area under BAM. | |
| *Apus pacificus* | Fork-tailed Swift | | M | Recorded in all regions of NSW. | Riparian woodland, swamps, low scrub, heathland, saltmarsh, grassland, Spinifex sandplains, open farmland and inland and coastal sand-dunes. | 0 | Unlikely. This species is mostly aerial and is unlikely to land in the study area due to unsuitable habitat. | No. No suitable habitat would be affected. | No |
| *Ardenna pacifica* | Wedge-tailed Shearwater | | M | Throughout the tropical Pacific and Indian Ocean roughly between latitudes 35°N and 35°S. | Nearly always found over pelagic waters, except when at colonies. They feed on fish, cephalopods, crustaceans and insects. | 1 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Artamus cyanopterus cyanopterus* | Dusky Woodswallow | V | | Widespread in NSW from coast to inland including the western slopes of the Great Dividing Range and farther west. Species have also been recorded in southern and southwestern Australia. | Woodlands and dry open sclerophyll forest, usually eucalypts and mallee associations. Also have recordings in shrub and heathlands and various modified habitats, including regenerating forests. In western NSW, this species is primarily associated | 5 | Unlikely. Eucalypt forest present in study area. Only five records all west of study area and most recent in 2000. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | with River Red Gum/Black Box/Coolabah open forest/woodland and associated with larger river/creek systems. | | | | |
| *Botaurus poiciloptilus* | Australasian Bittern | E | E | Found over most of NSW except for the far north-west. | Permanent freshwater wetlands with tall, dense vegetation, particularly *Typha* spp. and *Eleocharis* spp.. | 1 | No. No suitable wetland habitat with dense vegetation in the study area. | No. No suitable habitat would be affected. | No |
| *Burhinus grallarius* | Bush Stone-curlew | E | | In NSW, found sporadically in coastal areas, and west of the divide throughout the sheep-wheat belt. | In NSW, it occurs in lowland grassy woodland and open forest. | 1 | Unlikely. Forest habitats in study area not open. Only one record within 10 km from 2006. | No. No suitable habitat would be affected. | No |
| *Calidris acuminata* | Sharp-tailed Sandpiper | | M | Summer migrant. Widespread in most regions of NSW, especially in coastal areas, but sparse in the south-central Western Plain and east Lower Western Regions. | Shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. | 4 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |
| *Calidris canutus* | Red Knot | | E, M | Summer migrant to Australia. In NSW, widespread in suitable habitat along the coast. Occasionally recorded inland in all regions. | Intertidal mudflats, sandflats sheltered sandy beaches, estuaries, bays, inlets, lagoons, harbours, sandy ocean beaches, rock platforms, coral reefs, terrestrial saline wetlands near the coast, sewage ponds and | 0 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | saltworks. Rarely inland lakes or swamps. | | | | |
| *Calidris ferruginea* | Curlew Sandpiper | E | CE, M | Occurs along the entire coast of NSW, and sometimes in freshwater wetlands in the Murray-Darling Basin. | Littoral and estuarine habitats, including intertidal mudflats, non-tidal swamps, lakes and lagoons on the coast and sometimes inland. | 0 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |
| *Calidris melanotos* | Pectoral Sandpiper | | M | Summer migrant to Australia. Widespread but scattered in NSW. East of the Great Divide, recorded from Casino and Ballina, south to Ulladulla. West of the Great Divide, widespread in the Riverina and Lower Western regions. | Shallow fresh to saline wetlands, including coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. | 1 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |
| *Calyptorhynchus lathami* | Glossy Black-Cockatoo | V | | In NSW, widespread along coast and inland to the southern tablelands and central western plains, with a small population in the Riverina. | Open forest and woodlands of the coast and the Great Dividing Range where stands of sheoak occur. | 25 | Potential. Eucalypt forest in study area. | No. No breeding habitat (large hollow bearing trees) or foraging habitat (stands of Allocasuarina spp.) will be impacted. | No |
| *Chlidonias leucopterus* | White-winged Black Tern | | M | Summer migrant. Found in coastal and sub-coastal NSW, and at times well inland. | Large coastal and inland wetlands, saltfields, tidal | 1 | No. No suitable wetland habitat within | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | estuaries, lagoons, grassy swamps, and sewage ponds. | | the subject site. | | |
| *Chthonicola sagittata* | Speckled Warbler | V | | From south-eastern Qld, the eastern half of NSW and into Victoria, as far west as the Grampians, mostly on hills and tablelands of the Great Dividing Range and rarely on coast. | Eucalyptus-dominated communities with a grassy understorey and sparse shrub layer, often on rocky ridges or in gullies. | 3 | Potential. Eucalypt forest in study area. Three records from within 10 km, most recent in 2008. | No. This species was not recorded during targeted surveys. | No |
| *Circus assimilis* | Spotted Harrier | V | | Found throughout the Australian mainland, except in densely forested or wooded habitats, and rarely in Tasmania. | Grassy open woodland, inland riparian woodland, grassland, shrub steppe, agricultural land and edges of inland wetlands. | 2 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Climacteris picumnus victoriae* | Brown Treecreeper (eastern subspecies) | V | | From eastern through central NSW, west to Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell. | Eucalypt woodlands and dry open forest. | 5 | Potential. Eucalypt forest in study area. Five records within 10 km, most recent in 2013. | No. This species was not recorded during targeted surveys. | No |
| *Cuculus optatus* | Oriental Cuckoo | | M | Northern and eastern Australia, records mainly coastal in NSW south to Bega area. | Non breeding habitat: monsoonal rainforest, vine thickets, wet sclerophyll forest or open Casuarina, Acacia or Eucalyptus woodland. | 0 | Unlikely. Study area generally contains dry sclerophyll forest. No records in locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Daphoenositta chrysoptera* | Varied Sittella | V | | Distribution in NSW is nearly continuous from the coast to the far west. | Inhabits eucalypt forests and woodlands, mallee and Acacia woodland. | 16 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Dromaius novaehollandiae* | Emu population in the New South Wales North Coast Bioregion and Port Stephens local government area | E | | In north-eastern NSW, now restricted to coastal and near-coastal areas between Evans Head and Red Rock and a small isolated population further west in the Bungawalbin area. It is not known whether it persists in the Port Stephens area. | On the NSW north coast, found in grasslands, heathland, shrubland, open and shrubby woodlands, forest, swamps, sedgeland, tea-tree plantations and open farmland, and littoral rainforest. | 2 | No. Only one record of wild bird from within 10 km in 1992. Local population is most likely extinct (Roderick and Stuart, 2010). | No. No suitable habitat would be affected. | No |
| *Ephippiorhynchus asiaticus* | Black-necked Stork | E | | Coastal and subcoastal northern and eastern Australia, south to central-eastern NSW and with vagrants recorded further south and inland. | In NSW, floodplain wetlands of the major coastal rivers are key habitat. Also, minor floodplains, coastal sandplain wetlands and estuaries. | 34 | No. No suitable habitat. | No. No suitable habitat would be affected. | No |
| *Epthianura albifrons* | White-fronted Chat | V | | Occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the western part of the state. | Saltmarsh vegetation, open grasslands and sometimes low shrubs bordering wetland areas. | 1 | No. No suitable habitat. Only one record in within 10 km. | No. No suitable habitat would be affected. | No |
| *Erythrotriorchis radiatus* | Red Goshawk | E | V | In NSW, extends to ~30°S. Recent records confined to the Northern Rivers region north of the Clarence River. | Open woodland and forest, often along or near watercourses or wetlands. In NSW, preferred habitats include | 0 | No. Subject site is outside of species' normal range. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | mixed subtropical rainforest, Melaleuca swamp forest and coastal riparian Eucalyptus forest. | | No records within the locality. | | |
| *Falco hypoleucos* | Grey Falcon | E | | Arid and semi-arid zones. In NSW, found chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. | Shrubland, grassland and wooded watercourses, occasionally in open woodlands near the coast, and near wetlands. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Falco subniger* | Black Falcon | V | | Sparsely distributed in NSW, occurring mostly in inland regions. | Woodland, shrubland and grassland, especially riparian woodland and agricultural land. Often associated with streams or wetlands. | 1 | No. Subject site outside species' normal range which is more inland areas. One record from 1985 within 10 km. | No. No suitable habitat would be affected. | No |
| *Gallinago hardwickii* | Latham's Snipe | | M | Migrant to east coast of Australia, extending inland west of the Great Dividing Range in NSW. | Freshwater, saline or brackish wetlands up to 2000 m above sea-level; usually freshwater swamps, flooded grasslands or heathlands. | 54 | Unlikely. No suitable habitat in the study area. | No. No suitable habitat would be affected. | No |
| *Glossopsitta pusilla* | Little Lorikeet | V | | In NSW, found from the coast westward as far as Dubbo and Albury. | Dry, open eucalypt forests and woodlands, including remnant woodland patches and roadside vegetation. | 14 | Yes. Species recorded flying over subject site and likely to forage in | Yes. Species recorded in study area. | Yes |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Eucalypt forests within the study area. | | |
| *Grantiella picta* | Painted Honeyeater | V | V | Widely distributed in NSW, predominantly on the inland side of the Great Dividing Range but avoiding arid areas. | Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. | 0 | No. Study area is outside of species' normal range and does not contain suitable forest types. | No. No suitable habitat would be affected. | No |
| *Haematopus longirostris* | Pied Oystercatcher | E | | Thinly scattered along the entire NSW coast. | Intertidal flats of inlets and bays, open beaches and sandbanks. | 0 | No. Species restricted to coast and estuaries. | No. No suitable habitat would be affected. | No |
| *Haliaeetus leucogaster* | White-bellied Sea-Eagle | V | | Distributed along the coastline of mainland Australia and Tasmania, extending inland along some of the larger waterways, especially in eastern Australia. | Freshwater swamps, rivers, lakes, reservoirs, billabongs, saltmarsh and sewage ponds and coastal waters. Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, forest and urban areas. | 91 | Yes. Species recorded in subject site. | Yes. Species recorded using canal habitat. | Yes |
| *Hieraaetus morphnoides* | Little Eagle | V | | Throughout the Australian mainland, with the exception of the most densely-forested parts of the Dividing Range escarpment. | Open eucalypt forest, woodland or open woodland, including sheoak or Acacia woodlands and riparian woodlands of interior NSW. | 2 | Unlikely. Locality densely forested and only two | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | records within 10 km. | | |
| *Hirundapus caudacutus* | White-throated Needletail | | V, M | All coastal regions of NSW, inland to the western slopes and inland plains of the Great Divide. | Occur most often over open forest and rainforest, as well as heathland, and remnant vegetation in farmland. | 7 | Unlikely. This species is mostly aerial and is unlikely to land in the study area due to unsuitable habitat. | No. No suitable habitat would be affected. | No |
| *Hydroprogne caspia* | Caspian Tern | | M | Widespread in coastal and inland NSW. | Coastal offshore waters, beaches, mudflats, estuaries, rivers, lakes. | 2 | No. No suitable wetland habitat within the subject site. | No. No suitable habitat would be affected. | No |
| *Irediparra gallinacea* | Comb-crested Jacana | V | | In NSW, occurs south along the east coast to the Hunter region, with stragglers recorded in south-eastern NSW. | Permanent freshwater wetlands, either still or slow-flowing, with a good surface cover of floating vegetation or fringing and aquatic vegetation. | 1 | No. No suitable wetland habitat with dense floating aquatic vegetation present within study area. | No. No suitable habitat would be affected. | No |
| *Ixobrychus flavicollis* | Black Bittern | V | | In NSW, records are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland. | Terrestrial and estuarine wetlands. Also flooded grassland, forest, woodland, rainforest and mangroves where permanent water is present. | 1 | No. No suitable wetland habitat present within study area. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Lathamus discolor* | Swift Parrot | E | CE | Migrates from Tasmania to mainland in Autumn-Winter. In NSW, the species mostly occurs on the coast and south west slopes. | Box-ironbark forests and woodlands. | 7 | Potential. Eucalypt forest in study area. | No. Species not present in region during proposed works. Removal of a very small area of potential foraging habitat for wide ranging species would not affect species. Study area not mapped as important area under BAM. | No |
| *Limosa lapponica* | Bar-tailed Godwit | | M | Summer migrant to Australia. Widespread along the coast of NSW, including the offshore islands. Also, numerous scattered inland records. | Intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons, bays, seagrass beds, saltmarsh, sewage farms and saltworks, saltlakes and brackish wetlands near coasts, sandy ocean beaches, rock platforms, and coral reef-flats. Rarely inland wetlands, paddocks and airstrips. | 0 | No. No suitable wetland habitat for shorebirds within the subject site. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Lophoictinia isura* | Square-tailed Kite | V | | In NSW, it is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast. | Timbered habitats including dry woodlands and open forests, particularly timbered watercourses. | 2 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Melanodryas cucullata cucullata* | Hooded Robin (south-eastern form) | V | | Found throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies picata. | Open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Melithreptus gularis gularis* | Black-chinned Honeyeater (eastern subspecies) | V | | Widespread in NSW from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. Also Richmond and Clarence River areas and a few scattered sites in the Hunter, Central Coast and Illawarra regions. | Open forests or woodlands dominated by box and ironbark eucalypts, or by smooth-barked gums, stringybarks, river sheoaks and tea-trees. | 0 | Unlikely. Eucalypt forest present. No records in locality. | No. This species was not recorded during targeted surveys. | No |
| *Monarcha melanopsis* | Black-faced Monarch | | M | In NSW, occurs around the eastern slopes and tablelands of the Great Divide, inland to Coutts Crossing, Armidale, Widden Valley, Wollemi National Park and Wombeyan Caves. It is rarely recorded farther inland. | Rainforest, open eucalypt forests, dry sclerophyll forests and woodlands, gullies in mountain areas or coastal foothills, Brigalow scrub, coastal scrub, mangroves, parks and gardens. | 10 | Likely. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. Species not listed under BC Act. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Monarcha trivirgatus* | Spectacled Monarch | | M | Coastal eastern Australia south to Port Stephens in NSW. | Mountain/lowland rainforest, wooded gullies, riparian vegetation including mangroves. | 0 | Unlikely. Study area generally contains dry sclerophyll forest. No records in locality. | No. No suitable habitat would be affected. Species not listed under BC Act. | No |
| *Motacilla flava* | Yellow Wagtail | | M | Regular summer migrant to mostly coastal Australia. In NSW recorded Sydney to Newcastle, the Hawkesbury and inland in the Bogan LGA. | Swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land, lawns. | 0 | Unlikely. Marginal habitat only. No records from locality. | No. No suitable habitat would be affected. Species not listed under BC Act. | No |
| *Myiagra cyanoleuca* | Satin Flycatcher | | M | In NSW, widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains. | Eucalypt-dominated forests, especially near wetlands, watercourses, and heavily-vegetated gullies. | 2 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. Species not listed under BC Act. | No |
| *Neophema pulchella* | Turquoise Parrot | V | | Occurs along the length of NSW from the coastal plains to the western slopes of the Great Dividing Range. | Eucalypt and cypress pine open forests and woodlands, ecotones between woodland and grassland, or coastal forest and heath. | 2 | Unlikely. Marginal habitat only and few records. | No. This species was not recorded during targeted surveys. | No |
| *Ninox connivens* | Barking Owl | V | | Wide but sparse distribution in NSW, avoiding the most central arid regions. Core populations | Woodland and open forest, including fragmented remnants | 3 | Unlikely. Species not typically | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | exist on the western slopes and plains and in some northeast coastal and escarpment forests. | and partly cleared farmland, wetland and riverine forest. | | present in coastal areas. Only three records within 10 km, most recent in 1999. | | |
| *Ninox strenua* | Powerful Owl | V | | In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered records on the western slopes and plains. | Woodland, open sclerophyll forest, tall open wet forest and rainforest. | 17 | Potential. Eucalypt forest in study area. | Yes. Species may use study area as part of large foraging range. No breeding habitat present. | Yes |
| *Numenius madagascariensis* | Eastern Curlew | | CE, M | Summer migrant to Australia. Primarily coastal distribution in NSW, with some scattered inland records. | Estuaries, bays, harbours, inlets and coastal lagoons, intertidal mudflats or sandflats, ocean beaches, coral reefs, rock platforms, saltmarsh, mangroves, lakes, saltworks and sewage farms. | 1 | No. No suitable habitat. Only one record in within 10 km. | No. No suitable habitat would be affected. | No |
| *Oxyura australis* | Blue-billed Duck | V | | Widespread in NSW but is most concentrated in the southern Murray-Darling Basin area. | Coastal and inland wetlands and swamps. | 1 | No. No suitable habitat. Only one record within 10 km. | No. No suitable habitat would be affected. | No |
| *Pachycephala olivacea* | Olive Whistler | V | | In NSW chiefly occurs around Barrington Tops and the MacPherson Ranges, and from the Illawarra south to Victoria. In the south it is found inland to the | Mostly inhabits wet forests above about 500 m. | 0 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Snowy Mountains and the Brindabella Range. | | | | | |
| *Pandion cristatus* | Eastern Osprey | V | | Common around the northern NSW coast, and uncommon to rare from coast further south. Some records from inland areas. | Rocky shorelines, islands, reefs, mouths of large rivers, lagoons and lakes. | 0 | No. No suitable large waterbodies for habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Petroica boodang* | Scarlet Robin | V | | In NSW, it occurs from the coast to the inland slopes. | Dry eucalypt forests and woodlands, and occasionally in mallee, wet forest, wetlands and tea-tree swamps. | 4 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Petroica phoenicea* | Flame Robin | V | | In NSW, breeds in upland areas, and in winter many birds move to the inland slopes and plains, or occasionally to coastal areas. Likely that there are two separate populations in NSW, one in the Northern Tablelands, and another ranging from the Central to Southern Tablelands. | Breeds in upland tall moist eucalypt forests and woodlands. In winter uses dry forests, open woodlands, heathlands, pastures and native grasslands. Occasionally occurs in temperate rainforest, herbfields, heathlands, shrublands and sedgelands at high altitudes. | 0 | Unlikely. Suitable habitat types present. No records in locality. | No. No suitable habitat would be affected. | No |
| *Plegadis falcinellus* | Glossy Ibis | | M | Recorded over much of NSW. Spring/summer breeding migrant to southern Murray-Darling region and Macquarie Marshes. | Edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation. Occasionally estuaries, deltas, | 6 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | saltmarshes and coastal lagoons. | | | | |
| *Pomatostomus temporalis temporalis* | Grey-crowned Babbler (eastern subspecies) | V | | In NSW, occurs on the western slopes of the Great Dividing Range, and as far as Louth and Balranald on the western plains. Also occurs in woodlands in the Hunter Valley and in some locations on the north coast | Open woodland habitats; favours Box-gum woodlands on the slopes and Box-cypress and open Box woodlands on alluvial plains. | 34 | Yes. Species recorded in study area. | Yes. Species recorded in study area. | Yes |
| *Ptilinopus magnificus* | Wompoo Fruit-Dove | V | | In NSW, occurs south along coast and coastal ranges to the Hunter River. | Rainforest, low-elevation moist eucalypt forest and brush box forests. | 2 | Unlikely. Eucalypt forest present. Two records in locality, both from before 2000. | No. No suitable habitat would be affected. | No |
| *Ptilinopus regina* | Rose-crowned Fruit-Dove | V | | In NSW, found on coast and ranges north from Newcastle. Vagrants are occasionally found further south to Victoria. | Sub-tropical and dry rainforest, moist eucalypt forest and swamp forest, where fruit is plentiful. | 0 | Unlikely. Study area generally contains dry sclerophyll forest. No records in locality. | No. No suitable habitat would be affected. | No |
| *Rhipidura rufifrons* | Rufous Fantail | | M | Coastal and near coastal districts of northern and eastern Australia, including on and east of the Great Divide in NSW. | Wet sclerophyll forests, subtropical and temperate rainforests. Sometimes drier sclerophyll forests and woodlands. | 13 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Rostratula australis* | Australian Painted Snipe | E | E | In NSW most records are from the Murray-Darling Basin. Other recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys. | Swamps, dams and nearby marshy areas. | 0 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Sternula nereis nereis* | Australian Fairy Tern | | V | Known from NSW in the past, but it is unknown if it persists. | Embayments of a variety of habitats including offshore, estuarine or lake islands, wetlands and mainland coastline. Nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. | 0 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Stictonetta naevosa* | Freckled Duck | V | | Inland river systems, occurring as far as coastal NSW in times of drought. | Freshwater swamps and creeks, lakes, reservoirs, farm dams and sewage ponds. | 1 | No. No suitable habitat. Only one record in locality. | No. No suitable habitat would be affected. | No |
| *Thinornis rubricollis* | Hooded Plover | E | | Occurs in coastal NSW north to Sussex Inlet. Occasional records from the Shoalhaven River, Comerong Beach and Lake Illawarra. | Sandy ocean beaches, tidal bays and estuaries, rock platforms, rocky or sand-covered reefs, and small beaches in lines of cliffs. Also use near-coastal saline and freshwater lakes and lagoons. | 0 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Tringa nebularia* | Common Greenshank | | M | Summer migrant to Australia. Recorded in most coastal regions of NSW; also, widespread west of the Great Dividing Range, especially between the Lachlan | Terrestrial wetlands (swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans, saltflats, sewage farms and | 0 | No. No suitable wetland habitat for shorebirds | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | and Murray Rivers and the Darling River drainage basin, including the Macquarie Marshes, and north-west regions. | saltworks dams, inundated rice crops and bores) and sheltered coastal habitats (mudflats, saltmarsh, mangroves, embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms). | | within the subject site. | | |
| *Turnix maculosus* | Red-backed Button-quail | V | | Recorded infrequently in central-eastern and north-eastern NSW, with most records from the North Coast Bioregion; there are historical records south as far as Sydney and three outlying records from western NSW. | In NSW, uses grasslands, heath and crops. Elsewhere also found in open and savannah woodlands. | 0 | No. No suitable habitat. No records in locality. | No. No suitable habitat would be affected. | No |
| *Tyto longimembris* | Eastern Grass Owl | V | | Recorded occasionally in all mainland states. In NSW they are more likely to be resident in the north-east. | Areas of tall grass, including grass tussocks, swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. | 1 | No. No suitable areas of extensive tall grass habitat. Only one record in locality. | No. No suitable habitat would be affected. | No |
| *Tyto novaehollandiae* | Masked Owl | V | | Recorded over approximately 90% of NSW, excluding the most arid north-western corner. Most abundant on the coast but extends to the western plains. | Dry eucalypt forests and woodlands from sea level to 1100 m. | 7 | Potential. Eucalypt forest in study area. | Yes. Species may use study area as part of large foraging range. No breeding habitat present. | Yes |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Synemon plana* | Golden Sun Moth | E | CE | NSW populations are found in the area between Queanbeyan, Gunning, Young and Tumut. | Natural Temperate Grasslands and grassy Box-Gum Woodlands in which ground layer is dominated by *Rytidosperma* spp. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Cercartetus nanus* | Eastern Pygmy-possum | V | | In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. | Rainforest, sclerophyll forest (including Box-Ironbark), woodland and heath. | 1 | Unlikely. Eucalypt forest in study area. Only one record within locality from a hair sample in 2005. | No. No suitable habitat would be affected. | No |
| *Chalinolobus dwyeri* | Large-eared Pied Bat | V | V | Recorded from Rockhampton in Qld south to Ulladulla in NSW. Largest concentrations of populations occur in the sandstone escarpments of the Sydney basin and the NSW north-west slopes. | Wet and dry sclerophyll forests, Cyprus Pine dominated forest, woodland, sub-alpine woodland, edges of rainforests and sandstone outcrop country. | 1 | Unlikely. No nearby rocky roost habitat. Only one record from within 10 km. | No. No suitable habitat would be affected. Species not recorded in targeted surveys. | No |
| *Dasyurus maculatus* | Spotted-tailed Quoll | V | E | Found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Qld. | Rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. | 33 | Potential. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Falsistrellus tasmaniensis* | Eastern False Pipistrelle | V | | South-east coast and ranges of Australia, from southern Qld to Victoria and Tasmania. In NSW, records extend to the western slopes of the Great Dividing Range. | Tall (greater than 20 m) moist habitats. | 7 | Potential. Eucalypt forest in study area. | Yes. Species recorded during targeted surveys foraging in study area. | Yes |
| *Kerivoula papuensis* | Golden-tipped Bat | V | | Scattered locations on east coast of Australia to south of Eden in southern NSW. | Rainforest and adjacent wet and dry sclerophyll forest up to 1000 m. Also recorded in tall open forest, Casuarina-dominated riparian forest and coastal Melaleuca forests. | 1 | Unlikely. No rainforest or riparian forest. Only one record from within 10 km from 1999. | No. No suitable habitat would be affected. | No |
| *Miniopterus australis* | Little Bent-wined Bat | V | | East coast and ranges south to Wollongong in NSW. | Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. | 104 | Yes. Species recorded in subject site and known to use Balickera Tunnel. | Yes. Tunnel habitat will be impacted. | Yes |
| *Miniopterus orianae oceanensis* | Eastern Bent-winged Bat | V | | In NSW it occurs on both sides of the Great Dividing Range, from the coast inland to Moree, Dubbo and Wagga Wagga. | Rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland. | 27 | Yes. Species recorded in subject site and known to use Balickera Tunnel. | Yes. Tunnel habitat will be impacted. | Yes |
| *Mormopterus norfolkensis* | Eastern Freetail-bat | V | | Found along the east coast from south Qld to southern NSW. | Dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. | 23 | Potential. Eucalypt forest in study area. | Yes. Species recorded foraging in | Yes |

 

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | study area on one occasion. | |
| *Myotis macropus* | Southern Myotis | V | | In NSW, found in the coastal band. It is rarely found more than 100 km inland, except along major rivers. | Foraging habitat is waterbodies (including streams, or lakes or reservoirs) and fringing areas of vegetation up to 20 m. | 15 | Yes. Species recorded in subject site and known to use Balickera Tunnel. | Yes. Tunnel habitat will be impacted. | Yes |
| *Nyctophilus corbeni* | Corben's Long-eared Bat | V | V | Distribution coincides approximately with the Murray Darling Basin; the Pilliga Scrub region is the distinct stronghold for this species. | Mallee, *Allocasuarina luehmannii* (Buloke) and box eucalypt-dominated communities, especially box/ironbark/cypress-pine vegetation. | 0 | No. Subject site is outside of species' normal range. No records within the locality. | No. No suitable habitat would be affected. | No |
| *Petauroides volans* | Greater Glider | | V | The greater glider is restricted to eastern Australia, from the Windsor Tableland in north Queensland to central Victoria, with an elevational range from sea level to 1200 m. | Eucalypt forests and woodlands. | 0 | No. Highly detectable species with no records within 10 km of study area. | No. No suitable habitat would be affected. | No |
| *Petaurus australis* | Yellow-bellied Glider | V | | Along the eastern coast to the western slopes of the Great Dividing Range, from southern Qld to Victoria. | Tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. | 2 | No. No suitable habitat in the study area. Only two indirect records in locality, one from hair sample in 2005 | No. No suitable habitat would be affected. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | and one from feeding scars on a tree in 2006. | | |
| *Petaurus norfolcensis* | Squirrel Glider | V | | Widely though sparsely distributed on both sides of the Great Dividing Range in eastern Australia, from northern Qld to western Victoria. | Mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. | 41 | Likely. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Petrogale penicillata* | Brush-tailed Rock-wallaby | E | V | In NSW they occur from the Qld border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. | Rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges. | 0 | No. No suitable rocky habitat within or nearby the study area. No records within locality. | No. No suitable habitat would be affected. | No |
| *Phascogale tapoatafa* | Brush-tailed Phascogale | V | | In NSW it is mainly found east of the Great Dividing Range although there are occasional records west of the divide. | Dry sclerophyll open forest, heath, swamps, rainforest and wet sclerophyll forest. | 32 | Likely. Eucalypt forest in study area. | No. This species was not recorded during targeted surveys. | No |
| *Phascolarctos cinereus* | Koala | V | V | In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. There are sparse and possibly disjunct populations in the Bega District, | Eucalypt woodlands and forests. | 1056 | Likely. Eucalypt forest in study area. Large number of records in locality. | Yes. Species not recorded but likely to use site on occasion and preferred feed | Yes |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | and at several sites on the southern tablelands. | | | | trees present in subject site. | |
| *Potorous tridactylus tridactylus* | Long-nosed Potoroo | V | V | In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 mm. | Coastal heaths and dry and wet sclerophyll forests. | 0 | Unlikely. Dry sclerophyll forests present. No records within locality. | No. No suitable habitat would be affected. | No |
| *Pseudomys novaehollandiae* | New Holland Mouse | | V | Fragmented distribution across eastern NSW. | Open heathlands, woodlands and forests with a heathland understorey, vegetated sand dunes. | 8 | Unlikely. No suitable habitat with heathy understorey. | No. No suitable habitat would be affected. | No |
| *Pteropus poliocephalus* | Grey-headed Flying-fox | V | V | Along the eastern coast of Australia, from Bundaberg in Qld to Melbourne in Victoria. | Subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. | 75 | Yes. Species recorded flying over subject site and likely to forage in Eucalypt forests within the study area. | Yes. Species recorded in study area. | Yes |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail-bat | V | | There are scattered records of this species across the New England Tablelands and North West Slopes. Rare visitor in late summer and autumn to south-western NSW. | Almost all habitats, including wet and dry sclerophyll forest, open woodland, open country, mallee, rainforests, heathland and waterbodies. | 2 | Potential. Eucalypt forest in study area. | No. Species not recorded in targeted survey. | No |

| Scientific Name | Common Name | BC Act Status | EPBC Act Status | Distribution | Habitat | Records within 10 km | Likelihood of occurrence | Will habitat be impacted | Affected Species |
|---|---|---|---|---|---|---|---|---|---|
| *Scoteanax rueppellii* | Greater Broad-nosed Bat | V | | Both sides of the great divide, from the Atherton Tableland in Qld to north-eastern Victoria, mainly along river systems and gullies. In NSW it is widespread on the New England Tablelands. | Woodland, moist and dry eucalypt forest and rainforest. | 16 | Potential. Eucalypt forest in study area. | No. Species not recorded in targeted survey. | No |
| *Vespadelus troughtoni* | Eastern Cave Bat | V | | Found in a broad band on both sides of the Great Dividing Range south to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. | Dry open forest and woodland, near cliffs or rocky overhangs, cliff-lines in wet eucalypt forest and rainforest. | 3 | Unlikely. No cliff habitat nearby. | No. No suitable habitat would be affected. | No |

# Appendix C Flora survey data

**Table C-1: BAM Floristic Plot data**

| Family | Species | Common Name | Exotic | Growth Form Group | Plot 1 | | | Plot 2 | | | Plot 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance |
| Acanthaceae | *Brunoniella pumilio* | Dwarf Blue Trumpet | | Forb (FG) | | | | g | 0.2 | 50 | | | |
| Anthericaceae | *Tricoryne* spp. | | | Forb (FG) | g | 0.1 | 5 | g | 0.1 | 5 | | | |
| Apocynaceae | *Parsonsia straminea* | Common Silkpod | | Other (OG) | | | | m | 1 | 5 | | | |
| Araliaceae | *Polyscias* spp. | | | Shrub (SG) | | | | | | | g | 0.1 | 1 |
| Asteraceae | *Bidens pilosa* var. *pilosa* | | * | | g | 0.2 | 20 | | | | | | |
| Asteraceae | *Conyza bonariensis* | Flaxleaf Fleabane | * | | g | 0.1 | 1 | | | | | | |
| Asteraceae | *Cyanthillium cinereum* | | * | | g | 0.1 | 1 | | | | g | 0.1 | 50 |
| Asteraceae | *Hypochaeris radicata* | Catsear | * | | | | | g | 0.1 | 1 | g | 0.1 | 1 |
| Asteraceae | *Ozothamnus diosmifolius* | White Dogwood | | Shrub (SG) | | | | g | 0.1 | 1 | m | 0.1 | 5 |
| Asteraceae | *Solenogyne bellioides* | Solenogyne | | Forb (FG) | | | | g | 0.1 | 2 | g | 0.1 | 5 |
| Asteraceae | *Sonchus oleraceus* | Common Sowthistle | * | | g | 0.1 | 5 | | | | g | 0.1 | 2 |
| Asteraceae | *Tagetes minuta* | Stinking Roger | * | | g | 0.1 | 1 | | | | | | |
| Bignoniaceae | *Pandorea pandorana subsp. pandorana* | Wonga Vine | | Other (OG) | g | 0.1 | 5 | g | 0.1 | 1 | | | |
| Blechnaceae | *Blechnum spinulosum* | Small Rasp Fern | | Fern (EG) | | | | g | 0.1 | 2 | | | |
| Campanulaceae | *Lobelia purpurascens* | whiteroot | | Forb (FG) | g | 0.2 | 20 | g | 0.5 | 50 | g | 0.2 | 20 |
| Campanulaceae | *Wahlenbergia* spp. | Bluebell | | Forb (FG) | g | 0.1 | 20 | | | | | | |
| Chenopodiaceae | *Einadia trigonos* subsp. *stellulata* | | | Forb (FG) | g | 0.1 | 5 | | | | | | |
| Convolvulaceae | *Convolvulus erubescens* | Pink Bindweed | | Other (OG) | | | | | | | g | 0.1 | 5 |
| Convolvulaceae | *Dichondra repens* | Kidney Weed | | Forb (FG) | g | 0.2 | 100 | g | 0.1 | 50 | | | |
| Crassulaceae | *Crassula* spp. | Stonecrop | | Forb (FG) | g | 0.1 | 1 | | | | | | |
| Cyperaceae | *Carex* spp. | | | Grass & grasslike (GG) | | | | g | 0.2 | 20 | | | |
| Cyperaceae | *Cyperus* spp. | | | Grass & grasslike (GG) | g | 0.1 | 1 | g | 0.1 | 5 | | | |
| Dilleniaceae | *Hibbertia aspera* subsp. *aspera* | | | Shrub (SG) | g | 0.1 | 2 | g | 1 | 20 | g | 0.1 | 5 |
| Dilleniaceae | *Hibbertia* spp. | | | Shrub (SG) | | | | g | 1 | 20 | | | |
| Ericaceae | *Acrotriche divaricata* | | | Shrub (SG) | | | | | | | g | 0.1 | 2 |
| Ericaceae | *Brachyloma daphnoides* subsp. *daphnoides* | | | Shrub (SG) | g | 0.1 | 1 | | | | | | |
| Ericaceae | *Lissanthe strigosa* subsp. *strigosa* | | | Shrub (SG) | g | 0.1 | 1 | g | 0.2 | 5 | g | 0.1 | 2 |
| Fabaceae (Faboideae) | *Daviesia ulicifolia* subsp. *ulicifolia* | | | Shrub (SG) | g | 0.1 | 5 | | | | g | 0.1 | 1 |
| Fabaceae (Faboideae) | *Desmodium varians* | Slender Tick-trefoil | | Other (OG) | g | 0.1 | 1 | | | | | | |
| Fabaceae (Faboideae) | *Glycine clandestina* | Twining glycine | | Other (OG) | | | | | | | g | 0.1 | 10 |
| Fabaceae (Faboideae) | *Glycine microphylla* | Small-leaf Glycine | | Other (OG) | g | 0.1 | 10 | g | 0.1 | 5 | | | |
| Fabaceae (Faboideae) | *Hardenbergia violacea* | False Sarsaparilla | | Other (OG) | g | 0.1 | 2 | g | 0.1 | 2 | g | 0.1 | 10 |
| Fabaceae (Faboideae) | *Jacksonia scoparia* | Dogwood | | Shrub (SG) | | | | m | 0.1 | 2 | | | |

| Family | Species | Common Name | Exotic | Growth Form Group | Plot 1 | | | Plot 2 | | | Plot 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance |
| Fabaceae (Faboideae) | *Kennedia rubicunda* | Dusky Coral Pea | | Other (OG) | | | | | | | g | 1 | 20 |
| Fabaceae (Faboideae) | *Pultenaea villosa* | Hairy Bush-pea | | Shrub (SG) | | | | g | 0.2 | 10 | | | |
| Fabaceae (Mimosoideae) | *Acacia longifolia* subsp. *longifolia* | Sydney Golden Wattle | | Shrub (SG) | | | | m | 2 | 20 | m | 10 | 100 |
| Goodeniaceae | *Goodenia heterophylla* subsp. *heterophylla* | | | Forb (FG) | | | | | | | g | 0.1 | 20 |
| Lomandraceae | *Lomandra longifolia* | Spiny-headed Mat-rush | | Grass & grasslike (GG) | | | | g | 0.1 | 5 | g | 0.5 | 10 |
| Loranthaceae | *Dendrophthoe vitellina* | | | Other (OG) | m | 0.1 | 1 | | | | | | |
| Luzuriagaceae | *Eustrephus latifolius* | Wombat Berry | | Other (OG) | g | 0.1 | 1 | g | 0.1 | 5 | g | 0.1 | 5 |
| Malvaceae | *Pavonia hastata* | 0 | * | | g | 0.1 | 5 | | | | | | |
| Myrtaceae | *Angophora costata* | Sydney Red Gum | | Tree (TG) | | | | u | 5 | 6 | | | |
| Myrtaceae | *Callistemon salignus* | Willow Bottlebrush | | Shrub (SG) | | | | m | 2 | 5 | | | |
| Myrtaceae | *Corymbia maculata* | Spotted Gum | | Tree (TG) | | | | | | | u | 10 | 4 |
| Myrtaceae | *Eucalyptus acmenoides* | White Mahogany | | Tree (TG) | | | | u | 15 | 10 | u | 15 | 7 |
| Myrtaceae | *Eucalyptus piperita* | Sydney Peppermint | | Tree (TG) | | | | u | 25 | 1 | | | |
| Myrtaceae | *Eucalyptus punctata* | Grey Gum | | Tree (TG) | | | | | | | u | 20 | 10 |
| Myrtaceae | *Eucalyptus siderophloia* | Grey Ironbark | | Tree (TG) | | | | | | | u | 10 | 4 |
| Myrtaceae | *Eucalyptus tereticornis* | Forest Red Gum | | Tree (TG) | u | 35 | 20 | | | | | | |
| Myrtaceae | *Eucalyptus umbra* | Broad-leaved White Mahogany | | Tree (TG) | | | | u | 15 | 1 | | | |
| Myrtaceae | *Melaleuca ericifolia* | Swamp Paperbark | | Shrub (SG) | | | | m | 1 | 20 | | | |
| Myrtaceae | *Melaleuca linariifolia* | Flax-leaved Paperbark | | Shrub (SG) | | | | | | | m | 0.1 | 1 |
| Oxalidaceae | *Oxalis perennans* | | | Forb (FG) | g | 0.1 | 2 | | | | g | 0.1 | 1 |
| Phormiaceae | *Dianella caerulea* var. *caerulea* | | | Forb (FG) | | | | g | 0.2 | 20 | g | 0.1 | 5 |
| Phyllanthaceae | *Breynia oblongifolia* | Coffee Bush | | Shrub (SG) | m | 0.1 | 5 | m | 0.5 | 10 | g | 0.2 | 20 |
| Phyllanthaceae | *Glochidion ferdinandi* var. *ferdinandi* | Cheese Tree | | Tree (TG) | | | | m | 1 | 5 | | | |
| Pittosporaceae | *Billardiera scandens* | Hairy Apple Berry | | Other (OG) | | | | | | | g | 0.5 | 20 |
| Pittosporaceae | *Pittosporum revolutum* | Rough Fruit Pittosporum | | Shrub (SG) | | | | m | 0.1 | 2 | g | 0.1 | 1 |
| Poaceae | *Anisopogon avenaceus* | Oat Speargrass | | Grass & grasslike (GG) | | | | | | | g | 0.1 | 2 |
| Poaceae | *Aristida vagans* | Threeawn Speargrass | | Grass & grasslike (GG) | | | | g | 0.1 | 10 | g | 0.1 | 5 |
| Poaceae | *Bothriochloa macra* | Red Grass | | Grass & grasslike (GG) | | | | | | | g | 0.1 | 2 |
| Poaceae | *Briza minor* | Shivery Grass | * | | g | 0.1 | 1 | | | | | | |
| Poaceae | *Bromus catharticus* | Prairie Grass | * | | g | 0.1 | 1 | | | | | | |
| Poaceae | *Cymbopogon refractus* | Barbed Wire Grass | | Grass & grasslike (GG) | | | | g | 0.1 | 2 | | | |
| Poaceae | *Cynodon dactylon* | Common Couch | | Grass & grasslike (GG) | g | 2 | 100 | | | | | | |
| Poaceae | *Digitaria parviflora* | Small-flowered Finger Grass | | Grass & grasslike (GG) | | | | | | | g | 0.2 | 10 |
| Poaceae | *Echinopogon* spp. | A Hedgehog Grass | | Grass & grasslike (GG) | g | 0.1 | 1 | g | 0.1 | 20 | | | |
| Poaceae | *Ehrharta erecta* | Panic Veldtgrass | * | | g | 2 | 50 | | | | g | 0.1 | 5 |

| Family | Species | Common Name | Exotic | Growth Form Group | Plot 1 | | | Plot 2 | | | Plot 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance | Stratum & Layer | Cover | Abundance |
| Poaceae | *Entolasia marginata* | Bordered Panic | | Grass & grasslike (GG) | g | 0.1 | 1 | g | 1 | 20 | g | 3 | 100 |
| Poaceae | *Entolasia stricta* | Wiry Panic | | Grass & grasslike (GG) | g | 0.1 | 2 | | | | g | 0.1 | 10 |
| Poaceae | *Eragrostis curvula* | African Lovegrass | * | | g | 1 | 20 | | | | | | |
| Poaceae | *Imperata cylindrica* | Blady Grass | | Grass & grasslike (GG) | | | | g | 1 | 100 | g | 0.5 | 50 |
| Poaceae | *Melinis repens* | Red Natal Grass | * | | g | 25 | 500 | | | | | | |
| Poaceae | *Microlaena stipoides* var. *stipoides* | Weeping Grass | | Grass & grasslike (GG) | | | | g | 2 | 500 | g | 1 | 100 |
| Poaceae | *Oplismenus aemulus* | | | Grass & grasslike (GG) | | | | g | 1 | 100 | g | 1 | 50 |
| Poaceae | *Panicum simile* | Two-colour Panic | | Grass & grasslike (GG) | | | | | | | g | 2 | 100 |
| Poaceae | *Paspalidium distans* | | | Grass & grasslike (GG) | g | 0.1 | 2 | | | | g | 0.3 | 20 |
| Poaceae | *Paspalum dilatatum* | Paspalum | * | | g | 2 | 50 | g | 0.1 | 1 | g | 0.1 | 1 |
| Poaceae | *Themeda triandra* | | | Grass & grasslike (GG) | | | | g | 0.5 | 20 | | | |
| Proteaceae | *Persoonia linearis* | Narrow-leaved Geebung | | Shrub (SG) | m | 0.1 | 3 | m | 0.1 | 1 | g | 0.1 | 1 |
| Pteridaceae | *Cheilanthes distans* | Bristly Cloak Fern | | Fern (EG) | g | 0.1 | 5 | | | | | | |
| Pteridaceae | *Cheilanthes sieberi* subsp. *sieberi* | Rock Fern | | Fern (EG) | g | 1 | 100 | | | | g | 0.1 | 20 |
| Ranunculaceae | *Clematis glycinoides* var. *glycinoides* | | | Other (OG) | g | 0.1 | 1 | g | 0.1 | 1 | g | 0.1 | 1 |
| Rhamnaceae | *Alphitonia excelsa* | Red Ash | | Tree (TG) | m | 0.2 | 1 | | | | | | |
| Rubiaceae | *Gynochthodes jasminoides* | Sweet Morinda | | Other (OG) | | | | g | 0.1 | 1 | | | |
| Rubiaceae | *Opercularia* spp. | | | Forb (FG) | g | 0.1 | 1 | g | 0.1 | 1 | | | |
| Santalaceae | *Exocarpos cupressiformis* | Cherry Ballart | | Shrub (SG) | m | 0.2 | 1 | | | | g | 0.1 | 2 |
| Sapindaceae | *Dodonaea triquetra* | Large-leaf Hop-bush | | Shrub (SG) | m | 0.1 | 1 | m | 0.1 | 2 | g | 0.1 | 1 |
| Solanaceae | *Solanum prinophyllum* | Forest Nightshade | | Forb (FG) | g | 0.1 | 1 | | | | | | |
| Solanaceae | *Solanum* spp. | | | Forb (FG) | g | 0.1 | 5 | | | | | | |
| Verbenaceae | *Lantana camara* | Lantana | * | | m | 3 | 20 | m | 4 | 20 | m | 0.2 | 2 |
| Violaceae | *Viola hederacea* | Ivy-leaved Violet | | Forb (FG) | | | | g | 0.2 | 50 | | | |

# Appendix D Microbat trapping survey data

**Table D-1: Bat trapping results**

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.3 | 38.83 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.8 | 40.01 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.5 | 40.01 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.6 | 39.81 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 11.2 | 38.23 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 38.64 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.8 | 40.11 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 38.87 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.9 | 39.07 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 9 | 39.48 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 38.71 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 11 | 39.61 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 11.8 | 39.89 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 6 | 38.8 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.5 | 39.91 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.5 | 39.56 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 12 | 38.41 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 11 | 39.1 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 10 | 39.31 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 9.8 | 39.18 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 10.5 | 39.17 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.2 | 39.02 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 10 | 39.65 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 11 | 39.34 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9 | 39.8 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 10 | 39.87 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 10 | 39.7 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 9.5 | 39.43 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Sub-adult? | 7.5 | 38.71 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 10.8 | 38.56 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 11 | 38.8 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Sub-adult? | 11.1 | 39.84 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 9 | 37.64 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9 | 38.8 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Sub-adult? | 9 | 39.35 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 11 | 39.45 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.5 | 40.36 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9 | 38.55 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 12.8 | 40.96 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.8 | 39.61 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 5 | 38.87 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 40 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 38.92 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 38.74 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.5 | 38.58 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 37.92 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 39.4 |
| 10-Mar-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.2 | 38.81 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.5 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 39 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 10 | 41 |
| 10-Mar-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.7 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 37.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | | Adult | 7 | 38.6 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.25 | 40.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 36.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 40.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 38.6 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.25 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 5 | 40.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | | 40 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 39.05 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 4.5 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 4 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 5 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 5.5 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 5 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 39.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 41 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39.5 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 38 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 37 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.64 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.25 | 39.56 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 38.8 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.25 | 37.53 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 38.68 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.13 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 38.71 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.24 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39.01 |
| 9-Jun-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.1 | 40.56 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 37.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.5 | 38.68 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 10 | 38.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38.53 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 38.23 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.1 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 9 | 38.97 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 12.6 | 38.87 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 39.14 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.7 | 39.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.55 | 38.91 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 37.8 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.1 | 38.15 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 37.5 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.09 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 12 | 39.63 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.5 | 39.34 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.7 | 39.19 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40.06 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 37.54 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.7 | 39.43 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 38.2 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.05 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.8 | 39.43 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.36 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.15 | 38.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 38.97 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 37.9 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.3 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 37.59 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.9 | 38.42 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.8 | 39.15 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 39.4 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 37.34 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.58 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.3 | 38.5 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.8 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.7 | 38.89 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.2 | 40.7 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 39.42 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.2 | 38.75 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.77 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39.44 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.45 | 38.1 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.6 | 39.85 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.43 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39.99 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 40.74 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.15 | 39.41 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.8 | 39 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.8 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.15 | 37.25 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.6 | 38.57 |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 9-Jun-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | * | | | |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40.07 |
| 7-Sep-20 | Downstream | Myotis macropus | Southern Myotis | F | Adult | 11.5 | 40.58 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40.77 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9.5 | 39.2 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 39.3 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40.3 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8.5 | 39.36 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38.23 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 39.31 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40.33 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 40.54 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 38.87 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.35 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.7 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 39.33 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.61 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39.74 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | | Adult | 8 | 39.93 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.19 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.82 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39.6 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39.6 |
| 7-Sep-20 | Downstream | Myotis macropus | Southern Myotis | M | Adult | 10 | 39 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 39 |
| 7-Sep-20 | Downstream | Myotis macropus | Southern Myotis | F | Adult | 12 | 38 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 38.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 38.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 39 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40.6 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 40 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 38 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 40.6 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40.5 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 8 | 39 |
| 7-Sep-20 | Downstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 40.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 37 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6 | 39.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 40.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39.5 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 6.5 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6.5 | 40.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 6 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 39.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 37.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 40.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 40.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7.5 | 39.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | F | Adult | 7 | 40 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 39.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 38 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 38.5 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.6 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39 |
| 7-Sep-20 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 41.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 38.64 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 38.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 5 | 39.6 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 39.96 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 37.82 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.5 | 39.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 9 | 39.55 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 38.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 37.19 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 38.8 |

| Date | Portal | Species | Common name | Sex | Age | Weight (g) | Forearm (mm) |
|---|---|---|---|---|---|---|---|
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7 | 39 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.64 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 37.1 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 38.5 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8 | 39.89 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.75 | 40 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 7.5 | 40.65 |
| 27-Jan-21 | Upstream | Miniopterus australis | Little Bent-wing Bat | M | Adult | 8.75 | 41 |

Note: * denotes bats identified to species level but not processed due to large number of captures.

# Appendix E Fauna survey results and species list

**Table E-1: Fauna survey results and species list**

| Scientific name | Common name | BC Act Status | EPBC Act Status | Remote camera | Spotlighting | Diurnal | Harp Trapping | Ultrasonic | Incidental |
|---|---|---|---|---|---|---|---|---|---|
| **Amphibians** | | | | | | | | | |
| *Litoria fallax* | Eastern Sedge Frog | | | | x | | | | |
| *Litoria latopalmata* | Broad-palmed Rocket Frog | | | | x | | | | |
| *Litoria peronii* | Emerald-spotted Tree Frog | | | | x | | | | |
| *Litoria tyleri* | Tyler's Tree Frog | | | | x | | | | |
| *Litoria wilcoxii* | Eastern Stony Creek Frog | | | | x | | | | |
| *Pseudophryne coriacea* | Red-backed Toadlet | | | | x | | | | |
| *Uperoleia fusca* | Dusky Toadlet | | | | x | | | | |
| **Birds** | | | | | | | | | |
| *Acanthiza lineata* | Striated Thornbill | | | | | x | | | |
| *Acanthiza pusilla* | Brown Thornbill | | | | | x | | | |
| *Acanthorhynchus tenuirostris* | Eastern Spinebill | | | | | x | | | |
| *Anas superciliosa* | Pacific Black Duck | | | | | x | | | |
| *Cacomantis flabelliformis* | Fan-tailed Cuckoo | | | | | x | | | |
| *Calyptorhynchus funereus* | Yellow-tailed Black-Cockatoo | | | | | x | | | |
| *Centropus phasianinus* | Pheasant Coucal | | | | | x | | | |
| *Ceyx azureus* | Azure Kingfisher | | | | | x | | | |
| *Colluricincla harmonica* | Grey Shrike-thrush | | | | | x | | | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-shrike | | | | | x | | | |
| *Coracina papuensis* | White-bellied Cuckoo-shrike | | | | | x | | | |
| *Cormobates leucophaea* | White-throated Treecreeper | | | | | x | | | |
| *Corvus coronoides* | Australian Raven | | | | | x | | | |
| *Cracticus nigrogularis* | Pied Butcherbird | | | | | x | | | |
| *Cracticus tibicen* | Australian Magpie | | | | | x | | | |

| Scientific name | Common name | BC Act Status | EPBC Act Status | Remote camera | Spotlighting | Diurnal | Harp Trapping | Ultrasonic | Incidental |
|---|---|---|---|---|---|---|---|---|---|
| *Cracticus torquatus* | Grey Butcherbird | | | | | x | | | |
| *Dacelo novaeguineae* | Laughing Kookaburra | | | | | x | | | |
| *Dicaeum hirundinaceum* | Mistletoebird | | | | | x | | | |
| *Eopsaltria australis* | Eastern Yellow Robin | | | | | x | | | |
| *Falcunculus frontatus* | Crested Shrike-tit | | | | | x | | | |
| *Gallinago hardwickii* | Latham's Snipe | | | | | x | | | |
| *Geopelia humeralis* | Bar-shouldered Dove | | | | | x | | | |
| *Glossopsitta concinna* | Musk Lorikeet | | | | | x | | | |
| ***Glossopsitta pusilla*** | **Little Lorikeet** | **V** | | | | | | | **x** |
| ***Haliaeetus leucogaster*** | **White-bellied Sea-Eagle** | **V** | | | | **x** | | | **x** |
| *Haliastur sphenurus* | Whistling Kite | | | | | x | | | |
| *Lichenostomus chrysops* | Yellow-faced Honeyeater | | | | | x | | | |
| *Malurus cyaneus* | Superb Fairy-wren | | | | | x | | | |
| *Malurus lamberti* | Variegated Fairy-wren | | | | | x | | | |
| *Manorina melanocephala* | Noisy Miner | | | | | x | | | |
| *Meliphaga lewinii* | Lewin's Honeyeater | | | | | x | | | |
| *Melithreptus brevirostris* | Brown-headed Honeyeater | | | | | x | | | |
| *Melithreptus lunatus* | White-naped Honeyeater | | | | | x | | | |
| *Myzomela sanguinolenta* | Scarlet Honeyeater | | | | | x | | | |
| *Neochmia temporalis* | Red-browed Finch | | | | | x | | | |
| *Ocyphaps lophotes* | Crested Pigeon | | | | | x | | | |
| *Oriolus sagittatus* | Olive-backed Oriole | | | | | x | | | |
| *Pachycephala pectoralis* | Golden Whistler | | | | | x | | | |

| Scientific name | Common name | BC Act Status | EPBC Act Status | Remote camera | Spotlighting | Diurnal | Harp Trapping | Ultrasonic | Incidental |
|---|---|---|---|---|---|---|---|---|---|
| *Pachycephala rufiventris* | Rufous Whistler | | | | | x | | | |
| *Pardalotus punctatus* | Spotted Pardalote | | | | | x | | | |
| *Philemon corniculatus* | Noisy Friarbird | | | | | x | | | |
| *Platycercus eximius* | Eastern Rosella | | | | | x | | | |
| ***Pomatostomus temporalis*** | **Grey-crowned Babbler** | **V** | | | | **x** | | | |
| *Porphyrio porphyrio* | Purple Swamphen | | | | | x | | | |
| *Ptilonorhynchus violaceus* | Satin Bowerbird | | | x | | | | | |
| *Rhipidura albiscapa* | Grey Fantail | | | | | x | | | |
| *Rhipidura leucophrys* | Willie Wagtail | | | | | x | | | |
| *Sericornis frontalis* | White-browed Scrubwren | | | | | x | | | |
| *Trichoglossus haematodus* | Rainbow Lorikeet | | | | | x | | | |
| *Zosterops lateralis* | Silvereye | | | | | x | | | |
| **Mammals** | | | | | | | | | |
| *Austronomus australis* | White-striped Free-tailed Bat | | | | | | | x | |
| *Canis lupus** | Dingo, Domestic Dog | | | x | | | | | x |
| *Cervus timorensis** | Rusa Deer | | | x | | | | | x |
| *Chalinolobus gouldii* | Gould's Wattled Bat | | | | | | | x | |
| *Chalinolobus morio* | Chocolate Wattled Bat | | | | | | | x | |
| *Dama dama** | Fallow Deer | | | x | | | | | x |
| ***Falsistrellus tasmaniensis*** | **Eastern False Pipistrelle** | | | | | | | **x** | |
| *Macropus giganteus* | Eastern Grey Kangaroo | | | x | | | | | |
| *Macropus rufogriseus* | Red-necked Wallaby | | | x | | | | | |
| ***Micronomus norfolkensis*** | **Eastern Coastal Free-tailed Bat** | | | | | | | **x** | |

| Scientific name | Common name | BC Act Status | EPBC Act Status | Remote camera | Spotlighting | Diurnal | Harp Trapping | Ultrasonic | Incidental |
|---|---|---|---|---|---|---|---|---|---|
| ***Miniopterus australis*** | **Little Bent-winged Bat** | **V** | | | | **x** | **x** | **x** | |
| ***Miniopterus orianae oceanensis*** | **Large Bent-winged Bat** | **V** | | | | **x** | **x** | **x** | |
| ***Myotis macropus*** | **Southern Myotis** | **V** | | | | | **x** | **x** | |
| *Ozimops ridei* | Ride's Free-tailed Bat | | | | | | | x | |
| *Petaurus breviceps* | Sugar Glider | | | x | | | | | |
| *Pteropus poliocephalus* | Grey-headed Flying-fox | | | | x | | | | x |
| *Rattus rattus** | Black Rat | | | x | | | | | |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | | | | | | | x | |
| *Trichosurus vulpecula* | Common Brushtail Possum | | | x | x | | | | |
| *Vespadelus pumilus* | Eastern Forest Bat | | | | | | | x | |
| *Vulpes vulpes** | Fox | | | x | | | | | |
| *Wallabia bicolor* | Swamp Wallaby | | | x | | | | | |
| **Reptiles** | | | | | | | | | |
| *Intellagama lesueurii* | Eastern Water Dragon | | | | | x | | | |

*= exotic species

# Appendix F Bat call analysis

# Ultrasonic Analysis Report

19NEW-13555 – Hunter Water Balickera Microbat SIS – Microbat Ultrasonic Call Analysis Report.

This report was completed on the 9 June 2021.

## 1. Project background

Ultrasonic surveys were undertaken each quarter between March 2020 and January 2021 to record the calls of microbats roosting within the Balickera Tunnel, Balickera, NSW (the Study area). The results of these ultrasonic surveys will inform the Species Impact Statement (SIS) that is a requirement for proposed tunnel remediation works required to secure the water supply along Balickera Canal via Balickera Tunnel to Grahamstown Dam which supplies 70% of the water required for Newcastle. Ultrasonic surveys were also conducted at a number of potential alternative roost sites within a 50 km radius of the Study area to determine whether there were suitable alternative roosts within nightly flight range of Balickera Tunnel. Eco Logical Australia (ELA) was engaged by Hunter Water to undertake the necessary surveys associated with the Study area to inform the SIS.

This report outlines the methodology used to complete ultrasonic surveys for microbats at the Study area, and to review and analyse the recorded ultrasonic microbat calls. This report also presents the results of the data analysis.

## 2. Methods

During each survey event at Balickera Tunnel, two Wildlife Acoustics Song Meters (SM2+BAT) were set within the Study area, one at either end of the tunnel for a minimum of four nights and sometimes for longer (Table 2-1). Each detector was set to start recording ultrasonic microbat calls passively from 30 minutes prior to sunset and to stop recording 30 minutes after sunrise. Therefore, ultrasonic microbat call data was recorded across the entire night. The detectors were positioned to obtain maximum recordings of bats emerging from the tunnel portal and flying immediately in front of the portal entrances. At the upstream portal the detector microphone was attached to a metal beam suspended approximately 6 m above the canal and approximately 6 m from the tunnel entrance. At the downstream portal the detector was placed on the stop gate structure at the same height as the top of the tunnel portal approximately 4 m from the tunnel portal.

During the regional ultrasonic surveys, a Wildlife Acoustics Song Meter MiniBAT was set at the entrance to the potential roost or hand held during emergence surveys (M1 Tunnel). These regional surveys were conducted in September 2020 and details of survey locations and dates are listed in Table 2-2. Detectors left overnight were set to start recording ultrasonic microbat calls passively from 30 minutes prior to sunset and to stop recording 30 minutes after sunrise. Hand held detectors were set to start recording from 30 minutes prior to sunset until 1 hour after sunset, or once emergence had ceased, whichever was the sooner.

**Table 2-1: Details of the dates and locations of Balickera Tunnel ultrasonic surveys**

| Location | Date | # survey nights recorded | # survey nights analysed |
|---|---|---|---|
| Upstream portal | 9 - 13 March | 2 | 2* |
| Downstream portal | 9 - 13 March | 3.125 | 3.125* |
| Upstream portal | 9 - 16 June | 8 | 5# |
| Downstream portal | 9 - 16 June | 8 | 8 |
| Upstream portal | 7 - 11 September | 4.125 | 4.125 |
| Downstream portal | 7 - 11 September | 4.125 | 4.125 |
| Upstream portal | 25 - 29 January | 7 | 4# |
| Downstream portal | 25 - 29 January | 7 | 7 |
| Total | | 43.375 | 37.375 |

* SD card full before 4 nights of survey,# Min 4 nights required and large number of calls precluded analysis of complete set of data collected.

**Table 2-2. Details of the dates and locations of regional ultrasonic surveys**

| Location | Date | # survey nights |
|---|---|---|
| M1 Tunnel | 8-Sep | 0.125* |
| Dungog WTP Tunnel | 10-Sep | 0.25# |
| Brookfield Tunnel | 10-Sep | 1 |
| Tunnel 1 Richmond Vale Rail Trail | 7 and 8 Oct | 2 |
| Tunnel 2 Richmond Vale Rail Trail | 7 and 8 Oct | 2 |
| Tunnel 3 Richmond Vale Rail Trail | 7 and 8 Oct | 2 |
| Pacific Hwy Bridge Balickera Canal | 26-Jan | 1 |
| | | 8.375 |

* Emergence survey only, # first three hours of night only

# 3. Data Analysis

Data analysis for ultrasonic surveys conducted at Balickera Tunnel was conducted on at least four nights of ultrasonic data from each detector each season (where available, see Table 1). A total of 37.375 nights of data was analysed. Data analysis for ultrasonic surveys conducted at regional survey sites was based on either a single night / emergence survey of recording or two nights of recording, depending upon the location and totalled 8.375 survey nights.

Files were recorded as WAV sound files. These WAV files were viewed using the software program Anabat Insight (Version 1.9.7-0-g6302e49) (Titley Scientific) in either zero crossing (ZC) format and / or full spectrum formats. Prior to analysing the data, both the ZC and WAV files were subjected to a Decision Tree Analysis (DTA). The DTA is an automated process that applies noise filters and species-specific filters to the data. In this way, files that cannot be attributed to microbat echolocation calls (e.g. noises made by insects, vegetation, wind, train and vehicle movement) are removed from the analysis. Files are also sorted by characteristic frequency (one of the key identifiable features of microbat calls) to make the analysis more efficient and to separate files into frequency ranges for further analysis. The filtered data was then reviewed manually in both WAV and ZC formats using Anabat Insight (Titley Electronic: Version 1.9.0-4-g15fdd88) to confirm digitally allocated species identifications and to assign or adjust (where necessary) any incorrect species labels applied during the DTA.

The Study area is located within the North Coast biogeographical region as referred to in Pennay et al. 2004 and the ultrasonic call parameters used to identify microbats within the North Coast bioregion have been applied. It is acknowledged that the reference calls upon which the echolocation call identification guides were based do not represent a complete sample of microbat calls from every region in NSW. The reference calls were generated more than 16 years ago at a time when ultrasonic recording technology was less advanced and our knowledge of microbat species and their distributions was incomplete. In addition, some species of microbat display variation in their calls across different regions of NSW and the boundaries where these regional differences occur, differ for different species and are not well defined on a local scale. It is very difficult to provide certainty for the identification of some species based upon ultrasonic recording results alone, without the use of corroborating data such as capture and sighting records, and reference to the most current available literature on species distributions and call parameters, without conducting targeted trapping of the local microbat fauna and recording reference calls.

Call identifications were made by Alicia Scanlon from ELA using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from Sydney Basin, NSW (which is available at http://www.forest.nsw.gov.au/research/bats/default.asp). Species identification was guided by considering the probability of occurrence of a bat species based upon the general distribution information that is provided in Churchill (2008); Pennay et al. (2011), Van Dyck and Strahan (2008), Van Dyck et al. (2013) and on BatMap (https://www.ausbats.org.au/batmap.html) and the Atlas of Living Australia web page (https://www.ala.org.au/). A technical review of a sample of the calls was performed by Rod Armistead, also from ELA. Alicia and Rod have over 19 years of experience in the identification of ultrasonic call recordings.

To ensure reliable and accurate results the following protocols (adapted from Lloyd et al. 2006) were applied:

- Search phase calls were used when analysing the data because they contain more diagnostic features, rather than cruise phase calls or feeding buzzes (McKenzie et al. 2002)
- Recorded calls containing less than three pulses were not analysed as they are too short to confidently determine the identity of the species making the call (Law et al. 1999). These short sequences were either removed manually or were labelled as unidentifiable
- Calls made by bats that cannot be used for identification purposes such as social calls, short and low-quality calls, cruise and approach phase calls were removed from the analysis of species
- Sequences not attributed to microbat echolocation calls (e.g. insect buzzes, wind, train and vehicle movement) were dismissed from the analysis
- *Nyctophilus* spp. (Long-eared bats) are difficult to identify or separate confidently to species level based upon their recorded calls. Therefore, we have made no attempt to identify any *Nyctophilus* spp. calls recorded during this survey to species level (Pennay et al. 2004). There

are two non-threatened *Nyctophilus* species that could occur at the Study area, including *N. geoffroyi* (Lesser Long-eared Bat) and *N. gouldii* (Gould's Long-eared Bat)

- The Free-tailed Bats (previously referred to as the genus *Mormopterus or Tadarida*) have recently undergone taxonomic revision (Reardon et al. 2014) and now comprise four separate genus, including *Austronomus*, *Micronomus, Ozimops* and *Setirostris* (Table 3-1). This report uses nomenclature for Free-tailed Bat species as referred to in Jackson and Groves (2015). The correlation between nomenclature used in this report and that used in NSW State legislation is presented in Table 3-1 below. Published reference calls for the genus *Ozimops* (Pennay et al. 2004) contain errors (Michael Pennay and Greg Ford pers. comm.) and the call range of *O. ridei* is greater than previously documented
- Jackson & Groves (2015) list the Eastern Bent-winged Bat (*Miniopterus schreibersii oceanensis*) under the new name of *M. orianae* (Large Bent-winged Bat). However, we follow the NSW Department of Planning, Industry and Environment (DPIE) nomenclature as it applies to the eastern form of the species which occurs in NSW as a distinct sub-species; *M. o. oceanensis* (Large Bent-winged Bat) (see https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10534) (NSW DPIE (formerly the Office Environment and Heritage) 2019).

**Table 3-1: Correlations between current and previous nomenclature for the Free-tailed bats of NSW**

| Jackson and Groves 2015 | Previously known as | Common Name | BC Act |
|---|---|---|---|
| *Austronomus australis* | *Tadarida australis* | White-striped Free-tailed Bat | |
| *Micronomus norfolkensis* | *Mormopterus norfolkensis* | Eastern Coastal Free-tailed Bat | Vulnerable |
| *Ozimops petersi* | *Mormopterus* species 3 (small penis) | Inland Free-tailed Bat | |
| *Ozimops planiceps* | *Mormopterus* species 4 (long penis eastern form) | Southern Free-tailed Bat | |
| *Ozimops ridei* | *Mormopterus* species 2 | Ride's Free-tailed Bat | |
| *Setirostris eleryi* | *Mormopterus* species 6 | Bristle-faced Free-tailed Bat | Endangered |

# 4. Results

There were a total of 80,128 files containing bat calls recorded during this study across a total of 36.25 survey nights (Table 4-1). There were two occasions when a complete survey night was not recorded because the SD card was full or the batteries powering the detector were depleted (Table 5-11). Of the 80,128 files, 76,924 (96%) were able to be analysed to species or species group, with the remaining 3,204 (4%) of calls being of low quality, social calls, or contained call sequences that were too short to identify confidently to species level. There were few calls that were unable to be analysed which is unusual. Placement of the detectors directly in front of the entrance to a known roost site for at least four species of microbat was the main reason that the majority of calls recorded were able to be identified.

The calls of at least ten, and up to 18 microbat species were identified within the combined survey data, including seven species listed as vulnerable under the BC Act (Table 5-12). Five of the seven vulnerable species were confidently identified as being present within the subject site, including:

- *Falsistrellus tasmaniensis* (Eastern False Pipistrelle)
- *Micronomus norfolkensis* (Eastern Coastal Free-tailed Bat)
- *Miniopterus australis* (Little Bent-winged Bat)
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat)
- *Myotis macropus* (Southern Myotis)

Two other threatened species, the *Scoteanax rueppellii* (Greater Broad-nosed Bat) and *Vespadelus troughtoni* (Eastern Cave Bat) could also be present within the subject site but could not be positively identified from the recorded calls. Greater Broad-nosed Bat produces calls that overlap with several other species, including the threatened Eastern False Pipistrelle and non-threatened *Scotorepens orion* (Eastern Broad-nose Bat). There were some recorded calls that did not contain enough defining characteristics for a confident identification between Eastern False Pipistrelle, Eastern Broad-nosed Bat and Greater Broad-nosed Bat. The calls were assigned to a multi-species grouping. These three species are hollow roosting microbat species and would not roost within the tunnel in large numbers on a regular basis.

Similarly, Eastern Cave Bats produce calls that overlap with those of two other common species including *Vespadelus pumilus* (Eastern Forest Bat) and *V. vulturnus* (Little Forest Bat). Eastern Cave Bats are a threatened species known to roost in caves, boulder piles, mines and buildings (Churchill 2008). Whereas Eastern Forest Bats and Little Forest Bats are hollow roosting species. There was only one recorded location with an ultrasonic record of this species from within a 5 km radius of the Study area. There is none of its preferred sandstone outcrop habitat within nightly flight range of Balickera Tunnel. No Eastern Cave Bats were captured during harp trapping at the tunnel. The calls of Eastern Forest Bat were recorded confidently at the tunnel in January 2021. Calls potentially attributed to Eastern Cave Bat were recorded in September 2020 and January 2021. It is most likely that the recorded calls were made by Eastern Forest Bats or Little Forest Bats. Eastern Cave Bats are not likely to be present within the Study area.

**Table 4-1 Summary of ultrasonic recording results**

| Survey location and date | Total calls | Calls identified | # survey nights | Average # calls per night | % Little Bent-winged Bat | % Large Bent-winged Bat | % Southern Myotis |
|---|---|---|---|---|---|---|---|
| March 2020 upstream | 5807 | 5765 | 2 | 2904 | 82.0% | 2.5% | 13.1% |
| March 2020 downstream | 5109 | 4839 | 3.125 | 1648 | 82.0% | 2.5% | 13.1% |
| June 2020 upstream | 18402 | 18346 | 5 | 3680 | 87.6% | 4.5% | 7.7% |
| June 2020 downstream | 14465 | 13976 | 8 | 1808 | 82.1% | 3.6% | 4.5% |
| Sept 2020 upstream | 13178 | 13163 | 5 | 3214 | 95.0% | 0.8% | 3.7% |
| Sept 2020 downstream | 10367 | 9299 | 4.125 | 2529 | 72.8% | 0.9% | 21.9% |
| Jan 2021 upstream | 11041 | 10218 | 4 | 2760 | 65.8% | 1.2% | 31.6% |

| Survey location and date | Total calls | Calls identified | # survey nights | Average # calls per night | % Little Bent-winged Bat | % Large Bent-winged Bat | % Southern Myotis |
|---|---|---|---|---|---|---|---|
| Jan 2021 downstream | 1759 | 1318 | 5 | 352 | 54.8% | 3.0% | 4.6% |
| Totals | 80128 | 76924 | 36.25* | 2632 | 77.8% | 2.4% | 12.5% |
| Totals without Jan 2021 downstream | 78369 | 75606 | 31.25 | 2649 | 81.0% | 2.3% | 13.7% |

* There were two occasions when a complete survey night was not recorded because the SD card was full or the batteries powering the detector were exhausted.

There were four subterranean (caves, tunnels, derelict mines, stormwater drains, culverts and bridges) roosting microbat species recorded during this study. The four subterranean roosting species included:

- Large Bent-winged Bat
- Little Bent-winged Bat
- *Rhinolophus megaphyllus* (Eastern Horseshoe Bat)
- Southern Myotis.

Both Little Bent-winged Bats and Southern Myotis are also known to roost in tree hollows as well as subterranean structures (Churchill 2008). Evaluation of the calls recorded during the hour after sunset (emergence) provides clear evidence that all four species use Balickera Tunnel as roosting habitat to varying degrees throughout the year (Table 4-4 and Table 4-5).

*Chalinolobus morio* (Chocolate Wattled Bat) was also recorded and although this species is generally thought of as a tree hollow roosting species, it is also known to roost within subterranean structures (Churchill 2008). This species is likely to roost within the tunnel from time to time but there was only a single call recorded during the hour after sunset during January 2021 at the upstream portal that could have indicated that this species was roosting within the tunnel during these surveys (Table 4-4).

Species diversity varied between survey events and between the up and downstream portal (Table 4-2). A greater number of species were detected in calls recorded at Balickera Tunnel during spring and summer surveys than during winter and autumn surveys. There was also a tendency for a greater number of species to be recorded at the downstream portal than the upstream portal (Table 5-12).

Activity levels of microbats (calls per night) at Balickera Tunnel were very high. When all data was combined, the average number of calls recorded per night was 2,649. Call per night ranged between 1,648 calls recorded at the downstream portal in March 2020 to over twice that number with 3,680 calls per night recorded at the upstream portal in June 2020 (Table 5-11). Results for the downstream portal in January 2021 were discarded because the tunnel entrance was submerged, and no bats could emerge from it. For comparison, expected levels of activity for ultrasonic surveys conducted for the purposes of presence / absence range between 0 and 300 calls per night. The heightened activity levels recorded during this survey are consistent with Balickera Tunnel being a roost site for large numbers of bats.

There were a greater number of ultrasonic calls recorded per night at the upstream portal of the tunnel than the downstream portal of the tunnel (Table 5-11). This result was evident even when the January 2021 data was excluded from the analysis because the downstream portal was submerged and unable to be used by bats at that time forcing bats to use the upstream portal. This aligns with the knowledge that the majority of the roost sites within the tunnel are much closer to the upstream portal and indicates that bats preferentially exit / enter the tunnel from the upstream portal.

When only the hour of emergence was analysed the patters described above remained fairly static with the exception that no Large Bent-winged Bats were recorded emerging from the downstream portal (Table 4-3). The average number of calls recorded during emergence was greater at the upstream portal than the downstream portal during each season and overall (Table 5-13). There were minor fluctuations in the proportion of calls attributed to each threatened subterranean roosting species during emergence when compared with the nightly call averages (compare Table 5-11 to Table 5-13).

The spread of bat activity throughout the night for the cave roosting species; Little Bent-winged Bats, Large Bent-winged Bats, Southern Myotis and Eastern Horseshoe Bats shows a fairly consistent level of activity at both the upstream and downstream ends of the tunnel throughout the night and remains the same all year (Figure 4-1 to Figure 4-3).

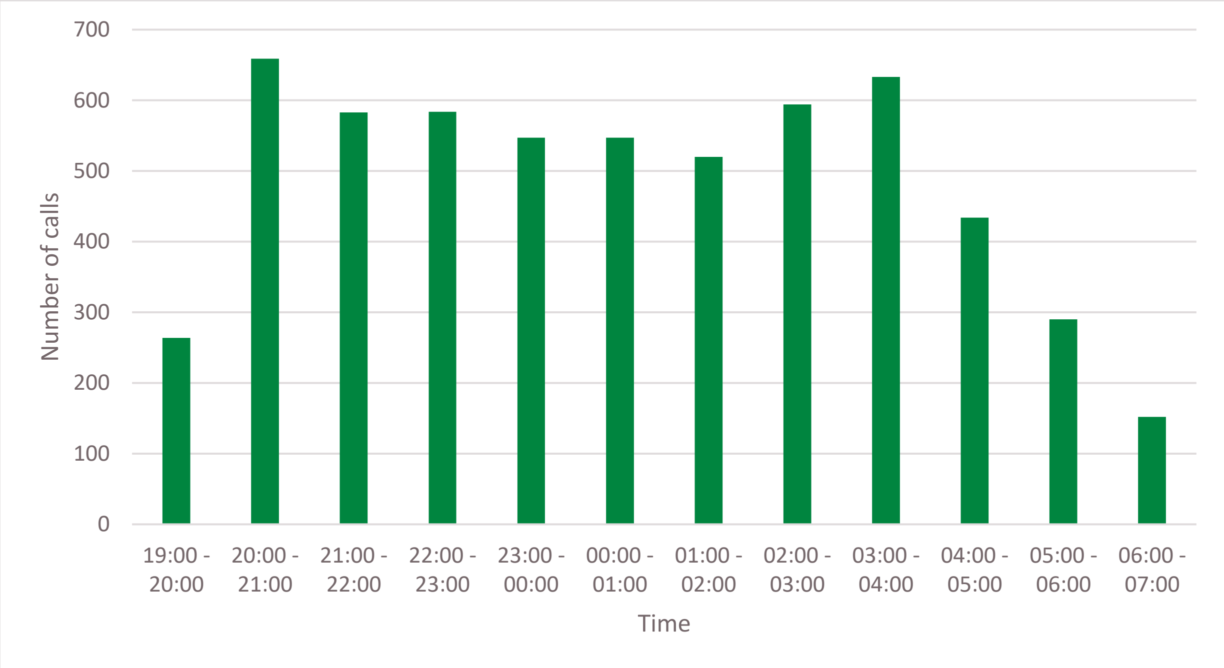


**Figure 4-1. Histogram of combined nightly call activity per hour recorded at the upstream portal between 9 and 10 March.**

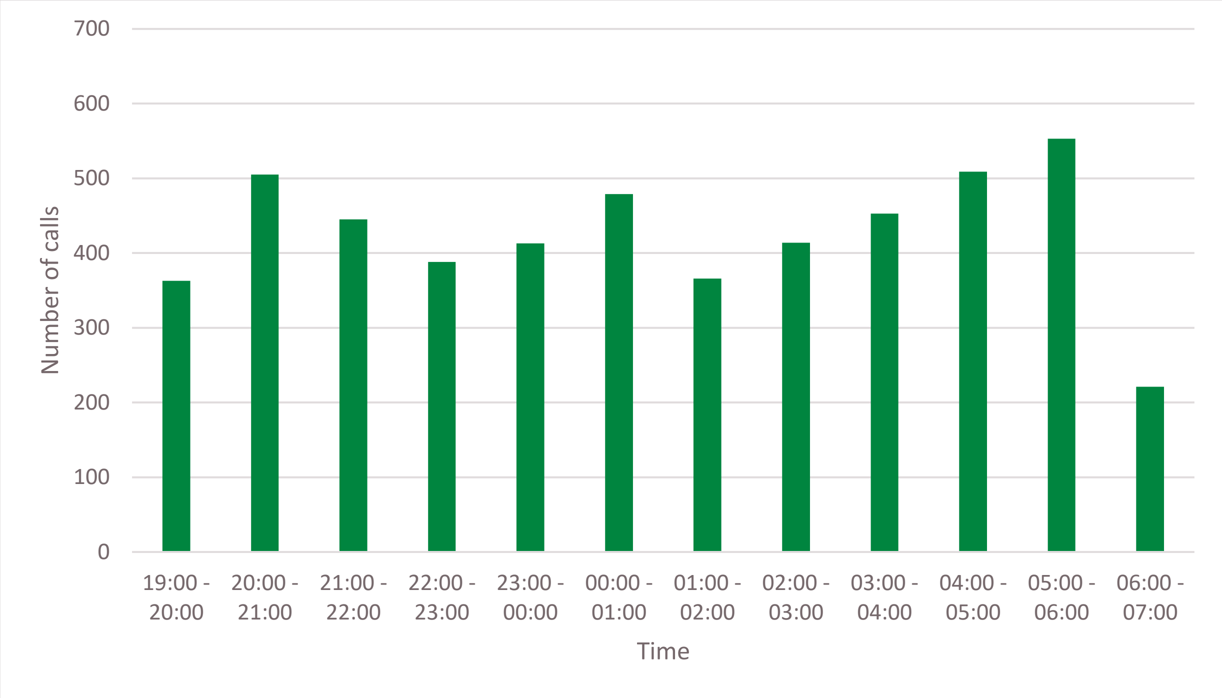


**Figure 4-2. Histogram of combined nightly call activity per hour recorded at the downstream portal between 9 and 11 March.**

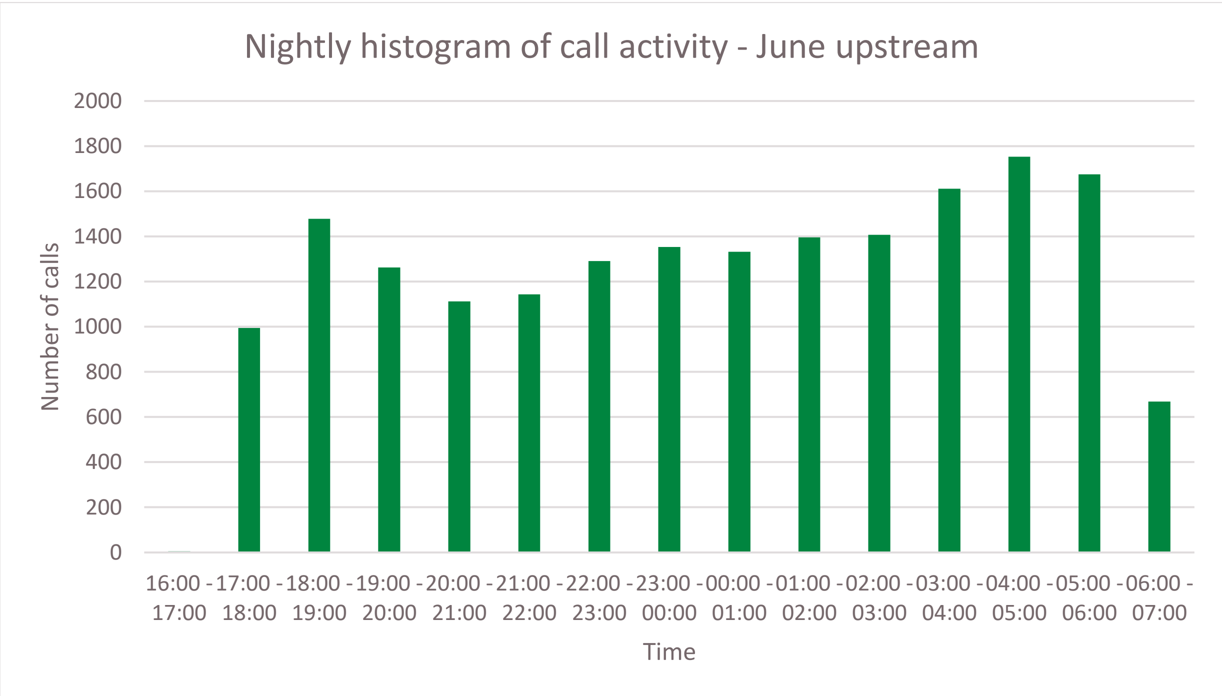


**Figure 4-3. Histogram of combined nightly call activity per hour recorded at the upstream portal between 9 and 13 June 2020.**

**Table 4-2: Species and species groups recorded during ultrasonic surveys at Balickera Tunnel between March 2020 and January 2021**

| Scientific Name | Common Name | Mar-20 | | Jun-20 | | Sep-20 | | Jan-21 | | Roosting in tunnel |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Up stream | Down stream | Up stream | Down stream | Up stream | Down stream | Up stream | Down stream | |
| *Austronomus australis* | White-striped Free-tailed Bat | N | Y | N | N | Y | N | Y | Y | N |
| *Chalinolobus gouldii* | Gould's Wattled Bat | N | Y | N | N | N | Y | Y | Y | N |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | N | Y | Y | Y | Y | Y | Y | Y | N |
| *Chalinolobus morio* | Chocolate Wattled Bat | Y | Y | Y | Y | Y | Y | Y | Y | N |
| *Chalinolobus morio / Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | N | N | N | Y | Y | Y | Y | Y | N |
| *Falsistrellus tasmaniensis** | Eastern False Pipistrelle | N | N | N | N | N | N | N | Y | N |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Greater Broad-nosed Bat / Eastern Broad-nosed Bat | N | Y | N | N | N | Y | Y | Y | N |
| *Micronomus norfolkensis** | Eastern Coastal Free-tailed Bat | N | N | N | Y | N | Y | N | N | N |
| *Micronomus norfolkensis* / Ozimops ridei* | Eastern Coastal Free-tailed Bat / Ride's Free-tailed Bat | N | N | N | N | N | Y | N | N | N |
| ***Miniopterus australis**** | **Little Bent-winged Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Miniopterus australis* / Vespadelus pumilus* | Little Bent-winged Bat / Eastern Forest Bat | N | N | N | N | Y | N | N | N | N |
| ***Miniopterus orianae oceanensis**** | **Large Bent-winged Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |

| Scientific Name | Common Name | Mar-20 | | Jun-20 | | Sep-20 | | Jan-21 | | Roosting in tunnel |
|---|---|---|---|---|---|---|---|---|---|---|
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Large Bent-winged Bat / Southern Forest Bat | N | Y | Y | N | Y | Y | N | Y | N |
| ***Myotis macropus**** | **Southern Myotis** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | Y | Y | N | Y | Y | Y | Y | Y | N |
| *Ozimops ridei* | Ride's Free-tailed Bat | N | N | Y | **N** | Y | Y | Y | Y | N |
| ***Rhinolophus megaphyllus*** | **Eastern Horseshoe Bat** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| *Vespadelus pumilus* | Eastern Forest Bat | N | N | N | N | N | N | N | Y | |
| *Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | N | N | N | N | Y | N | Y | Y | N |

# Threatened species under BC Act

**Table 4-3. Summary of average number of calls recorded and proportion attributed to each species during emergence* only**

| Location | Survey date | AvgeCalls during emergence | % Little Bent-winged Bat | % Large Bent-winged Bat | % Southern Myotis |
|---|---|---|---|---|---|
| Upstream | Mar 2020 | 291 | 77% | 1% | 21% |
| Upstream | Jun 2020 | 222 | 88% | 3% | 9% |
| Upstream | Sep 2020 | 198 | 98% | 1% | 1% |
| Upstream | Jan 2021 | 192 | 63% | 0% | 36% |
| | | | | | |
| Downstream | Mar 2020 | 145 | 82% | 0% | 11% |
| Downstream | Jun 2020 | 149 | 89% | 0% | 5% |
| Downstream | Sep 2020 | 119 | 74% | 0% | 26% |
| Downstream | Jan 2021 | | | | |

* Emergence correlates with thermal camera recording and begins from the sighting of the first bat to emerge from the tunnel and concludes one hour later.

**Table 4-4. Summary of the number of calls per species recorded each hour at the upstream portal between 25 and 28 Jan 2021, Balickera Tunnel, with the hours covering emergence highlighted in bold and italicised, emergence began at 8:25 pm**

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| ***25/01/2021*** | ***20:00 - 21:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***58*** |
| ***25/01/2021*** | ***20:00 - 21:00*** | ***Myotis macropus*** | ***Southern Myotis*** | ***27*** |
| ***25/01/2021*** | ***21:00 - 22:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***208*** |
| ***25/01/2021*** | ***21:00 - 22:00*** | ***Myotis macropus*** | ***Southern Myotis*** | ***60*** |
| 25/01/2021 | 21:00 - 22:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 3 |
| 25/01/2021 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 301 |
| 25/01/2021 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 75 |
| 25/01/2021 | 22:00 - 23:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 6 |
| 25/01/2021 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 258 |
| 25/01/2021 | 23:00 - 00:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 25/01/2021 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 87 |
| 25/01/2021 | 23:00 - 00:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 3 |
| 25/01/2021 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 228 |
| 25/01/2021 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 18 |
| 25/01/2021 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 72 |
| 25/01/2021 | 00:00 - 01:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 8 |
| 25/01/2021 | 01:00 - 02:00 | *Chalinolobus morio* | Chocolate Wattled Bat | 1 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 25/01/2021 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 254 |
| 25/01/2021 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 13 |
| 25/01/2021 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 65 |
| 25/01/2021 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 253 |
| 25/01/2021 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 14 |
| 25/01/2021 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 59 |
| 25/01/2021 | 02:00 - 03:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 4 |
| 25/01/2021 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 304 |
| 25/01/2021 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 7 |
| 25/01/2021 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 68 |
| 25/01/2021 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 236 |
| 25/01/2021 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 98 |
| 25/01/2021 | 04:00 - 05:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 2 |
| 25/01/2021 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 221 |
| 25/01/2021 | 05:00 - 06:00 | *Myotis macropus* | Southern Myotis | 36 |
| 25/01/2021 | 05:00 - 06:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 2 |
| ***26/01/2021*** | ***20:00 - 21:00*** | ***Chalinolobus morio*** | ***Chocolate Wattled Bat*** | ***2*** |
| ***26/01/2021*** | ***20:00 - 21:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***65*** |
| ***26/01/2021*** | ***20:00 - 21:00*** | ***Myotis macropus*** | ***Southern Myotis*** | ***26*** |
| ***26/01/2021*** | ***21:00 - 22:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***193*** |
| ***26/01/2021*** | ***21:00 - 22:00*** | ***Myotis macropus*** | ***Southern Myotis*** | ***102*** |
| 26/01/2021 | 21:00 - 22:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 26/01/2021 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 254 |
| 26/01/2021 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 92 |
| 26/01/2021 | 22:00 - 23:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 2 |
| 26/01/2021 | 23:00 - 00:00 | *Chalinolobus morio* | Chocolate Wattled Bat | 1 |
| 26/01/2021 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 214 |
| 26/01/2021 | 23:00 - 00:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 26/01/2021 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 84 |
| 26/01/2021 | 23:00 - 00:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 13 |
| 26/01/2021 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 176 |
| 26/01/2021 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 10 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 26/01/2021 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 67 |
| 26/01/2021 | 00:00 - 01:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 6 |
| 26/01/2021 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 160 |
| 26/01/2021 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 6 |
| 26/01/2021 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 49 |
| 26/01/2021 | 01:00 - 02:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 11 |
| 26/01/2021 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 177 |
| 26/01/2021 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 22 |
| 26/01/2021 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 73 |
| 26/01/2021 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 1 |
| 26/01/2021 | 02:00 - 03:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 26/01/2021 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 215 |
| 26/01/2021 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 28 |
| 26/01/2021 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 49 |
| 26/01/2021 | 03:00 - 04:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 4 |
| 26/01/2021 | 04:00 - 05:00 | *Chalinolobus morio* | Chocolate Wattled Bat | 1 |
| 26/01/2021 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 216 |
| 26/01/2021 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 129 |
| 26/01/2021 | 04:00 - 05:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 4 |
| 26/01/2021 | 05:00 - 06:00 | *Chalinolobus morio* | Chocolate Wattled Bat | 3 |
| 26/01/2021 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 188 |
| 26/01/2021 | 05:00 - 06:00 | *Myotis macropus* | Southern Myotis | 67 |
| 26/01/2021 | 05:00 - 06:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| ***27/01/2021*** | ***20:00 - 21:00*** | **Miniopterus australis** | ***Little Bent-winged Bat*** | ***131*** |
| ***27/01/2021*** | ***20:00 - 21:00*** | **Myotis macropus** | ***Southern Myotis*** | ***97*** |
| ***27/01/2021*** | ***20:00 - 21:00*** | **Rhinolophus megaphyllus** | ***Eastern Horseshoe Bat*** | ***1*** |
| ***27/01/2021*** | ***21:00 - 22:00*** | **Miniopterus australis** | ***Little Bent-winged Bat*** | ***284*** |
| ***27/01/2021*** | ***21:00 - 22:00*** | **Myotis macropus** | ***Southern Myotis*** | ***74*** |
| 27/01/2021 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 213 |
| 27/01/2021 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 52 |
| 27/01/2021 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 191 |
| 27/01/2021 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 116 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 27/01/2021 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 222 |
| 27/01/2021 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 110 |
| 27/01/2021 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 201 |
| 27/01/2021 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 120 |
| 27/01/2021 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 173 |
| 27/01/2021 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 136 |
| 27/01/2021 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 142 |
| 27/01/2021 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 96 |
| 27/01/2021 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 35 |
| 27/01/2021 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 116 |
| 27/01/2021 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 2 |
| 27/01/2021 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 32 |
| 27/01/2021 | 05:00 - 06:00 | *Myotis macropus* | Southern Myotis | 51 |
| *28/01/2021* | *20:00 - 21:00* | Miniopterus australis | *Little Bent-winged Bat* | *10* |
| *28/01/2021* | *20:00 - 21:00* | Myotis macropus | *Southern Myotis* | *99* |
| *28/01/2021* | *21:00 - 22:00* | Miniopterus australis | *Little Bent-winged Bat* | *36* |
| *28/01/2021* | *21:00 - 22:00* | Myotis macropus | *Southern Myotis* | *158* |
| 28/01/2021 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 86 |
| 28/01/2021 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 78 |
| 28/01/2021 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 76 |
| 28/01/2021 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 59 |
| 28/01/2021 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 100 |
| 28/01/2021 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 31 |
| 28/01/2021 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 122 |
| 28/01/2021 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 72 |
| 28/01/2021 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 1 |
| 28/01/2021 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 143 |
| 28/01/2021 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 74 |
| 28/01/2021 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 156 |
| 28/01/2021 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 100 |
| 28/01/2021 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 123 |
| 28/01/2021 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 111 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 28/01/2021 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 70 |
| 28/01/2021 | 05:00 - 06:00 | *Myotis macropus* | Southern Myotis | 93 |

**Table 4-5. Summary of the number of calls per species recorded each hour at the downstream portal between 9 and 16 June 2020, Balickera Tunnel, with the hours covering emergence highlighted in bold and italicised, emergence began at 5:09 pm**

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| ***9/06/2020*** | ***16:00 - 17:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***2*** |
| ***9/06/2020*** | ***17:00 - 18:00*** | ***Miniopterus australis*** | ***Little Bent-winged Bat*** | ***165*** |
| ***9/06/2020*** | ***17:00 - 18:00*** | ***Myotis macropus*** | ***Southern Myotis*** | ***2*** |
| 9/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 138 |
| 9/06/2020 | 18:00 - 19:00 | *Myotis macropus* | Southern Myotis | 7 |
| 9/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 87 |
| 9/06/2020 | 19:00 - 20:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 19:00 - 20:00 | *Myotis macropus* | Southern Myotis | 22 |
| 9/06/2020 | 19:00 - 20:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 9/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 79 |
| 9/06/2020 | 20:00 - 21:00 | *Myotis macropus* | Southern Myotis | 19 |
| 9/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 100 |
| 9/06/2020 | 21:00 - 22:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 9/06/2020 | 21:00 - 22:00 | *Myotis macropus* | Southern Myotis | 80 |
| 9/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 136 |
| 9/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 44 |
| 9/06/2020 | 22:00 - 23:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 8 |
| 9/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 219 |
| 9/06/2020 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 55 |
| 9/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 152 |
| 9/06/2020 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 49 |
| 9/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 145 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 9/06/2020 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 58 |
| 9/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 164 |
| 9/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 27 |
| 9/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 192 |
| 9/06/2020 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 13 |
| 9/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 176 |
| 9/06/2020 | 04:00 - 05:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |
| 9/06/2020 | 04:00 - 05:00 | *Myotis macropus* | Southern Myotis | 4 |
| 9/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 142 |
| 9/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 9/06/2020 | 05:00 - 06:00 | *Myotis macropus* | Southern Myotis | 9 |
| 9/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 30 |
| 9/06/2020 | 06:00 - 07:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| *10/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *8* |
| 10/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 1 |
| 10/06/2020 | 19:00 - 20:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 10/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 1 |
| 10/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 3 |
| 10/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 3 |
| 10/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 4 |
| 10/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 3 |
| 10/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 1 |
| 10/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 5 |
| 10/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 5 |
| 10/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 3 |
| 11/06/2020 | 17:00 - 18:00 | *Miniopterus australis* | Little Bent-winged Bat | 9 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 11/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 2 |
| 11/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 2 |
| 11/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 11/06/2020 | 04:00 - 05:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| *12/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *102* |
| *12/06/2020* | *17:00 - 18:00* | *Miniopterus orianae oceanensis* | *Large Bent-winged Bat* | *4* |
| 12/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 18 |
| 12/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 42 |
| 12/06/2020 | 19:00 - 20:00 | *Myotis macropus* | Southern Myotis | 1 |
| 12/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 41 |
| 12/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 65 |
| 12/06/2020 | 21:00 - 22:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 12/06/2020 | 21:00 - 22:00 | *Myotis macropus* | Southern Myotis | 1 |
| 12/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 134 |
| 12/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 12/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 190 |
| 12/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 237 |
| 12/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 175 |
| 12/06/2020 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 12/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 62 |
| 12/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 12/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 91 |
| 12/06/2020 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 12/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 122 |
| 12/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 154 |
| 12/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 12/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 55 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 12/06/2020 | 06:00 - 07:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 7 |
| 12/06/2020 | 06:00 - 07:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| *13/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *110* |
| 13/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 67 |
| 13/06/2020 | 18:00 - 19:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 6 |
| 13/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 82 |
| 13/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 41 |
| 13/06/2020 | 20:00 - 21:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 13/06/2020 | 20:00 - 21:00 | *Myotis macropus* | Southern Myotis | 1 |
| 13/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 39 |
| 13/06/2020 | 21:00 - 22:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 13/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 139 |
| 13/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 6 |
| 13/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 256 |
| 13/06/2020 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 1 |
| 13/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 249 |
| 13/06/2020 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |
| 13/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 68 |
| 13/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 9 |
| 13/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 30 |
| 13/06/2020 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 13/06/2020 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 1 |
| 13/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 116 |
| 13/06/2020 | 04:00 - 05:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 6 |
| 13/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 154 |
| 13/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 13/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 49 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 13/06/2020 | 06:00 - 07:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |
| *14/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *92* |
| 14/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 31 |
| 14/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 112 |
| 14/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 85 |
| 14/06/2020 | 20:00 - 21:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 14/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 27 |
| 14/06/2020 | 21:00 - 22:00 | *Myotis macropus* | Southern Myotis | 1 |
| 14/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 120 |
| 14/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 14/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 186 |
| 14/06/2020 | 23:00 - 00:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 14/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 164 |
| 14/06/2020 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 14/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 81 |
| 14/06/2020 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 14/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 26 |
| 14/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 9 |
| 14/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 30 |
| 14/06/2020 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 9 |
| 14/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 21 |
| 14/06/2020 | 04:00 - 05:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 14/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 28 |
| 14/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| 14/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 6 |
| *15/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *131* |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| *15/06/2020* | *17:00 - 18:00* | *Miniopterus orianae oceanensis* | *Large Bent-winged Bat* | *1* |
| 15/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 179 |
| 15/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 233 |
| 15/06/2020 | 19:00 - 20:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 1 |
| 15/06/2020 | 19:00 - 20:00 | *Myotis macropus* | Southern Myotis | 1 |
| 15/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 285 |
| 15/06/2020 | 20:00 - 21:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 8 |
| 15/06/2020 | 20:00 - 21:00 | *Myotis macropus* | Southern Myotis | 4 |
| 15/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 234 |
| 15/06/2020 | 21:00 - 22:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 17 |
| 15/06/2020 | 21:00 - 22:00 | *Myotis macropus* | Southern Myotis | 5 |
| 15/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 145 |
| 15/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 2 |
| 15/06/2020 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 5 |
| 15/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 224 |
| 15/06/2020 | 23:00 - 00:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 7 |
| 15/06/2020 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 17 |
| 15/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 201 |
| 15/06/2020 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |
| 15/06/2020 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 20 |
| 15/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 224 |
| 15/06/2020 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 11 |
| 15/06/2020 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 2 |
| 15/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 194 |
| 15/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 23 |
| 15/06/2020 | 02:00 - 03:00 | *Myotis macropus* | Southern Myotis | 8 |
| 15/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 210 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 15/06/2020 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 11 |
| 15/06/2020 | 03:00 - 04:00 | *Myotis macropus* | Southern Myotis | 3 |
| 15/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 242 |
| 15/06/2020 | 04:00 - 05:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 15/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 247 |
| 15/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 34 |
| 15/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 111 |
| 15/06/2020 | 06:00 - 07:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 3 |
| *16/06/2020* | *17:00 - 18:00* | *Miniopterus australis* | *Little Bent-winged Bat* | *84* |
| *16/06/2020* | *17:00 - 18:00* | *Miniopterus orianae oceanensis* | *Large Bent-winged Bat* | *1* |
| 16/06/2020 | 18:00 - 19:00 | *Miniopterus australis* | Little Bent-winged Bat | 283 |
| 16/06/2020 | 19:00 - 20:00 | *Miniopterus australis* | Little Bent-winged Bat | 193 |
| 16/06/2020 | 19:00 - 20:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |
| 16/06/2020 | 19:00 - 20:00 | *Myotis macropus* | Southern Myotis | 24 |
| 16/06/2020 | 20:00 - 21:00 | *Miniopterus australis* | Little Bent-winged Bat | 207 |
| 16/06/2020 | 20:00 - 21:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 16 |
| 16/06/2020 | 20:00 - 21:00 | *Myotis macropus* | Southern Myotis | 45 |
| 16/06/2020 | 20:00 - 21:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 16/06/2020 | 21:00 - 22:00 | *Miniopterus australis* | Little Bent-winged Bat | 216 |
| 16/06/2020 | 21:00 - 22:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 52 |
| 16/06/2020 | 21:00 - 22:00 | *Myotis macropus* | Southern Myotis | 47 |
| 16/06/2020 | 22:00 - 23:00 | *Miniopterus australis* | Little Bent-winged Bat | 188 |
| 16/06/2020 | 22:00 - 23:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 37 |
| 16/06/2020 | 22:00 - 23:00 | *Myotis macropus* | Southern Myotis | 20 |
| 16/06/2020 | 22:00 - 23:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 16/06/2020 | 23:00 - 00:00 | *Miniopterus australis* | Little Bent-winged Bat | 173 |
| 16/06/2020 | 23:00 - 00:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 36 |

| Date | Time | Scientific Name | Common Name | Number of calls |
|---|---|---|---|---|
| 16/06/2020 | 23:00 - 00:00 | *Myotis macropus* | Southern Myotis | 9 |
| 16/06/2020 | 23:00 - 00:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 16/06/2020 | 00:00 - 01:00 | *Miniopterus australis* | Little Bent-winged Bat | 148 |
| 16/06/2020 | 00:00 - 01:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 47 |
| 16/06/2020 | 00:00 - 01:00 | *Myotis macropus* | Southern Myotis | 16 |
| 16/06/2020 | 00:00 - 01:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 6 |
| 16/06/2020 | 01:00 - 02:00 | *Miniopterus australis* | Little Bent-winged Bat | 233 |
| 16/06/2020 | 01:00 - 02:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 14 |
| 16/06/2020 | 01:00 - 02:00 | *Myotis macropus* | Southern Myotis | 1 |
| 16/06/2020 | 02:00 - 03:00 | *Miniopterus australis* | Little Bent-winged Bat | 228 |
| 16/06/2020 | 02:00 - 03:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 5 |
| 16/06/2020 | 03:00 - 04:00 | *Miniopterus australis* | Little Bent-winged Bat | 203 |
| 16/06/2020 | 03:00 - 04:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 13 |
| 16/06/2020 | 04:00 - 05:00 | *Miniopterus australis* | Little Bent-winged Bat | 233 |
| 16/06/2020 | 05:00 - 06:00 | *Miniopterus australis* | Little Bent-winged Bat | 226 |
| 16/06/2020 | 05:00 - 06:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 24 |
| 16/06/2020 | 05:00 - 06:00 | *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 1 |
| 16/06/2020 | 06:00 - 07:00 | *Miniopterus australis* | Little Bent-winged Bat | 118 |
| 16/06/2020 | 06:00 - 07:00 | *Miniopterus orianae oceanensis* | Large Bent-winged Bat | 4 |

# 5. Results tables

**Table 5-1. Downstream portal ultrasonic survey results as nightly calls recorded per species, 9 – 10 March 2020, Balickera Tunnel**

| Scientific Name | Common Name | 3/9/2020 | 3/10/2020 | 3/11/2020 | 3/12/2020# | Grand Total |
|---|---|---|---|---|---|---|
| *Austronomus australis* | White-striped Free-tailed Bat | 4 | 0 | 0 | 1 | 5 |
| *Chalinolobus gouldii* | Gould's Wattled Bat | 0 | 1 | 1 | 0 | 2 |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 0 | 1 | 0 | 0 | 1 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 0 | 6 | 0 | 0 | 6 |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Greater Broad-nosed Bat / Eastern Broad-nosed Bat | 2 | | 0 | | 2 |
| *Miniopterus australis** | Little Bent-winged Bat | 1042 | 1266 | 1506 | 152 | 3966 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 54 | 37 | 31 | 0 | 122 |
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Large Bent-winged Bat / Southern Forest Bat | 1 | 7 | 3 | 0 | 11 |
| *Myotis macropus** | Southern Myotis | 313 | 230 | 75 | 7 | 625 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 7 | 2 | 0 | 0 | 9 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 71 | 6 | 3 | 0 | 80 |
| Social calls | | 3 | 10 | 0 | 0 | 13 |
| Unidentifiable calls | | 107 | 63 | 89 | 11 | 270 |
| Total identifiable calls | | 1494 | 1566 | 1619 | 160 | 4839 |

 

| Scientific Name | Common Name | 3/9/2020 | 3/10/2020 | 3/11/2020 | 3/12/2020# | Grand Total |
|---|---|---|---|---|---|---|
| Total calls | | **1601** | **1629** | **1708** | **171** | **5109** |
| | | | | | | |
| Percentage *M. australis* | | 69.7% | 80.8% | 93.0% | 95.0% | 82.0% |
| Percentage *M. o. oceanensis* | | 3.6% | 2.4% | 1.9% | 0.0% | 2.5% |
| Percentage *M. macropus* | | 21.4% | 14.8% | 4.6% | 4.4% | 13.1% |

**Table 5-2. Upstream portal ultrasonic survey results as nightly calls recorded per species, 9 – 11 March 2020, Balickera Tunnel**

| Scientific Name | Common Name | 3/9/2020 | 3/10/2020 | Grand Total |
|---|---|---|---|---|
| *Chalinolobus morio* | Chocolate Wattled Bat | 1 | 1 | 2 |
| *Miniopterus australis** | Little Bent-winged Bat | 3055 | 2334 | 5389 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 48 | 51 | 99 |
| *Myotis macropus** | Southern Myotis | 191 | 67 | 258 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 4 | 0 | 4 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 10 | 0 | 10 |
| Social | | 2 | 1 | 3 |
| Unidentifiable calls | | 31 | 11 | 42 |
| Total identifiable calls | | 3311 | 2454 | 5765 |
| Total calls | | **3342** | **2465** | **5807** |
| | | | | |
| Percentage *M. australis* | | 92.3% | 95.1% | 93.5% |
| Percentage *M. o. oceanensis* | | 1.4% | 2.1% | 1.7% |
| Percentage *M. macropus* | | 5.8% | 2.7% | 4.5% |

**Table 5-3. Downstream portal ultrasonic survey results as nightly calls recorded per species, 9 – 16 June 2020, Balickera Tunnel**

| Scientific Name | Common Name | 6/9/2020 | 6/10/2020 | 6/11/2020 | 6/12/2020 | 6/13/2020 | Grand Total |
|---|---|---|---|---|---|---|---|
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 2 | 4 | 2 | 0 | 0 | 8 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 0 | 0 | 2 | 0 | 0 | 2 |
| *Miniopterus australis** | Little Bent-winged Bat | 3684 | 3123 | 2950 | 3333 | 2990 | 16080 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 99 | 50 | 284 | 244 | 157 | 834 |
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Large Bent-winged Bat / Southern Forest Bat | 2 | 0 | 8 | 1 | 0 | 11 |
| *Myotis macropus** | Southern Myotis | 263 | 286 | 115 | 191 | 534 | 1389 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 2 | 8 | 0 | 1 | 5 | 16 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 0 | 2 | 0 | 0 | 0 | 2 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 0 | 0 | 0 | 2 | 2 | 4 |
| Social | | 0 | 2 | 1 | 0 | 0 | 3 |
| Unidentifiable calls | | 10 | 4 | 21 | 13 | 5 | 53 |
| Total identifiable calls | | 4052 | 3473 | 3361 | 3772 | 3688 | 18346 |
| Total calls | | 4062 | 3479 | 3383 | 3785 | 3693 | 18402 |
| | | | | | | | |
| Percentage *M. australis* | | 90.9% | 89.9% | 87.8% | 88.4% | 81.1% | 87.6% |
| Percentage *M. o. oceanensis* | | 2.4% | 1.4% | 8.4% | 6.5% | 4.3% | 4.5% |

| Scientific Name | Common Name | 6/9/2020 | 6/10/2020 | 6/11/2020 | 6/12/2020 | 6/13/2020 | Grand Total |
|---|---|---|---|---|---|---|---|
| Percentage *M. macropus* | | 6.5% | 8.5% | 3.4% | 5.1% | 14.6% | 7.7% |

**Table 5-4. Upstream portal ultrasonic survey results as nightly calls recorded per species, 9 – 13 June 2020, Balickera Tunnel**

| Scientific Name | Common Name | 6/9/2020 | 6/10/2020 | 6/11/2020 | 6/12/2020 | 6/13/2020 | 6/14/2020 | 6/15/2020 | 6/16/2020 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 0 | 0 | 4 | 1 | 0 | 0 | 2 | 7 | 14 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 0 | 0 | 0 | 1 | 0 | 0 | 51 | 39 | 91 |
| *Chalinolobus morio / Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| *Micronomus norfolkensis** | Eastern Coastal Free-tailed Bat | 0 | 0 | 1 | 2 | 0 | 2 | 6 | 0 | 11 |
| *Miniopterus australis** | Little Bent-winged Bat | 1927 | 37 | 975 | 1488 | 1409 | 1009 | 2860 | 2733 | 11476 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 16 | 1 | 2 | 27 | 41 | 32 | 127 | 253 | 499 |
| *Myotis macropus** | Southern Myotis | 389 | 0 | 0 | 2 | 3 | 1 | 65 | 162 | 622 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 1 | 0 | 172 | 293 | 64 | 313 | 66 | 332 | 1241 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 10 | 20 |
| Unidentifiable calls | | 27 | 9 | 208 | 87 | 28 | 98 | 22 | 10 | 489 |
| Total identifiable calls | | 2342 | 38 | 1154 | 1815 | 1517 | 1357 | 3177 | 3538 | 13976 |
| Total calls | | **2369** | **47** | **1362** | **1902** | **1545** | **1455** | **3199** | **3548** | **14465** |

| Scientific Name | Common Name | 6/9/2020 | 6/10/2020 | 6/11/2020 | 6/12/2020 | 6/13/2020 | 6/14/2020 | 6/15/2020 | 6/16/2020 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Percentage *M. australis* | | 82.3% | 97.4% | 84.5% | 82.0% | 92.9% | 74.4% | 90.0% | 77.2% | 82.1% |
| Percentage *M. o. oceanensis* | | 0.7% | 2.6% | 0.2% | 1.5% | 2.7% | 2.4% | 4.0% | 7.2% | 3.6% |
| Percentage *M. macropus* | | 16.6% | 0.0% | 0.0% | 0.1% | 0.2% | 0.1% | 2.0% | 4.6% | 4.5% |

**Table 5-5. Downstream portal ultrasonic survey results as nightly calls recorded per species, 7 – 10 Sept 2020, Balickera Tunnel**

| Scientific Name | Common Name | 9/7/2020 | 9/8/2020 | 9/9/2020 | 9/10/2020 | 9/11/2020# | Grand Total |
|---|---|---|---|---|---|---|---|
| *Chalinolobus gouldii* | Gould's Wattled Bat | 1 | 0 | 0 | 0 | 0 | 1 |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride’s Free-tailed Bat | 1 | 2 | 0 | 0 | 0 | 3 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 4 | 4 | 0 | 1 | 0 | 9 |
| *Chalinolobus morio / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Cave Bat / Little Forest Bat | 115 | 19 | 0 | 0 | 0 | 134 |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Greater Broad-nosed Bat / Eastern Broad-nosed Bat | 1 | 1 | 0 | 0 | 0 | 2 |
| *Micronomus norfolkensis** | Eastern Coastal Free-tailed Bat | 13 | 2 | 0 | 5 | 0 | 20 |
| *Micronomus norfolkensis* / Ozimops ridei* | Eastern Coastal Free-tailed Bat / Ride's Free-tailed Bat | 54 | 16 | 0 | 4 | 0 | 74 |
| *Miniopterus australis** | Little Bent-winged Bat | 1641 | 1796 | 1273 | 1910 | 150 | 6770 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 18 | 51 | 1 | 10 | 0 | 80 |
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Eastern Bent-winged Bat / Southern Forest Bat | 9 | 11 | 1 | 0 | 0 | 21 |

| Scientific Name | Common Name | 9/7/2020 | 9/8/2020 | 9/9/2020 | 9/10/2020 | 9/11/2020# | Grand Total |
|---|---|---|---|---|---|---|---|
| *Myotis macropus** | Southern Myotis | 311 | 177 | 1437 | 69 | 23 | 2017 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 6 | 2 | 11 | 0 | 0 | 19 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 14 | 14 | 0 | 3 | 0 | 31 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 46 | 48 | 2 | 10 | 3 | 109 |
| *Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | 7 | 2 | 0 | 0 | 0 | 9 |
| Unidentifiable calls | | 215 | 194 | 382 | 259 | 18 | 1068 |
| Total identifiable calls | | 2241 | 2145 | 2725 | 2012 | 176 | 9299 |
| Total calls | | **2456** | **2339** | **3107** | **2271** | **194** | **10367** |
| | | | | | | | |
| Percentage *M. australis* | | 73.2% | 83.7% | 46.7% | 94.9% | 85.2% | 72.8% |
| Percentage *M. o. oceanensis* | | 0.8% | 2.4% | 0.0% | 0.5% | 0.0% | 0.9% |
| Percentage *M. macropus* | | 14.1% | 8.3% | 53.1% | 3.4% | 13.1% | 21.9% |

**Table 5-6. Upstream portal ultrasonic survey results as nightly calls recorded per species, 7 – 10 June 2020, Balickera Tunnel**

| Scientific Name | Common Name | 9/7/2020 | 9/8/2020 | 9/9/2020 | 9/10/2020 | 9/11/2020# | Grand Total |
|---|---|---|---|---|---|---|---|
| *Austronomus australis* | White-striped Free-tailed Bat | 11 | 10 | 1 | 11 | 0 | 33 |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 1 | 1 | 0 | 0 | 0 | 2 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 0 | 1 | 1 | 0 | 0 | 2 |

| Scientific Name | Common Name | 9/7/2020 | 9/8/2020 | 9/9/2020 | 9/10/2020 | 9/11/2020# | Grand Total |
|---|---|---|---|---|---|---|---|
| *Chalinolobus morio / Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat | 1 | 1 | 0 | 0 | 0 | 2 |
| *Miniopterus australis** | Little Bent-winged Bat | 2826 | 2822 | 3190 | 3386 | 277 | 12501 |
| *Miniopterus australis* / Vespadelus pumilus* | Little Bent-winged Bat / Eastern Forest Bat | 0 | 1 | 0 | 0 | 0 | 1 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 32 | 41 | 4 | 24 | 1 | 102 |
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Large Bent-winged Bat / Southern Forest Bat | 0 | 4 | 0 | 2 | 0 | 6 |
| *Myotis macropus** | Southern Myotis | 42 | 35 | 294 | 95 | 18 | 484 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 0 | 1 | 5 | 2 | 0 | 8 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 0 | 1 | 0 | 2 | 0 | 3 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 0 | 1 | 2 | 3 | 4 | 10 |
| Social | | 4 | 4 | 0 | 0 | 1 | 9 |
| Unidentifiable calls | | 0 | 5 | 4 | 4 | 2 | 15 |
| Total identifiable calls | | 2917 | 2923 | 3497 | 3525 | 301 | 13163 |
| Total calls | | **2917** | **2928** | **3501** | **3529** | **303** | **13178** |
| | | | | | | | |
| Percentage *M. australis* | | 96.9% | 96.5% | 91.2% | 96.1% | 92.0% | 95.0% |
| Percentage *M. o. oceanensis* | | 1.1% | 1.4% | 0.1% | 0.7% | 0.3% | 0.8% |
| Percentage *M. macropus* | | 1.4% | 1.2% | 8.6% | 2.8% | 6.0% | 3.7% |

**Table 5-7. Downstream portal ultrasonic survey results as nightly calls recorded per species, 25 – 31 Jan 2021, Balickera Tunnel**

| Scientific Name | Common Name | 1/25/2021 | 1/26/2021 | 1/27/2021 | 1/30/2021 | 1/31/2021 | Grand Total |
|---|---|---|---|---|---|---|---|
| *Austronomus australis* | White-striped Free-tailed Bat | 0 | 0 | 6 | 0 | 0 | 6 |
| *Chalinolobus gouldii* | Gould's Wattled Bat | 28 | 10 | 0 | 3 | 3 | 44 |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 29 | 7 | 0 | 4 | 5 | 45 |
| *Chalinolobus morio* | Chocolate Wattled Bat | 0 | 5 | 0 | 0 | 1 | 6 |
| *Chalinolobus morio / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Cave Bat / Little Forest Bat | 5 | 35 | 0 | 0 | 0 | 40 |
| *Falsistrellus tasmaniensis** | Eastern False Pipistrelle | 8 | 1 | 0 | 0 | 0 | 9 |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Greater Broad-nosed Bat / Eastern Broad-nosed Bat | 108 | 58 | 0 | 21 | 43 | 230 |
| *Miniopterus australis** | Little Bent-winged Bat | 225 | 412 | 0 | 42 | 43 | 722 |
| *Miniopterus orianae oceanensis** | Large Bent-winged Bat | 16 | 8 | 0 | 5 | 10 | 39 |
| *Miniopterus orianae oceanensis* / Vespadelus regulus* | Eastern Bent-winged Bat / Southern Forest Bat | 1 | 3 | 0 | 0 | 0 | 4 |
| *Myotis macropus** | Southern Myotis | 15 | 35 | 8 | 0 | 1 | 59 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 0 | 2 | 0 | 0 | 0 | 2 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 23 | 4 | 0 | 4 | 4 | 35 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 23 | 30 | 0 | 0 | 4 | 57 |

| Scientific Name | Common Name | 1/25/2021 | 1/26/2021 | 1/27/2021 | 1/30/2021 | 1/31/2021 | Grand Total |
|---|---|---|---|---|---|---|---|
| *Vespadelus pumilus* | Eastern Forest Bat | | 1 | | | 1 | 2 |
| *Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | 3 | 15 | 0 | 0 | 0 | 18 |
| Unidentifiable calls | | 110 | 135 | 42 | 71 | 83 | 441 |
| Total identifiable calls | | 484 | 626 | 14 | 79 | 115 | 1318 |
| Total calls | | 594 | 761 | 56 | 150 | 198 | 1759 |
| | | | | | | | 74.9289369 |
| Percentage M. australis | | 46.5% | 65.8% | 0.0% | 53.2% | 37.4% | 54.8% |
| Percentage M. o. oceanensis | | 3.3% | 1.3% | 0.0% | 6.3% | 8.7% | 3.0% |
| Percentage M. macropus | | 3.1% | 5.9% | 57.1% | 0.0% | 0.9% | 4.6% |

**Table 5-8. Upstream portal ultrasonic survey results as nightly calls recorded per species, 25 – 29 Jan 2021, Balickera Tunnel**

| Scientific Name | Common Name | 1/25/2021 | 1/26/2021 | 1/27/2021 | 1/28/2021 | Grand Total |
|---|---|---|---|---|---|---|
| *Austronomus australis* | White-striped Freetail Bat | 5 | 0 | 5 | 1 | 11 |
| *Chalinolobus gouldii* | Gould's Wattled Bat | 2 | 3 | 0 | 0 | 5 |
| *Chalinolobus gouldii / Ozimops ridei* | Gould's Wattled Bat / Ride's Free-tailed Bat | 0 | 5 | 2 | 0 | 7 |
| *Chalinolobus morio* | Chocolate Wattled bat | 1 | 7 | 0 | 0 | 8 |
| *Chalinolobus morio / Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Chocolate Wattled Bat / Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | 5 | 12 | 0 | 0 | 17 |
| *Falsistrellus tasmaniensis* / Scoteanax rueppellii* / Scotorepens orion* | Eastern False Pipistrelle / Eastern Broad-nosed Bat / Greater Broad-nosed Bat | 1 | 3 | 0 | 0 | 4 |
| *Miniopterus australis* | Little Bentwing-bat | 2232 | 1858 | 1624 | 922 | 6726 |

| Scientific Name | Common Name | 1/25/2021 | 1/26/2021 | 1/27/2021 | 1/28/2021 | Grand Total |
|---|---|---|---|---|---|---|
| *Miniopterus orianae oceanensis** | Eastern Bentwing-bat | 57 | 69 | 0 | 0 | 126 |
| *Myotis macropus** | Southern Myotis | 639 | 736 | 970 | 876 | 3221 |
| *Myotis macropus / Nyctophilus spp.* In this region *N. geoffroyi* and *N. gouldi* are known to occur. | Southern Myotis / Long-eared Bats. In this region Lesser Long-eared Bat and Gould's Long-eared Bat are known to occur. | 8 | 3 | 0 | 0 | 11 |
| *Ozimops ridei* | Ride's Free-tailed Bat | 2 | 1 | 1 | 4 | 8 |
| *Rhinolophus megaphyllus* | Eastern Horseshoe Bat | 28 | 43 | 1 | 0 | 72 |
| *Vespadelus pumilus / Vespadelus troughtoni* / Vespadelus vulturnus* | Eastern Forest Bat / Eastern Cave Bat / Little Forest Bat | 2 | | | | 2 |
| | | | | | | |
| Unidentifiable calls | | 135 | 84 | 354 | 250 | 823 |
| Total identifiable calls | | 2982 | 2740 | 2603 | 1803 | 10218 |
| Total calls | | 3117 | 2824 | 2957 | 2053 | 11041 |
| | | | | | | |
| Percentage *M. australis* | | 74.8% | 67.8% | 62.4% | 51.1% | 65.8% |
| Percentage *M. o. oceanensis* | | 1.9% | 2.5% | 0.0% | 0.0% | 1.2% |
| Percentage *M. macropus* | | 21.7% | 27.0% | 37.3% | 48.6% | 31.6% |

# 6. Ultrasonic Call Analysis Limitations

Calls were positively identified when the defining characteristics were present and there was no chance of confusion between species with overlapping and/or similar calls. In this survey, there were some call sequences that could not be positively identified to species level. Further, some species recorded in this survey can have call profiles that overlap with other species.

When overlap occurs, species with similar call profiles are assigned to multi species groups of two or three potential species depending on the characteristics displayed in the recorded call sequences. Calls with intermediate characteristics were assigned mixed species labels. Microbats change their calls in response to the situations requiring more or different information such as when emerging from roosts (as evident in this study), flying in clutter, when approaching a prey item and during some types of social interaction. At these times, microbats tend to increase the steepness and characteristic frequency of their calls whilst decreasing the time between pulses, distorting the call shape and making positive identification difficult.

The species recorded in this survey with overlapping call profiles are described below.

The calls of *Chalinolobus gouldii* (Gould's Wattled Bat), *Ozimops ridei* (Ride's Free-tailed Bat) and *Micronomus norfolkensis* (Eastern Coastal Free-tailed Bat) can be difficult to separate overlapping between 30 and 36 kHz. Calls were identified as Ride's Free-tailed Bat when the call shape was flat (slope S1 of less than 100 OPS generally) and the frequency was between 24 – 36 kHz. Calls were identified as Eastern Coastal Free-tailed Bat when the call shape was flat, there was alternation in frequency between consecutive pulses and the frequency was between 30 and 36 kHz. Gould's Wattled Bat was distinguished by a frequency of 27.5 – 32.5 kHz and alternation in call frequency between pulses. When no distinguishing characteristics were present calls were assigned to multi-species groups.

The calls of Greater Broad-nosed Bat, Eastern False Pipistrelle and Eastern Broad-nosed Bat can be difficult to separate as their call frequencies and some other call characteristics overlap. Descriptions of the characteristics of the calls of each of these species are provided below:

- Eastern False Pipistrelle calls have a characteristic frequency between 35 and 39 kHz, display curved, often steep pulses without up-sweeping tails and sometimes with down-sweeping tails. The pre-characteristic section is often long (greater than 3 kHz). This species can only be separated from Eastern Broad-nosed Bat when the characteristic frequency is above 37 kHz.
- Greater Broad-nosed Bats can be distinguished by a frequency of 32 – 36 kHz, lack of a tail or short down-sweeping tail, frequency of the knee greater than 37 kHz, and drop of more than 3 kHz from the knee to the characteristic section. A longer pre-characteristic section can separate Greater Broad-nosed Bats from Eastern False Pipistrelles at lower frequencies (below 36.5 kHz).
- Eastern Broad-nosed Bat calls fall between 34.5 and 37 kHz, are curved without tails or sometimes down-sweeping tails. The frequency of the knee is most often greater than 38 kHz. This species cannot be distinguished from Eastern False Pipistrelle or Greater Broad-nosed Bat where they overlap.

In those cases when the calls could not be assigned to any one species individually, they were consequently labelled as multi-species combination dependent upon which of the characteristics matched the call profile.

The calls of Large Bent-winged Bat overlap in frequency with those of *Vespadelus regulus* Southern Forest Bat between 45 and 47 kHz in this region of NSW. Large Bent-winged Bat calls were distinguished by the following characteristics: a down-sweeping tail and the pulse shape and time between calls was variable (43 – 48.5 kHz). Southern Forest Bat calls are curved, have a regular pulse shape and generally up-sweeping tails. When no distinguishing characteristics were present calls were assigned to multi-species groups.

Southern Myotis calls can be easily confused with those of the Nyctophilus group of species because certain elements of the call profiles overlap, and it is not always possible to separate these calls. Calls were identified as *Nyctophilus* spp. when the time between calls (TBC) was higher than 95 milliseconds (ms) and the initial slope S1 was lower than 300 octaves per second (OPS). Calls were identified as Southern Myotis when the time between calls (TBC) was lower than 75ms and the initial slope S1 was greater than 400 OPS. Where the TBC was between 75 and 95ms and the OPS was between 300 and 400 calls were assigned a mixed species label of Southern Myotis / Long-eared Bats (Pennay, Law and Reinhold 2004).

It is likely that the majority of the recorded calls can be attributed to Southern Myotis because of the following reasons:

- The variable shape and slope of many of the pulses in a sequence is characteristic of Southern Myotis, a feature often observed in Southern Myotis calls recorded around a roost (Alicia Scanlon pers. comm. and comparison with reference calls gathered from several northern NSW Southern Myotis roost sites)
- The location where calls were recorded directly over water and immediately outside a known roost for Southern Myotis aligns with the roosting and foraging habitat preferences of Southern Myotis.
- Nyctophilus species are not known to roost in subterranean structures and their calls are very quiet, generally only picked up when within a few metres of the detector microphone. Given the lack of hollow bearing trees surrounding the tunnel entrances or lining the banks of Balickera Canal, there were expected to be very few Nyctophilus species calls recorded at either tunnel entrance.

The calls of Chocolate Wattled Bat, Little Bent-winged Bat, Eastern Forest Bat, Eastern Cave Bat and Little Forest Bat overlap to varying degrees above 50 kHz. Calls were identified as Chocolate Wattled Bat when they displayed a curved call shape with a down-sweeping tail in the frequency range of 48.5 – 53 kHz. Calls were identified as Little Bent-winged Bat if they displayed curved calls with downward sweeping tails, within the higher frequency range of 54.5 – 64.5 kHz. Calls were identified as Eastern Forest Bat when they displayed a curved shape and up sweeping tails within the frequency range of 53 – 58 kHz. Curved calls with up-sweeping tails recorded between 49 - 53 kHz were labelled as Eastern Cave Bat / Eastern Forest Bat / Little Forest Bat. Calls with no tails falling between 53.5 and 58 kHz were labelled as Little Bent-winged Bat / Eastern Forest Bat. Calls with no tails falling between 48.5 and 53 kHz were labelled as Chocolate Wattled Bat / Eastern Cave Bat / Eastern Forest Bat / Little Forest Bat.

Different bat species' calls differ in fundamental ways related to the foraging mode or the general activity of each species. Calls of different species and the different types of calls produced by each species (cruise, search, social, approach, attack) are not equally recorded by ultrasonic detectors. Weather and climatic conditions affect the quality and quantity of recorded data as well as the availability of insect prey and, therefore, the suitability of each site at a given time to provide foraging habitat.

# 7. Example Call Profiles

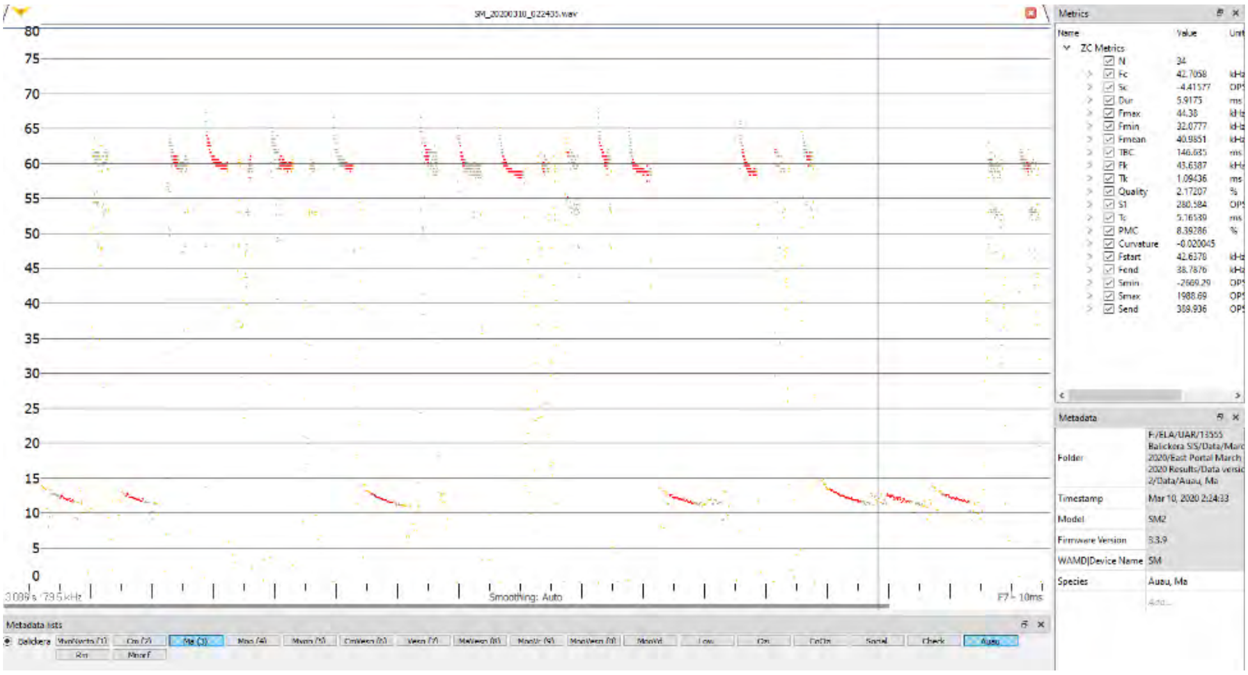

**Figure 7-1. Call profile for *Austronomus australis* (White-striped Free-tailed Bat) lower call and *Miniopterus australis* (Little Bent-winged Bat) upper call recorded at the downstream portal at Balickera Tunnel at 0224 (2:24 a.m.) on 10 March 2020.**

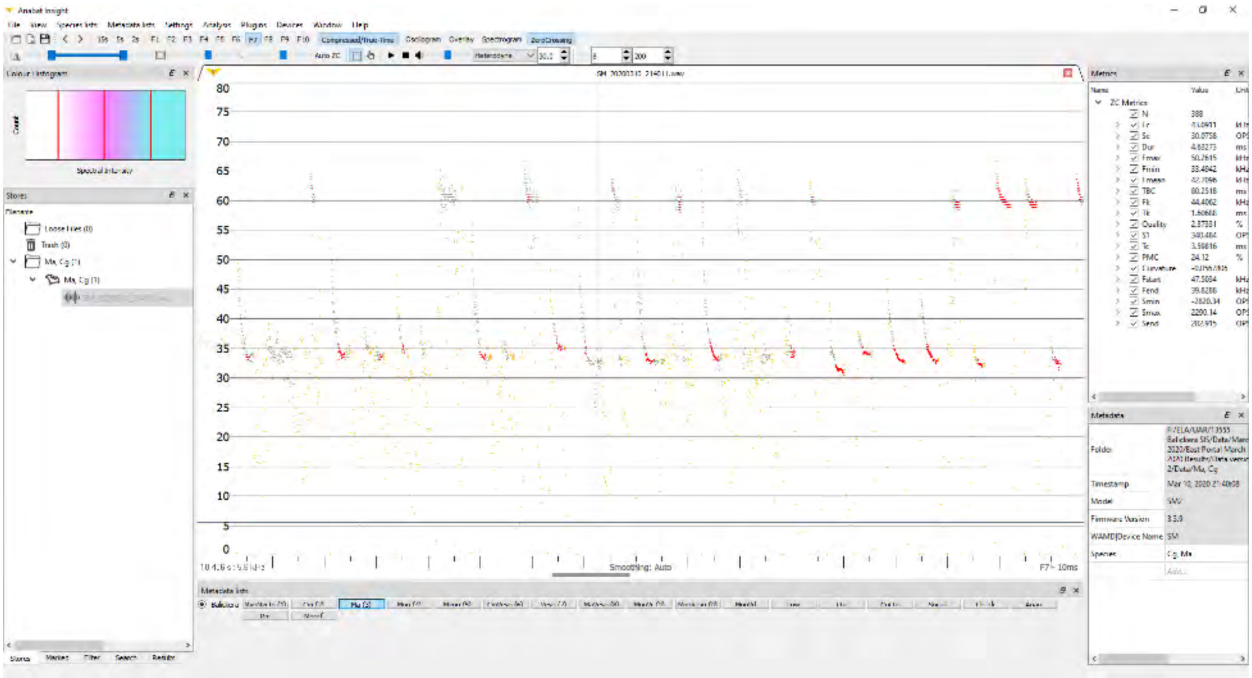

**Figure 7-2. Call profile for *Chalinolobus gouldii* (Gould's Wattled Bat) lower call and *Miniopterus australis* (Little Bent-winged Bat) recorded at the downstream portal of Balickera Tunnel at 2140 (9.40 p.m.) on 10 March 2021.**

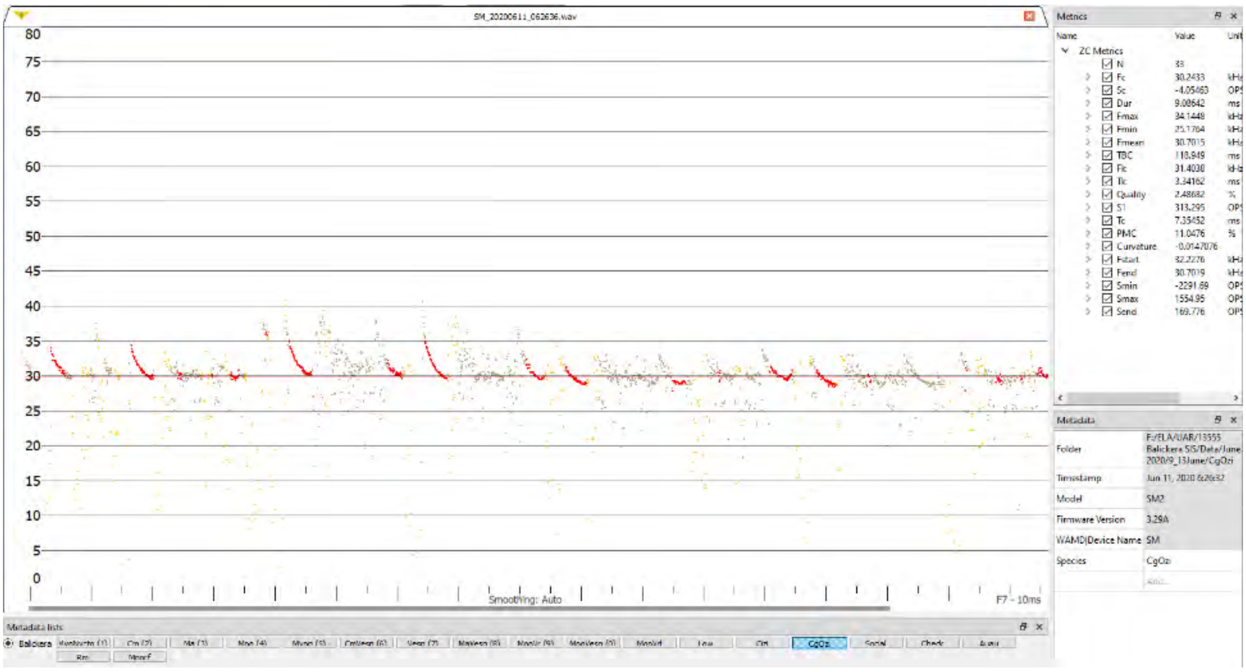


**Figure 7-3. Potential call profile for Chalinolobus gouldii (Gould's Wattled Bat) / Ozimops ridei (Ride's Free-tailed Bat) recorded at the upstream portal of Balickera Tunnel at 0626 (6:26 a.m.) on 11 June 2020.**

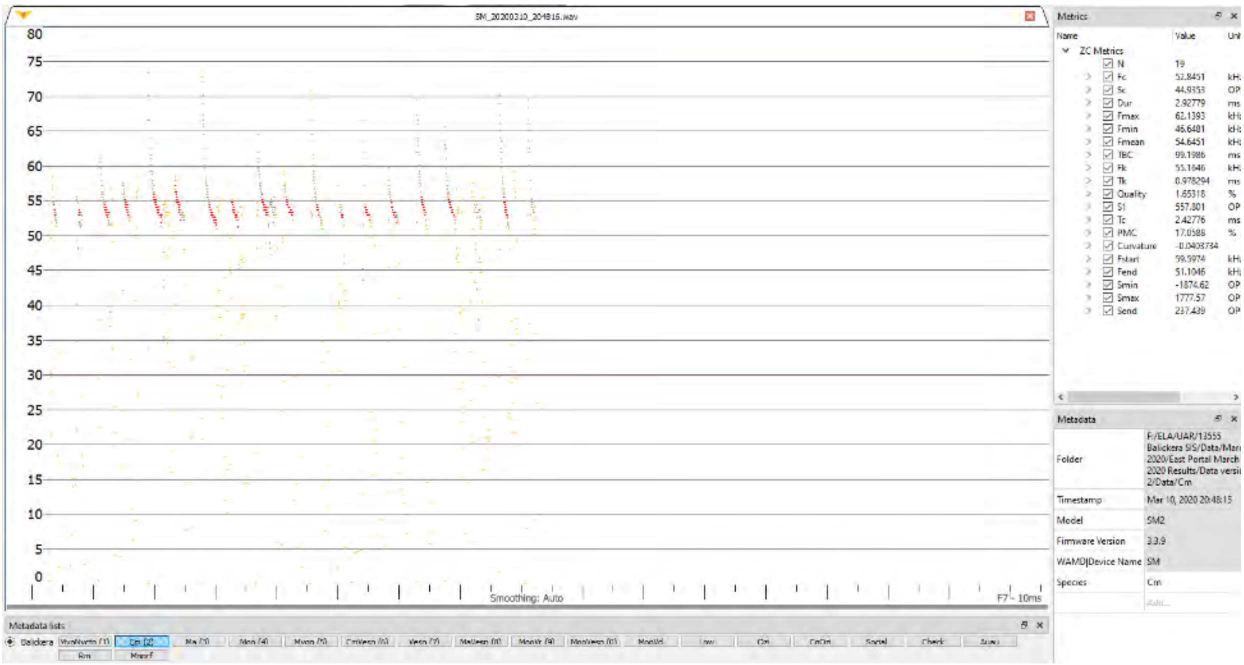


**Figure 7-4. Call profile for *Chalinolobus morio* (Chocolate Wattled Bat) recorded at the downstream portal of Balickera Tunnel at 2048 (10.48 p.m.) on 10 March 2020.**

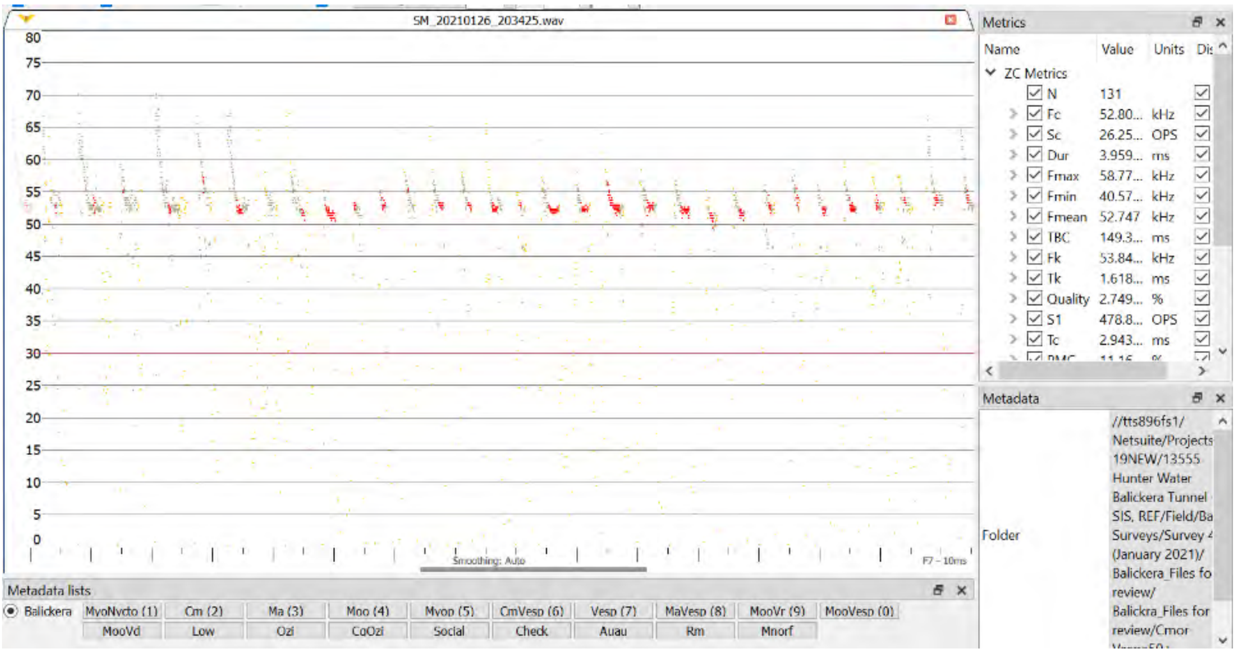


**Figure 7-5. Potential call profile for *Chalinolobus morio* (Chocolate Wattled Bat) / *Vespadelus pumilus* (Eastern Forest Bat) / *V. troughtoni* (Eastern Cave Bat) / *V. vulturnus* (Little Forest Bat) recorded at Balickera Tunnel at 2034 (8:34 p.m.) on 26 January 2021.**

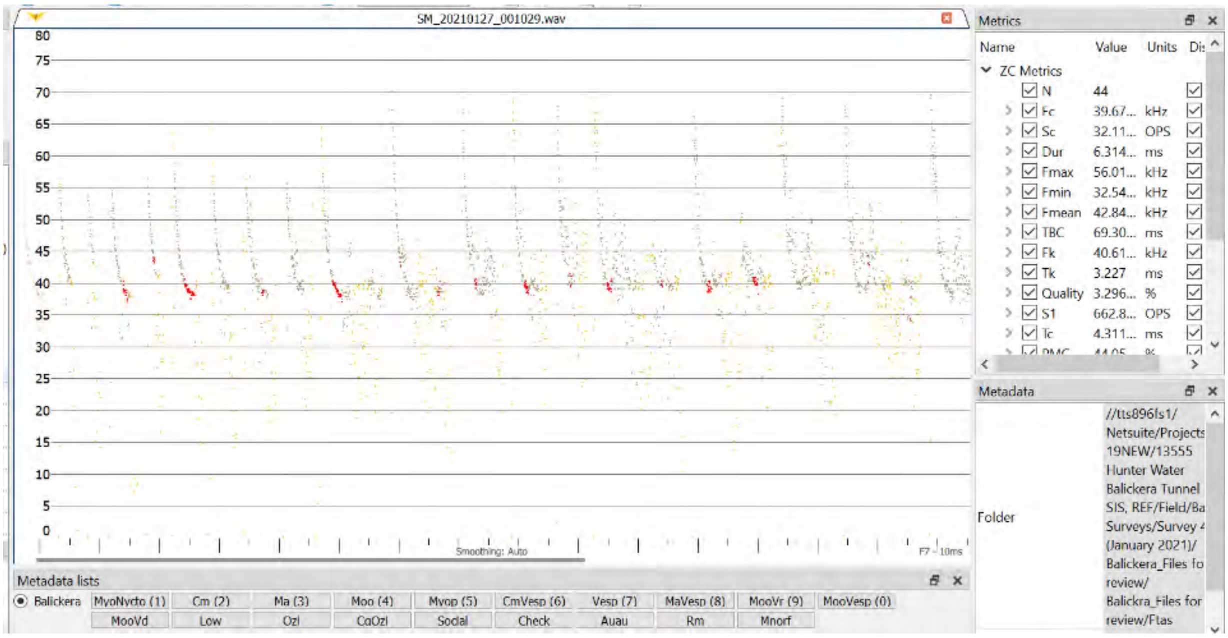


**Figure 7-6. Call profile for *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) recorded at Balickera Tunnel at 0010 (12.10 a.m.) on 27 January 2021.**

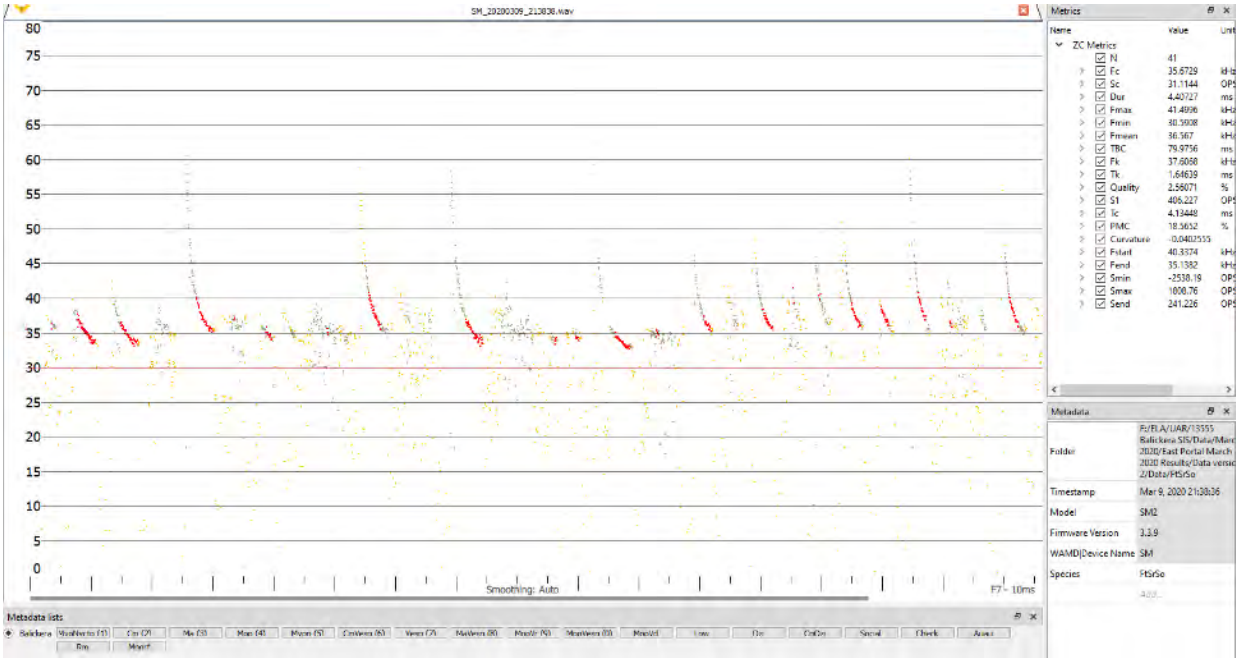

**Figure 7-7. Potential call profile for *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) / *Scoteanax rueppellii* (Greater Broad-nosed Bat) / *Scotorepens orion* (Eastern Broad-nosed Bat) recorded at the downstream portal of Balickera Tunnel at 2138 (9:38 p.m.) on 9 March 2020.**

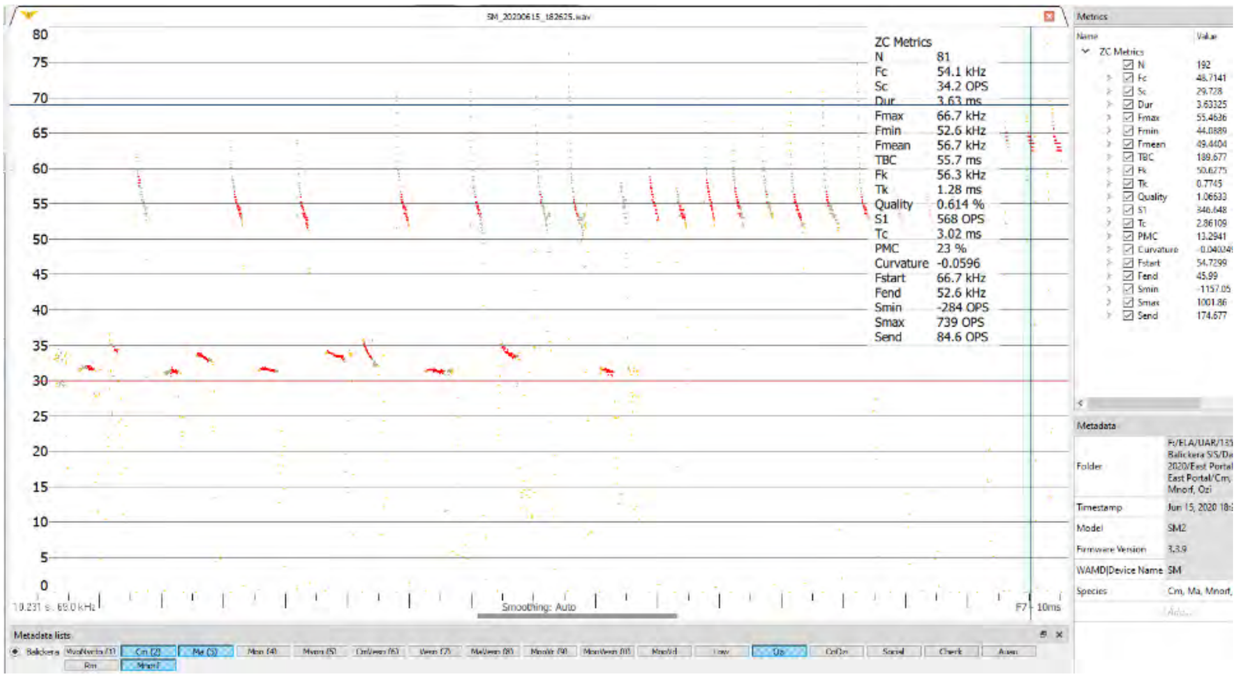


**Figure 7-8. Call profile for *Micronomus norfolkensis* (Eastern Coastal Free-tailed Bat) lower call, and *Chalinolobus morio* (Chocolate Wattled Bat) upper call recorded at the downstream portal of Balickera Tunnel at 1826 (6:26 p.m.) on 15 June 2020.**

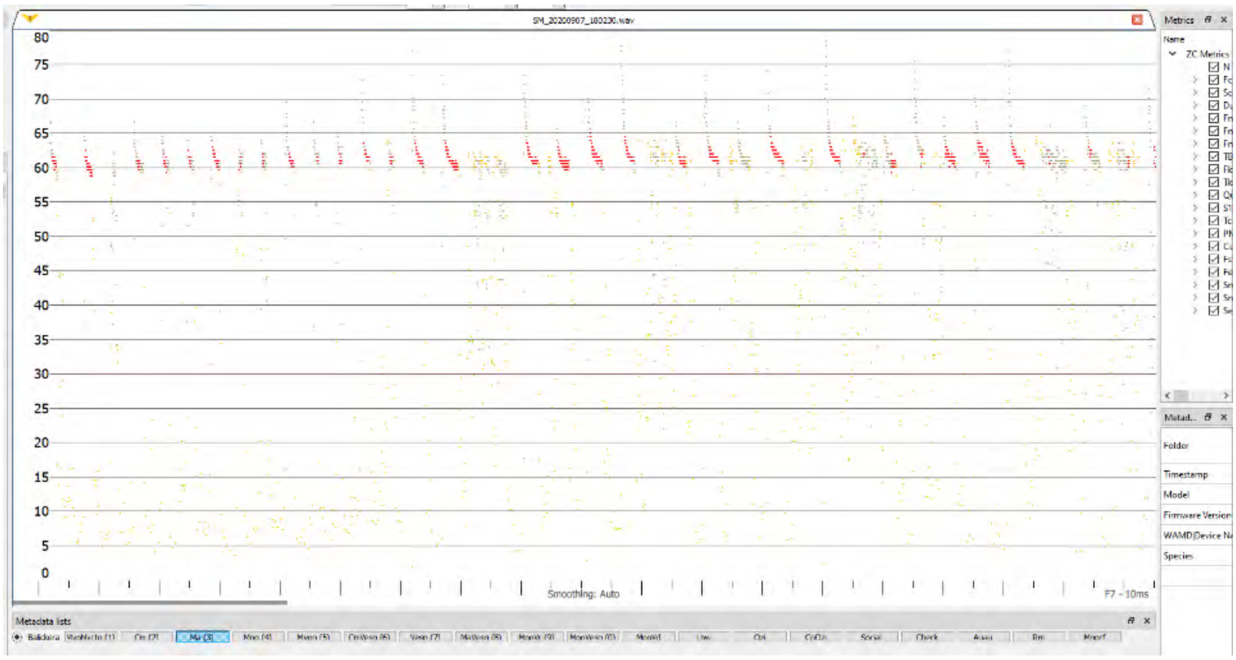

**Figure 7-9: Call profile for *Miniopterus australis* (Little Bent-winged Bat) recorded at the upstream portal of Balickera Tunnel at 1802 (6.02 p.m.) on September 2020.**

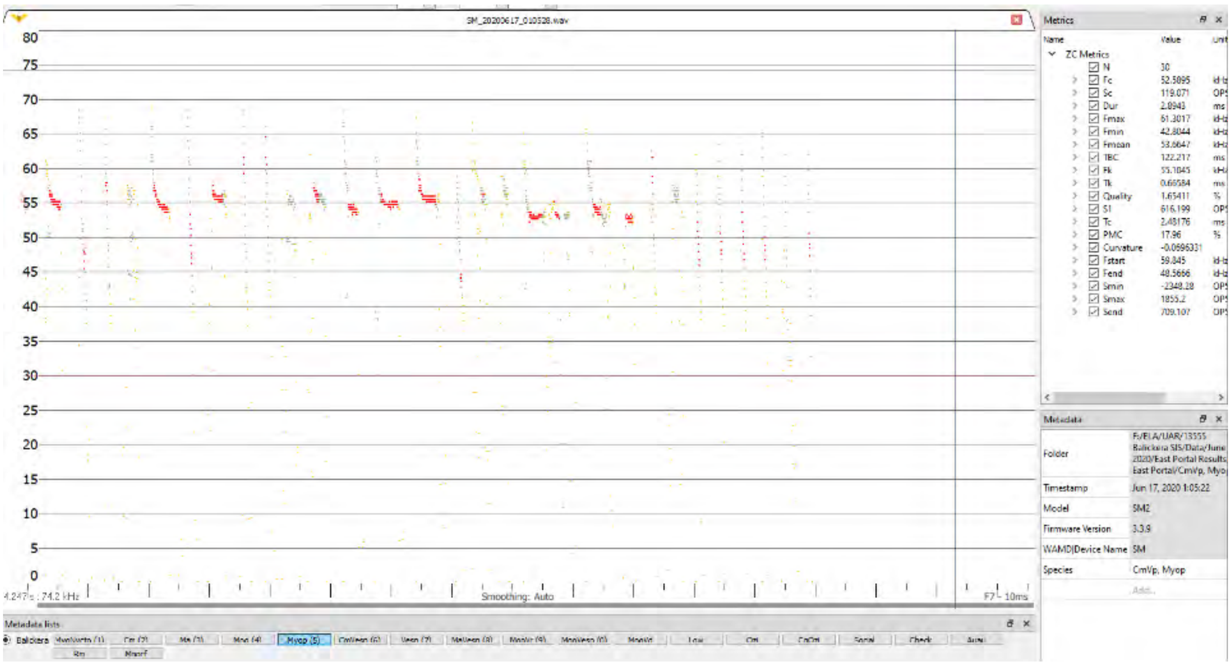

**Figure 7-10. Potential call profile for *Miniopterus australis* (Little Bent-winged Bat) / *Vespadelus pumilus* (Eastern Forest Bat) upper curved call, and *Myotis macropus* (Southern Myotis) near vertical call recorded at the downstream portal of Balickera Tunnel at 0105 (1:05 a.m.) on 17 June 2020.]**

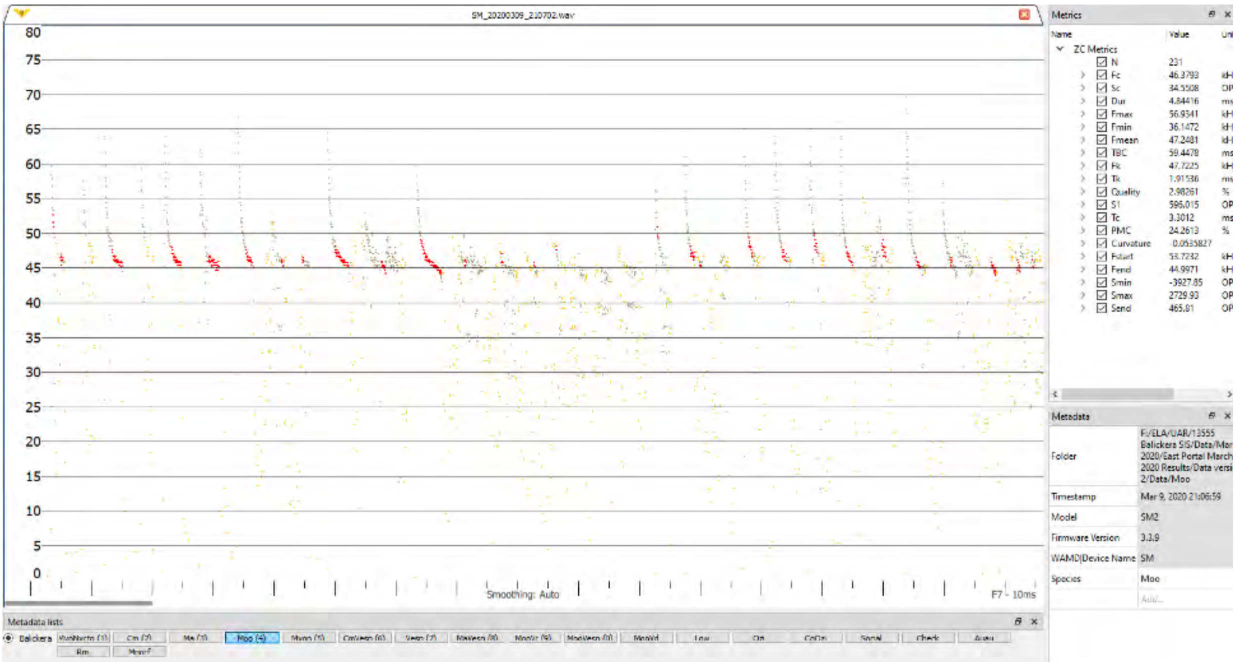


**Figure 7-11. Call profile for *Miniopterus orianae oceanensis* (Large Bent-winged Bat) recorded at the downstream portal of Balickera Tunnel at 2107 (9:07 p.m.) on 9 March 2020.**

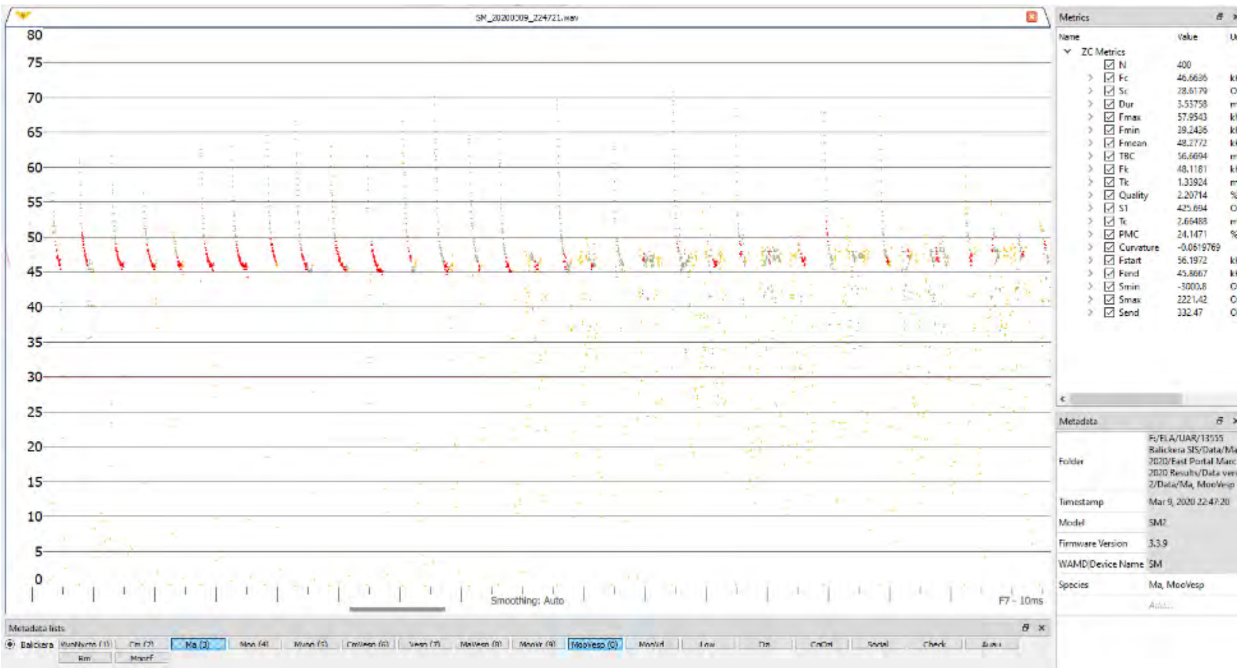


**Figure 7-12. Potential call profile for *Miniopterus orianae oceanensis* (Large Bent-winged Bat) / *Vespadelus regulus* (Southern Forest Bat) recorded at the downstream portal of Balickera Tunnel at 2247 (10:47 p.m.) on 9 March 2020.**

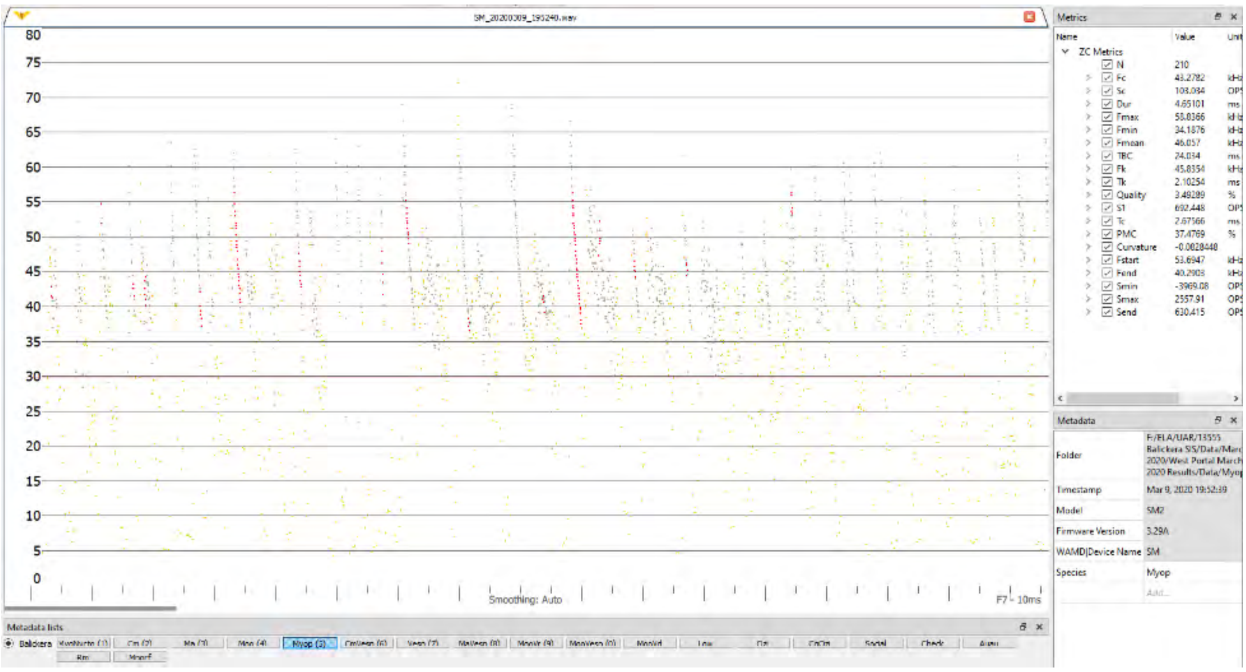

**Figure 7-13. Call profile for *Myotis macropus* (Southern Myotis) recorded at the upstream portal of Balickera Tunnel at 1952 (7:52 pm) on 9 March 2020.**


**Figure 7-14. Potential call profile for *Myotis macropus* (Southern Myotis) / *Nyctophilus geoffroyi* (Lesser Long-eared Bat) / *N. gouldi* (Gould's Long-eared Bat) recorded at the upstream portal of Balickera Tunnel at 2232 (10:32 p.m.) on 30 September 2020.**

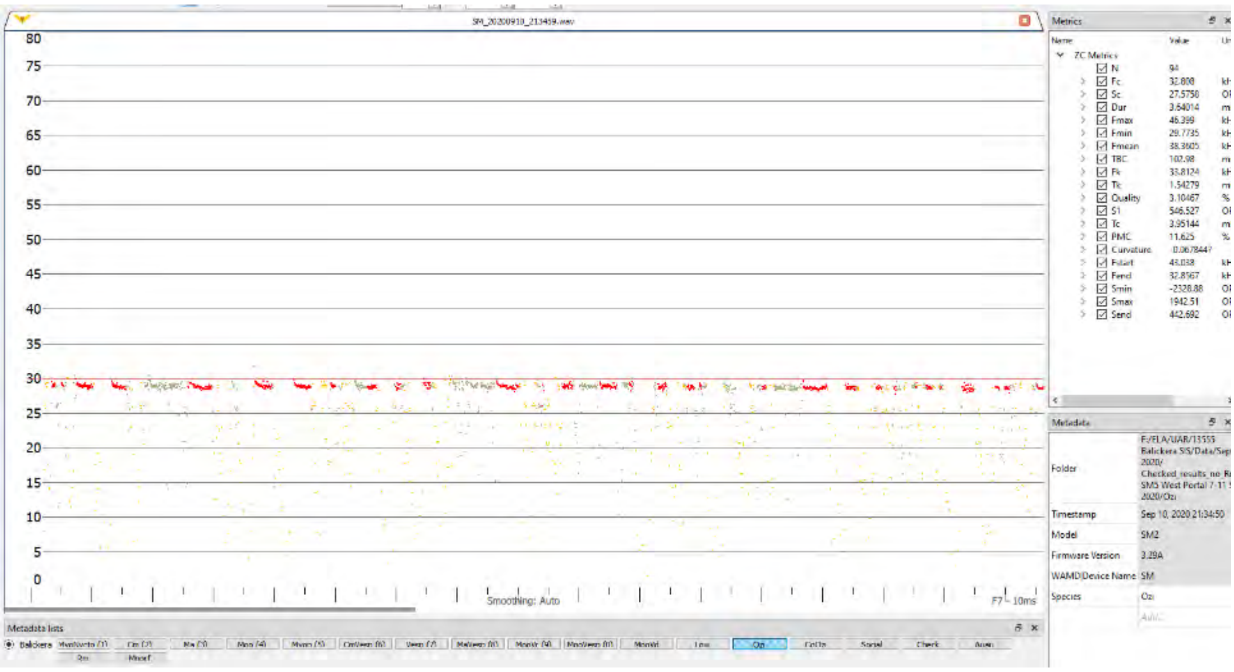

**Figure 7-15. Call profile *Ozimops ridei* (Ride's Free-tailed Bat) recorded at the upstream portal of Balickera Tunnel at 2134 (9.34 p.m.) on 10 September 2020.**

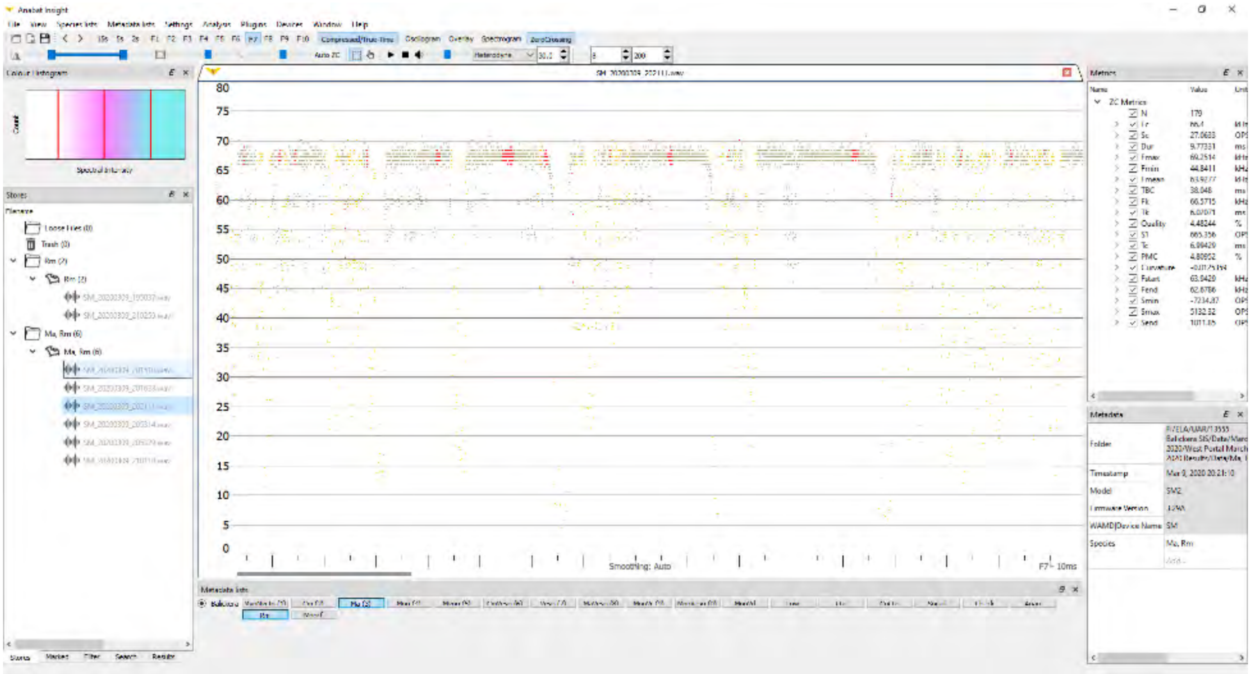

**Figure 7-16. Call profile for *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) recorded at the upstream portal of Balickera Tunnel at 2021 (8:21 p.m.) on 9 March 2020.**

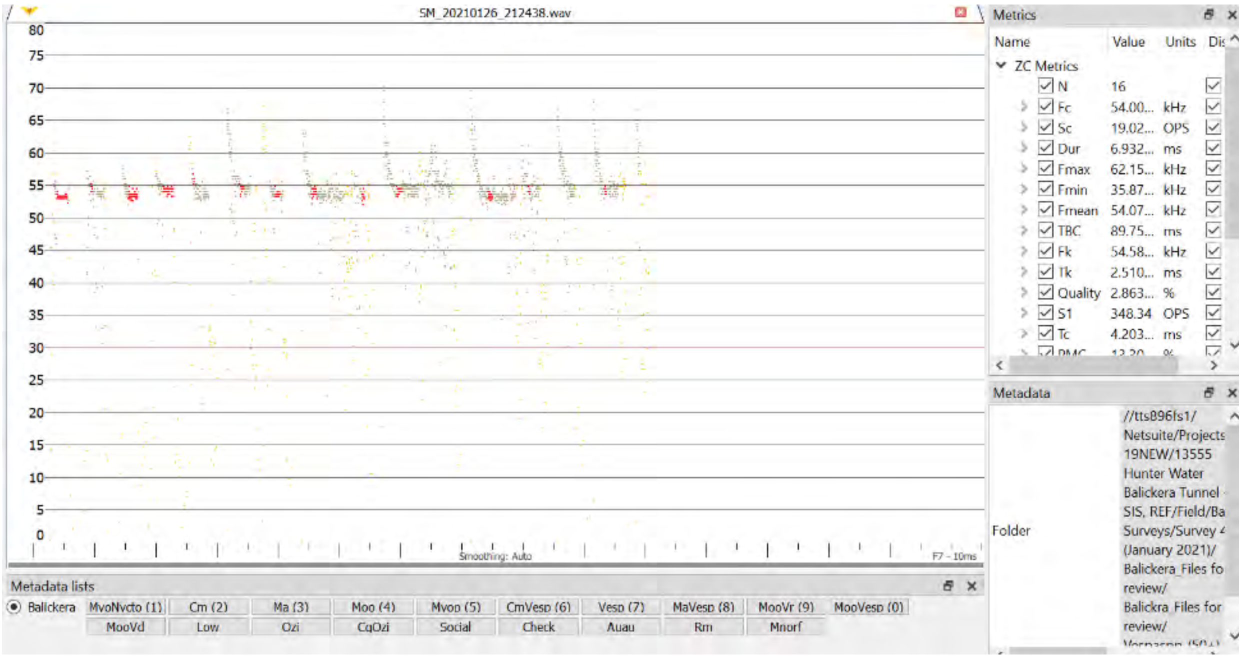

**Figure 7-17. Call profile for *Vespadelus pumilus* (Eastern Forest Bat) recorded at Balickera Tunnel at 2124 (9:24 p.m.) on 26 January 2021.**

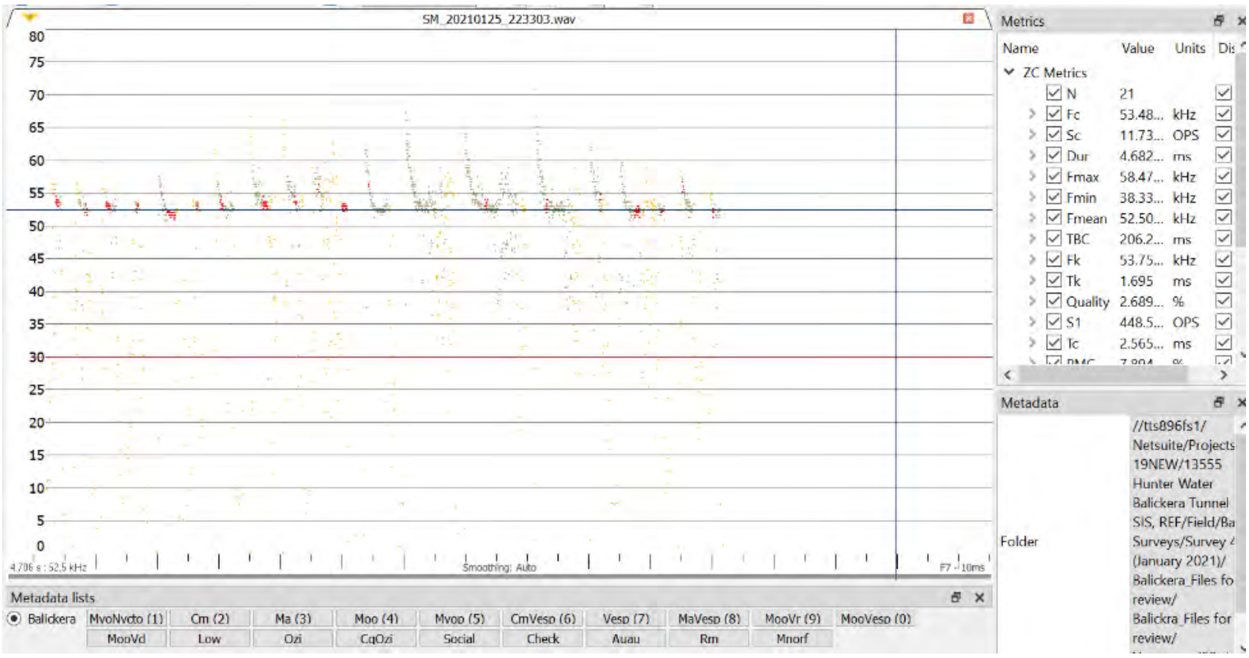

**Figure 7-18. Potential call profile for *Vespadelus pumilus* (Eastern Forest Bat) / *V. troughtoni* (Eastern Cave Bat) / *V. vulturnus* (Little Forest Bat) recorded at Balickera Tunnel at 2233 (10:33 p.m.) on 25 January 2021.**

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# Appendix G BAM Credit Report

# BAM Credit Summary Report

## Proposal Details

Assessment Id
00025758/BAAS19034/21/00025759

Proposal Name
BalickeraTunnel_SIS

BAM data last updated *
08/06/2021

Assessor Name
Tom  Schmidt

Report Created
11/06/2021

BAM Data version *
42

Assessor Number
BAAS19034

BAM Case Status
Open

Date Finalised
To be finalised

Assessment Revision
1

Assessment Type
Part 5 Activities

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

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

| Zone | Vegetation zone name | TEC name | Current Vegetation integrity score | Change in Vegetation integrity (loss / gain) | Area (ha) | BC Act Listing status | EPBC Act listing status | Species sensitivity to gain class (for BRW) | Biodiversity risk weighting | Potential SAII | Ecosystem credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast** | | | | | | | | | | | |
| 1 | 1588_Good | Not a TEC | 40.4 | 40.4 | 0.05 | | | High Sensitivity to Potential Gain | 1.75 | | 1 |
| | | | | | | | | | | **Subtotal** | **1** |
| | | | | | | | | | | **Total** | **1** |

## Species credits for threatened species

| Vegetation zone name | Habitat condition (Vegetation Integrity) | Change in habitat condition | Area (ha)/Count (no. individuals) | BC Act Listing status | EPBC Act listing status | Biodiversity risk weighting | Potential SAII | Species credits |
|---|---|---|---|---|---|---|---|---|
| ***Haliaeetus leucogaster / White-bellied Sea-Eagle ( Fauna )*** | | | | | | | | |
| 1588_Good | 40.4 | 40.4 | 0.05 | Vulnerable | Not Listed | 2 | False | 1 |
| | | | | | | | **Subtotal** | **1** |
| ***Myotis macropus / Southern Myotis ( Fauna )*** | | | | | | | | |
| 1588_Good | 40.4 | 40.4 | 0.05 | Vulnerable | Not Listed | 2 | False | 1 |
| | | | | | | | **Subtotal** | **1** |
| ***Phascolarctos cinereus / Koala ( Fauna )*** | | | | | | | | |
| 1588_Good | 40.4 | 40.4 | 0.05 | Vulnerable | Vulnerable | 2 | False | 1 |
| | | | | | | | **Subtotal** | **1** |

# Appendix H NSW BC Act Test of significance

Under Part 7, division 1 of the NSW BC Act, the test of significance is to be taken into account for the purposes of determining whether a proposed activity or activity is likely to significantly affect threatened species or ecological communities, or their habitats. This test has been applied to affected species identified within this SIS. Tests of significance are provided below, and some species have been categorised into functional groups to streamline the assessment.

## LITTLE BENT- WINGED BAT

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The Balickera Tunnel is not known to be a maternity roost for the Little Bent-winged Bat. The species occurs in large enough numbers within the tunnel (2000 – 6000) to represent a significant portion (potentially >50%) of the nearest breeding colony, and represents 5% of the national population. The roost represents the most southerly permanently inhabited roosting habitat of its size for this species. Individuals are present in the tunnel year round. A large portion of the breeding population of Little Bent-winged Bats migrates from winter / hibernation roosts to maternity roosts each year in spring and summer to give birth and raise young (Churchill 2008), and this is true of the females and some of the males at Balickera Tunnel.<br>Bats remaining at the tunnel over summer are largely non breeding males. Non-breeding males are also an important component of the population as future mates contributing to the ongoing reproductive output of the population.<br>The majority of the roost sites within the tunnel are within 500m of the upstream portal. The roost sites comprise both natural rock surface (main Little Bent-winged Bat roosts) and vertical holes in the concrete lined sections.<br>The proposal will involve permanent changes to the structure of roosting habitat within the tunnel. A layer of shotcrete will be applied to the concrete lined sections including the vertical holes used as roosting habitat. Some areas of Little and Large Bent-winged Bat roosting habitat located on the natural rock surfaces will also be permanently changed through the application of shotcrete and additional rock bolting.<br>The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts. The microbat management plan (MMP, Appendix J) sets out provisions for documenting the location and measurements (area, contouring) of roosting habitat and requirements for recreation where impacts cannot be avoided.<br>The proposal will temporarily exclude all bats from the tunnel for a period of up to 5 months at a time when the majority of pregnant females have already migrated to maternity roosts. By the time bats are returning from maternity roosts in late summer / early autumn (February / March) there are still ample food resources available regionally to allow bats additional time to locate and assimilate into alternative roost sites. Tunnel remediation works will be complete in autumn (April / May), leaving time for bats to inhabit the tunnel again over winter. The MMP (Appendix J) outlines in detail the timing and methodology to be applied to the exclusion process, which will be staged to occur at one end of the tunnel at a time. The MMP (Appendix J) also includes a microbat monitoring program that will be undertaken prior to, during the exclusion and construction phase and post construction works at Balickera Tunnel. The monitoring |

| BC Act | Question | Response |
|---|---|---|
| | | program includes Balickera Tunnel, bat boxes installed as compensatory habitat and a series of alternative roost sites / control sites. It also includes radio tracking of a sample of bats excluded from the tunnel which aims to provide information on bat movements immediately prior to and post exclusion from a significant roost site.<br>Little Bent-winged Bats are capable of roosting in a range of subterranean structures including caves, derelict mines, tunnels, bridges and culverts, buildings and tree hollows. There is likely to be movement of individuals between roosts within a broad regional area, and this behaviour has been documented by Dwyer (1968) at a series of Little Bent-winged Bat roosts in northern NSW and also for their larger cousins, Large Bent-winged Bats and Southern Bent-winged Bats.<br>There are three potential alternative Little Bent-winged Bat roosts capable of accommodating the approximately 2000 bats that would be displaced during a tunnel exclusion conducted over summer (Brookfield Tunnel, Pilchers Mtn and Dungog WTP Tunnel) within nightly flight range of Balickera Tunnel. There are three other alternative roosts with a reduced capacity (500 - 1000 bats between all three roosts) that could easily be reached by bats using an interim roost as a stepping stone.<br>There is a good chance that the majority of bats excluded from the tunnel will locate and assimilate into one of the known alternative roosts. Exclusion conducted during late December should not have an adverse effect on the reproductive cycle of this species and the viability of the local population because it will not impact on breeding females. The species will be temporarily excluded from the tunnel during works, reducing the amount of roosting habitat available locally. However, this will only be a short-term impact, with at least 75% of the roosting habitat in the tunnel to be available at the completion of tunnel remediation works, either in original form or as recreated habitat. There is capacity within the network of alternative roosts within a 50 km radius to accommodate bats that would otherwise be roosting at Balickera between December and April. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community: | Not applicable. |

| BC Act | Question | Response |
|---|---|---|
| | Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | Access to the roosting habitat of this species within Balickera Tunnel will be removed temporarily, for a period of up to 5 months during exclusion. Bats returning from maternity roosts at the end of summer (February / March) will continue to be excluded from the tunnel and will need to assimilate into alternative roost sites.<br>Some roosting habitat will be permanently lost due to the application of shotcrete and rock bolts over portions of the existing tunnel surface, however the main roosting areas (two areas on natural rock surface and up to 40 of the vertical cylindrical 20cm diameter holes) will be retained in existing format, where possible or recreated using shotcrete during tunnel remediation works. During the time period of the temporary exclusion (early summer) the species has the ability to migrate hundreds of kilometres to maternity roosts and any individuals that have not already migrated to maternity roosts will have the ability to relocate to one of the alternative roost sites available within a 50 km radius.<br>A small area (0.05 ha) of potential foraging habitat will be removed for the proposal. This habitat is connected to large regions of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for this species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur because of the proposed works. This species is highly mobile, capable of flying 33 km from roost sites in a night. Individuals are likely to move between a network of roosts within a region and this behaviour has been recorded in Large Bent-winged Bats. The subject site is surrounded by similar suitable habitat to be retained, including three other known alternative roost sites within nightly flight range, and several more that are attainable over 2 – 3 nights of flight from Balickera Tunnel. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The tunnel is a significant roosting resource for the Little Bent-winged Bat and is part of a network of roost sites available to local populations of this species. The population of bats recorded using the tunnel during surveys for this SIS represents potentially >50% of the nearest breeding colony and 5% of the national population of the species. The roost is the most southerly permanently inhabited roosting habitat of its size for this species. The tunnel plays an important role in facilitating social interactions, provides refuge from the elements during rest and torpor as well as a safe place for foraging even when the weather is poor outside the tunnel. A maternity roost in Queensland at Mt Etna has been recorded to be orders of magnitude larger, but there are few large winter roosts of this size known throughout NSW. It is used by this species year round and attains peak occupancy over winter. It is not a maternity roost. It is a winter |

| BC Act | Question | Response |
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| | | hibernation roost and also likely to be a mating / copulation roost for this species. It is vitally important that the roosting habitat is preserved for the long-term survival of this species.<br>The area of foraging habitat proposed to be impacted represents a relatively small area of potential foraging habitat and is not expected to be important for the long-term survival of these species in the locality. The loss of access to roosting habitat will only be temporary during works, and several other roosts are known to be available for this species to use during this time. At least 75% of the existing microbat roosting habitat will be available for use by all three species of bat at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. However, the extent of vegetation to be cleared is minimal (0.05 ha) and is unlikely to have a substantial impact on the suitability of the site for usage by the species. |
| Conclusion | Is there likely to be a significant impact? | Yes. A significant impact is likely if the recommended amelioration and mitigation measures (including exclusion of all bats from the tunnel) as set out in the MMP (Appendix I) are not implemented. Conducting tunnel remediation works without due consideration of the impacts to roosting bats will lead to reduced fitness, reduced survival, injury, illness and potentially death of a large number of Little Bent-winged Bats as a result of disturbance, exhaustion, starvation or predation. A residual risk remains that Little Bent-winged Bats will not return to roost in the tunnel following completion of works, even if at least 75% of the roosting habitat remains available to them. Bent-winged Bats are known to be sensitive to disturbance at roost sites and disturbance has been known to cause roost abandonment. This warrants the application of the precautionary principle. As such, if a significant impact is identified from the post exclusion monitoring results, Hunter Water have agreed to set aside funds for the implementation of appropriate adaptive mitigation / contingency measures (in consultation with BCD/DPIE) to offset the loss of habitat, as detailed in the MMP. |

## LARGE BENT-WINGED BAT

| BC Act | Question | Response |
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| 7.3.1 a) | In the case of a threatened species: | The Balickera Tunnel is not known to be a maternity roost for the Large Bent-winged Bat. The species occurs in smaller numbers within the tunnel (300 – 500) than Little Bent-winged Bats. However, the tunnel is an important |

| BC Act | Question | Response |
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| | whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | roost site for the local populations and individuals are present in the tunnel year round. The Large Bent-winged Bat population in the tunnel is less than 1% of the total population in Australia. A large portion of the breeding population of Large Bent-winged Bats migrates from winter / hibernation roosts to maternity roosts each year in spring and summer to give birth and raise young.<br><br>No Large Bent-winged Bats were captured during the current study. Results from previous studies indicate that this species is generally absent from the tunnel over summer but that it may contain a few non breeding males. Non-breeding males are also an important component of the population as future mates contributing to the ongoing reproductive output of the population.<br><br>The majority of the roost sites within the tunnel are within 500m of the upstream portal. The roost sites comprise both natural rock surface (main Little Bent-winged Bat roosts) and vertical holes in the concrete lined sections.<br><br>The proposal will involve permanent changes to the structure of roosting habitat within the tunnel. A layer of shotcrete will be applied to the concrete lined sections including the vertical holes used as roosting habitat. Some areas of Little and Large Bent-winged Bat roosting habitat located on the natural rock surfaces will also be permanently changed through the application of shotcrete and additional rock bolting.<br><br>The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts. The microbat management plan (MMP, Appendix J) sets out provisions for documenting the location and measurements (area, contouring) of roosting habitat and requirements for recreation where impacts cannot be avoided.<br><br>The proposal will temporarily exclude all bats from the tunnel for a period of up to 5 months at a time when the majority of pregnant females have already migrated to maternity roosts. By the time bats are returning from maternity roosts in late summer (February / March) there are still ample food resources available regionally to allow bats additional time to locate and assimilate into alternative roost sites. Tunnel remediation works will be complete in autumn (April / May), leaving time for bats to inhabit the tunnel again over winter. The MMP (Appendix J) outlines in detail the timing and methodology to be applied to the exclusion process, which will be staged to occur at one end of the tunnel at a time. The MMP (Appendix J) also includes a microbat monitoring program that will be undertaken prior to, during the exclusion and construction phase and post construction works at Balickera Tunnel. The monitoring program includes Balickera Tunnel, bat boxes installed as compensatory habitat and a series of alternative roost sites / control sites. It also includes radio tracking of a |

| BC Act | Question | Response |
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| | | sample of bats excluded from the tunnel which aims to provide information on bat movements immediately prior to and post exclusion from a significant roost site.<br>Large Bent-winged Bats are capable of roosting in a range of subterranean structures including caves, derelict mines, tunnels, bridges and culverts (Churchill 2008). There is movement of individuals between roosts within a territorial area, which generally encompasses a network of suitable roost sites. Flight ranges of up to 65 km from roost sites have been recorded.<br>There are several potential alternative Large Bent-winged Bat roosts within nightly flight range that are capable of accommodating all of the Large Bent-winged Bats that would be displaced during tunnel exclusion. One of these, Dungog WTP is a significant roost site for Large Bent-winged Bats estimated to contain 2000+ bats and occupied year round.<br>There is a good chance that the majority of bats excluded from the tunnel will locate and assimilate into one of the known alternative roosts. Exclusion conducted during late December should not have an adverse effect on the reproductive cycle of this species and the viability of the local population because no breeding females will be impacted. The species will be temporarily excluded from the tunnel during works, reducing the amount of roosting habitat available locally. However, this will only be a short-term impact, with at least 75% of the roosting habitat in the tunnel to be available at the completion of tunnel remediation works, either in original form or as recreated habitat. There is capacity within the network of alternative roosts within a 50 km radius to accommodate bats that would otherwise be roosting at Balickera between December and April. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that | Not applicable. |

| BC Act | Question | Response |
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| | its local occurrence is likely to be placed at risk of extinction. | |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | Access to the roosting habitat of this species within Balickera Tunnel will be removed temporarily, for a period of up to 5 months during exclusion. Bats returning from maternity roosts at the end of summer (February / March) will continue to be excluded from the tunnel and will need to assimilate into alternative roost sites.<br>Some roosting habitat will be permanently lost, due to the application of shotcrete and rock bolts over portions of the existing tunnel surface, however the main roosting areas (two areas on natural rock surface and up to 40 of the vertical cylindrical 20cm diameter holes) will be retained in existing format, where possible or recreated using shotcrete during tunnel remediation works. During the time period of the temporary exclusion (early summer) the species has the ability to migrate hundreds of kilometres to maternity roosts and any individuals that have not already migrated to maternity roosts will have the ability to relocate to one of the alternative roost sites available within a 50 km radius.<br>A small area (0.05 ha) of potential foraging habitat will be removed for the proposal. This habitat is connected to large regions of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for this species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur because of the proposed works. This species is highly mobile, capable of flying up to 65 km from roost sites in a night. Individuals move between a network of roosts within a region. The subject site is surrounded by similar suitable habitat to be retained, including several other known alternative roost sites within nightly flight range, one of which; Dungog WTP Tunnel, is a much larger roost for Large Bent-winged Bats than Balickera. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The tunnel is a significant roosting resource for the Large Bent-winged Bat and is part of a network of roost sites available to local populations of this species. The tunnel plays an important role in facilitating social interactions, provides refuge from the elements during rest and torpor as well as a safe place for foraging even when the weather is poor outside the tunnel. It is not a maternity roost. It is a winter hibernation roost and also likely to be a mating / copulation roost for this species. It is important that the roosting habitat is preserved for the long-term survival of this species.<br>The loss of access to roosting habitat will only be temporary during works, and several other roosts are known to be available for this species to use during this time. At least 75% of the existing microbat roosting habitat will be available for use by all three species of bat at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |

| BC Act | Question | Response |
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| | area of outstanding biodiversity value (either directly or indirectly). | |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. However, the extent of vegetation to be cleared is minimal (0.05 ha) and is unlikely to have a substantial impact on the suitability of the site for usage by the species. |
| Conclusion | Is there likely to be a significant impact? | Yes. A significant impact is likely if the recommended amelioration and mitigation measures (including exclusion of all bats from the tunnel) as set out in the MMP (Appendix I) are not implemented. Conducting tunnel remediation works without due consideration of the impacts to roosting bats will lead to reduced fitness, reduced survival, injury, illness and potentially death of a large number of Large Bent-winged Bats as a result of disturbance, exhaustion, starvation or predation. A residual risk remains that Little Bent-winged Bats will not return to roost in the tunnel following completion of works, even if at least 75% of the roosting habitat remains available to them. Bent-winged Bats are known to be sensitive to disturbance at roost sites and disturbance has been known to cause roost abandonment. This warrants the application of the precautionary principle. As such, if a significant impact is identified from the post exclusion monitoring results, Hunter Water have agreed to set aside funds for the implementation of appropriate adaptive mitigation / contingency measures (in consultation with BCD/DPIE) to offset the loss of habitat, as detailed in the MMP. |

## SOUTHERN MYOTIS

| BC Act | Question | Response |
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| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The Balickera Tunnel is a significant maternity roost for Southern Myotis, with the colony estimated to be between 50 and 200 bats at peak occupancy at the end of summer. Colonies of this size are known but usually group size is around 15 to 30. The colony roosting within Balickera Tunnel represents 2% of the national population.<br>Colonies are generally centred on maternity roost sites where a dominant male defends a harem of between one and 12 females, with larger colonies the result of multiple harems. Dispersing and non-breeding males move between a network of roosts within a territorial region.<br>The proposed works will temporarily exclude all bats from the tunnel for a period of up to 5 months at a time when females may be pregnant, and/ or have recently given birth to pups that have not been weaned or are unable to fly. Pups are weaned around 8 weeks of age.<br>The majority of the roost sites within the tunnel are within 500m of the upstream portal. The roost sites comprise both natural rock surface (main Little Bent-winged Bat roosts) and vertical holes in the concrete lined sections (main Southern Myotis breeding and roosting sites). |

| BC Act | Question | Response |
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| | | The proposal will involve permanent changes to the structure of roosting habitat within the tunnel. A layer of shotcrete will be applied to the concrete lined sections including the vertical holes used as roosting and breeding habitat by Southern Myotis. Some areas of Little and Large Bent-winged Bat roosting habitat located on the natural rock surfaces will also be permanently changed through the application of shotcrete and additional rock bolting.<br>The structure and integrity of existing microbat roosting habitat will be preserved through avoidance of impacts, where possible. Where impacts cannot be avoided to significant areas of roosting habitat (two main cluster roost sites on natural rock substrate and at least 40 vertical holes in the concrete lined sections) roosting habitat will be carefully documented and recreated using shotcrete during tunnel remediation works. The project ecologist will be required to approve satisfactory completion of the recreated roosting habitat. The aim will be to ensure at least 75% of the existing microbat roosting habitat is available for use by all three species at the conclusion of the proposed works, either in original format or a combination of original format and replicated roosts. The microbat management plan (MMP, Appendix J) sets out provisions for documenting the location and measurements (area, contouring) of roosting habitat and requirements for recreation where impacts cannot be avoided.<br>Southern Myotis are capable of roosting in a range of subterranean structures including caves, derelict mines, tunnels, bridges and culverts as well as tree hollows and amongst vegetation (Churchill 2008). Flight ranges of 10 -12 km from roost sites have been recorded.<br>There are three alternative maternity roost sites known within nightly flight range of the tunnel, two of which are capable of accommodating the number of bats that would be displaced from Balickera Tunnel during remediation works.<br>There is a good chance that the majority of Southern Myotis excluded from the tunnel will locate and assimilate into one of the known alternative roosts or start a new roost within bat boxes recommended to be installed beneath the Pacific Highway Bridge over Balickera Canal. The MMP (Appendix J) also includes a microbat monitoring program that will be undertaken prior to, during the exclusion and construction phase and post construction works at Balickera Tunnel. The monitoring program includes Balickera Tunnel, bat boxes installed as compensatory habitat and a series of alternative roost sites / control sites. It also includes radio tracking of a sample of bats excluded from the tunnel which aims to provide information on bat movements immediately prior to and post exclusion from a significant roost site. Approval from TfNSW will be required prior to box installation.<br>Exclusion conducted during late December will disrupt the reproductive cycle of this species and will reduce the survival rate of pups born in October / November as some may not be ready to fly when the roost is excluded. There is also the potential for the loss of the second litter of pups due to be born in January / February as a result of poor condition in breeding females due to the stress involved in finding alternative roost whilst pregnant and parenting young from the first breeding event. The first breeding event is believed to be more important than the |

| BC Act | Question | Response |
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| | | second. This is because a higher proportion of females will breed during the first event. The second breeding event is more easily affected by the reduced condition of females who have already given birth to one pup and devoted significant energy to lactation. Under the worst case scenario, the loss of all pups from a single year's breeding is unlikely to reduce the viability of the local population because there are several more maternity roosts known within a 50 km radius of the tunnel and food resources for Southern Myotis in the area are high, particularly so at the present time with the dam at record high levels and mild conditions experienced throughout the year following many years of drought.<br>The species will be temporarily excluded from the tunnel during works, reducing access to local roosting habitat over a single breeding season which has two birthing events. However, this will only a be a short-term impact, with at least 75% of the roosting habitat in the tunnel to be available at the completion of tunnel remediation works, either in original form or as recreated habitat during remediation works. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | Access to the roosting habitat of this species within Balickera Tunnel will be removed temporarily, for a period of up to 5 months during exclusion. Southern Myotis will have from late autumn onwards to reinhabit the tunnel and prepare for the next breeding season.<br>Some roosting habitat will be permanently lost, due to the application of shotcrete and rock bolts over portions of the existing tunnel surface, however the main roosting areas (two areas on natural rock surface and up to 40 |

| BC Act | Question | Response |
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| | | of the vertical cylindrical 20cm diameter holes) will be retained in existing format, where possible or recreated using shotcrete during tunnel remediation works.<br>A small area (0.05 ha) of potential foraging habitat will be removed for the proposal. This habitat is connected to large regions of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for this species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur because of the proposed works. This species is highly mobile, capable of flying 10 -12 km from roost sites in a night. The subject site is surrounded by similar suitable habitat to be retained, including several other known alternative roost sites within nightly flight range. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The tunnel is a significant roosting and breeding resource for a large Southern Myotis maternity colony. It is part of a network of maternity roosts available within the local area, centred upon the high quality foraging resources contained within Grahamstown Dam and the Williams River. The tunnel plays a role in facilitating social interactions, is used for giving birth and raising young, including providing a safe place for the young bats to learn to fly and forage, is likely a site where mating and copulation takes place, provides refuge from the elements during rest and torpor as well as a safe place for foraging even when the weather is poor outside the tunnel. It is used by this species year round and attains peak occupancy over summer and early autumn following the second breeding event. It is also a winter hibernation roost. It is important that the roosting habitat which serves the needs of Southern Myotis throughout the year and at different stages of the lifecycle, is preserved for the long-term survival of this species.<br>The area of vegetated habitat proposed to be impacted represents a relatively small area of potential foraging habitat and is not expected to be important for the long-term survival of these species in the locality. The loss of roosting habitat will only be temporary during works (for a period of 5 months), and several other roosts are known to be available for this species to use during this time |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process ‘clearing of native vegetation’. However, the extent of vegetation to be cleared is minimal (0.05 ha) and is unlikely to have a substantial impact on the suitability of the site for usage by the species. |

| BC Act | Question | Response |
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| Conclusion | Is there likely to be a significant impact? | Yes. A significant impact is likely if the recommended amelioration and mitigation measures (including exclusion of all bats from the tunnel) as set out in the MMP (Appendix I) are not implemented. Conducting tunnel remediation works without due consideration of the impacts to roosting bats will lead to reduced fitness, reduced survival, injury, illness and potentially death of a large number of Southern Myotis as a result of disturbance, exhaustion, starvation or predation.<br>Under the current work schedule and even following the MMP, with exclusion planned for December there is still the potential for the loss of Southern Myotis pups born in October (could be up to 75 pups) if they are unable to fly at the time of exclusion which warrants the application of the precautionary principle in considering a significant impact likely. This loss could be minimised by conducting the exclusion as late as possible in December and providing alternative roosting habitat as close as possible to the tunnel. If a significant impact is identified from the post exclusion monitoring results, Hunter Water have agreed to set aside funds for the implementation of appropriate adaptive mitigation / contingency measures (in consultation with BCD/DPIE) to offset the loss of Southern Myotis, as detailed in the MMP. It is not possible to avoid impacts to all species of bats inhabiting the tunnel as there are conflicting optimal time periods to conduct an exclusion for the different species of bat.<br>Southern Myotis will readily inhabit and breed in bat boxes if installed in suitable locations. Bent-winged Bats are not known to inhabit bat boxes in large numbers. There are fewer Southern Myotis within the tunnel than the other two species. There are at least two Southern Myotis maternity roosts within nightly flight range of the tunnel that could provide additional alternative roosting habitat. The potential loss of all young from two breeding events (approx. 150 pups) and five adult Southern Myotis is considered to be more easily recovered from by local populations of Southern Myotis than would the loss of hundreds or more adult Bent-winged Bats if the exclusion is carried out at a time when a greater number of Bent-winged Bats were present. |

## EASTERN FALSE PIPISTRELLE AND EASTERN COAST FREETAILED BAT

| BC Act | Question | Response |
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| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a relatively small area<br>(0.05 ha) of foraging habitat only for these species, in consideration of similar habitat in immediate surrounding area. These minor impacts to the lifecycle of these species are unlikely to increase the risk of extinction to a viable local population of the Eastern False Pipistrelle and Eastern Coast Freetail Bat. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: | Not applicable. |

| BC Act | Question | Response |
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| | Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat will be removed for the proposal. Minor noise, light and dust disturbance during construction may occur but is unlikely to impact these mobile bat species occasionally foraging in the study area. This habitat is connected to large regions of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for this species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for these species will occur because of the proposal. This species is highly mobile, and the subject site is surrounded by similar suitable habitat to be retained, including other known roost sites. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat and is not expected to be important for the long-term survival of these species in the locality. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. However, the extent of vegetation to be cleared is minimal (0.05 ha) and is unlikely to have a substantial impact on the suitability of the site for usage by the species. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to Eastern False Pipistrelle and Eastern Coast-Free-tailed Bat is expected as a result of the proposal. |

## KOALA

| BC Act | Question | Response |
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| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a very small area (0.05 ha) of potential foraging habitat in the form of regenerating Eucalyptus forested areas and primary koala feed trees (*Eucalyptus tereticornis*). Similar habitat is present in the immediate surrounding area which will not be removed under this proposal. These minor impacts to the lifecycle of this species are unlikely to increase the risk of extinction to a viable local population of the Koala. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat in the form of regenerating Eucalyptus forested areas and primary koala feed trees (*Eucalyptus tereticornis*) will be removed for the proposal. This habitat is connected to larger areas of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for the Koala to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur as a result of the proposal. This species is mobile and the subject site is surrounded by similar suitable habitat to be retained. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat and is not expected to be important for the long-term survival of this species in the locality. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to the Koala is expected as a result of the proposal. |

## GREY-HEADED FLYING FOX

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a very small area (0.05 ha) of potential foraging habitat in the form of mature flowering eucalyptus (*Eucalyptus tereticornis*) trees. No roosting individuals or Flying fox camps were recorded within the study area. Similar habitat is present in the immediate surrounding area which will not be removed under this proposal. These minor impacts to the lifecycle of this species are unlikely to increase the risk of extinction to a viable local population of the Grey-headed Flying Fox. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat in the form of forest including mature flowering *Eucalyptus* spp. will be removed for the proposal. This habitat is connected to larger areas of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for this species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur as a result of the proposal. These species are highly mobile, and the subject site is surrounded by similar suitable habitat to be retained. |

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat (no Flying fox camps were recorded) and is not expected to be important for the long-term survival of this species in the locality. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to the Grey-headed Flying Fox is expected as a result of the proposal. |

## WHITE-BELLIED SEA-EAGLE

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a very small area (0.05 ha) of potential foraging habitat in the form of forest and mature eucalypts near a large waterbody, which will be cleared to allow vehicular access to the tunnel and some temporary removal of foraging habitat when sections of the canal are dewatered during construction. Approximately 700 m of canal upstream and 200 m downstream of tunnel will be dewatered during the construction works. These minor impacts to the lifecycle of this species are unlikely to increase the risk of extinction to a viable local population of the White-bellied Sea Eagle. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat in the form of forest will be removed for the proposal. Approximately 700 m of canal upstream and 200 m downstream of tunnel will be dewatered during the construction works. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur as a result of the proposal. This species is mobile and the subject site is surrounded by similar suitable habitat to be retained. This habitat is connected to larger areas of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for these species to forage. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat (no large stick nests were observed) and is not expected to be important for the long-term survival of these species in the locality. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to the White-bellied Sea-Eagle is expected as a result of the proposal. |

## POWERFUL OWL AND MASKED OWL

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a relatively small area<br>(0.05 ha) of foraging habitat (in the form of forests and edge of forests only for these species), particularly in consideration of similar habitat in the immediate surrounding area. These minor impacts to the lifecycle of these species are unlikely to increase the risk of extinction to a viable local population of the Powerful Owl and Masked Owl. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: | Not applicable. |

| BC Act | Question | Response |
|---|---|---|
| | Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat will be removed for the proposal. This habitat is connected to larger areas of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for these species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur because of the proposal. These species are highly mobile, and the subject site is surrounded by similar suitable habitat to be retained. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat and is not expected to be important for the long-term survival of these species in the locality. |
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. However, the extent of vegetation to be cleared is minimal (0.05 ha) and is unlikely to have a substantial impact on the suitability of the site for usage by the species. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to Powerful Owl and Masked Owl is expected as a result of the proposal. |

## LITTLE LORIKEET & GREY-CROWNED BABBLER

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 a) | In the case of a threatened species:<br>whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction | The study area represents a very small area (0.05 ha) of potential foraging habitat in the form of forested areas and mature flowering eucalyptus trees (*Eucalyptus tereticornis*). No hollow bearing trees or stick nests were recorded within the study area. Similar habitat is present in the immediate surrounding area which will not be removed under this proposal. These minor impacts to the lifecycle of this species are unlikely to increase the risk of extinction to a viable local population of the Little Lorikeet and Grey-crowned Babbler. |
| 7.3.1 b) i | In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:<br>Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or | Not applicable. |
| 7.3.1 b) ii | In the case of an endangered ecological community or critically endangered ecological community:<br>Whether the proposed development or activity is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. | Not applicable. |
| 7.3.1 c) i | In relation to the habitat of a threatened species or ecological community:<br>The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity | A small area (0.05 ha) of potential foraging habitat in the form of forest including mature flowering *Eucalyptus* spp. will be removed for the proposal. This habitat is connected to larger areas of intact habitat and as such, the removal of this habitat will not likely have a significant impact on the area available for these species to forage. |
| 7.3.1 c) ii | In relation to the habitat of a threatened species or ecological community:<br>Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity | No isolation of habitat for this species will occur as a result of the proposal. These species are highly mobile and the subject site is surrounded by similar suitable habitat to be retained. |
| 7.3.1 c) iii | In relation to the habitat of a threatened species or ecological community:<br>The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality. | The area of habitat proposed to be impacted represents a relatively small area of potential foraging habitat (no hollow bearing trees or stick nests were recorded) and is not expected to be important for the long-term survival of these species in the locality. |

| BC Act | Question | Response |
|---|---|---|
| 7.3.1 d) | Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly). | No areas of outstanding biodiversity value are located on or in proximity to the subject land. |
| 7.3.1 e) | Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process. | The proposal is part of the key threatening process 'clearing of native vegetation'. |
| Conclusion | Is there likely to be a significant impact? | No significant impact to the Little Lorikeet and Grey Crowned Babbler is expected as a result of the proposal. |

# Appendix I Commonwealth EPBC Act Significant impact criteria assessments

The EPBC Act administrative guidelines on significance set out 'Significant Impact Criteria' (DotE 2013) that are to be used to assist in determining whether a proposed action is likely to have a significant impact on matters of national environmental significance. Matters listed under the EPBC Act as being of national environmental significance include:

- Listed threatened species and ecological communities
- Listed migratory species
- Wetlands of International Importance
- The Commonwealth marine environment
- World Heritage properties
- National Heritage places
- Nuclear actions
- A water resource, in relation to coal seam gas development and large coal mining development.

Specific 'Significant Impact Criteria' are provided for each matter of national environmental significance except for threatened species and ecological communities in which case separate criteria are provided for species listed as endangered and vulnerable under the EPBC Act.

The following section assesses impacts on threatened ecological communities and fauna species against the relevant significant impact criteria. These are:

- Koala – Listed as Vulnerable under the EPBC Act
- Grey-headed Flying-fox – listed as Vulnerable under the EPBC Act.

## KOALA AND GREY-HEADED FLYING-FOX

| Criterion | Question | Response |
|---|---|---|
| An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: | | |
| 1) | lead to a long-term decrease in the size of an important population of a species | The proposal will result in the removal of a very small area(0.05 ha) of potential foraging habitat, in an area with extensive similar habitat in the surroundings. No Grey-headed Flying-fox camps will be impacted. As such, no decrease in an important population is expected as a result of the proposal. |
| 2) | reduce the area of occupancy of an important population | Due to the relatively small scale of habitat removal in an area of extensive potential habitat, no reduction in area of occupancy of these species will occur. |
| 3) | fragment an existing important population into two or more populations | Due to the relatively small scale of habitat removal in an area of extensive potential habitat, no fragmentation for these species will occur. |
| 4) | adversely affect habitat critical to the survival of a species | No critical habitat for these species is likely to be impacted by the proposal. |
| 5) | disrupt the breeding cycle of an important population | Due to the small scale of clearing and timing of works the breeding cycles of the Koala and Grey-headed Flying-fox are unlikely to be disrupted by the proposal. |
| 6) | modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline | No decline in populations of Koala or Grey-headed Flying-fox are expected due to the small scale of habitat removal in an area of extensive similar habitat. |
| 7) | result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat | The proposal is unlikely to result in additional invasive species that are harmful to the Koala or Grey-headed Flying-fox becoming established in the area. Recommendations have been provided to reduce the risk of invasive plants becoming established in the subject land. |
| 8) | introduce disease that may cause the species to decline, or | The proposal is considered unlikely to introduce disease that would cause populations of Koala or Grey-headed Flying-fox in the locality to decline. |
| 9) | interfere substantially with the recovery of the species. | The proposal is unlikely to interfere with any future recovery of the Koala or Grey-headed Flying-fox. |
| **Conclusion** | **Is there likely to be a significant impact?** | No significant impact on the Koala or Grey-headed Flying-fox is expected as a result of the proposal. |

# Appendix J Microbat Management Plan

# Balickera Tunnel Remediation Works Microbat Management Plan

## 1. Project description and scope of works

Hunter Water are proposing to upgrade Balickera Tunnel at Balickera, NSW. The tunnel requires remediation works to improve longevity and operating performance, including:

- Shotcreting in concrete lined sections
  Existing lined tunnel (excluding portal sections) to be sprayed with approximately 150 mm of shotcrete, and 200 mm of shotcrete in the concrete lined portal sections
- Shotcreting in natural rock sections where the structural rock mass quality is poor (Q<1). Approximately 20% of existing unlined tunnel is anticipated to be sprayed with shotcrete
- Rock bolting in natural rock sections where the structural rock mass quality is poor (1<Q<10) or where critical wedges or planes of weakness are identified (Q of any level)
  The minimum spacing for rock bolts will be 1.1 m lateral x 1.5 m longitudinal or 1.7 m lateral x 1.5 m longitudinal and the number of spot rock bolts will replicate the number of bolts currently installed
- The works will be carried out from both ends of the tunnel at the same time, progressing in 3 m sections and operating 24 hours a day.

Several microbat species, including three species listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) have previously been recorded roosting within Balickera Tunnel. Eco Logical Australia Pty Ltd (ELA) was contracted by Hunter Water Corporation to prepare a Microbat Management Plan (MMP) to accompany a Species Impact Statement (SIS), supporting the Review of Environmental Factors (REF) for remediation works within the Balickera Tunnel. As such, ELA conducted targeted microchiropteran bat (microbat) surveys of the Balickera Tunnel and surrounding area to inform the REF and SIS.

Biodiversity surveys, including microbat surveys, conducted by ELA between March 2020 and January 2021, identified microbat habitat within the Balickera Tunnel and within several artificial structures within nightly flight range of the four species that roost within the tunnel. Microbat roosting habitat for all four species has also previously been identified in a number of the surrounding natural cave systems. In addition, a small area (0.05 ha) of native vegetation that represents microbat foraging habitat will be removed for the tunnel remediation works. The surveys recorded Little Bent-winged Bat (*Miniopterus australis)*, Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Southern Myotis (*Myotis macropus*) and Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) roosting within Balickera Tunnel. This supports previous studies that identified the tunnel and surrounding areas as supporting roosting habitat for these four species (Ecotone 1995, 2000, Pells Consulting 2015, Biosis 2017, 2018, GHD 2018). Large Bent-winged Bats, Little Bent-winged Bats and Southern Myotis are listed as vulnerable under the BC Act and are known to roost in derelict mines, tunnels, bridges, culverts and other similar man-made structures. Hunter Water Cooperation has therefore identified the need for an MMP for the works at Balickera Tunnel.

The aim of the MMP is to establish potential measures to mitigate the impacts of remediation works on roosting and/or breeding microbats within the tunnel and outline requirements to manage risks to microbats prior to, during and after construction works. An MMP is required for the proposal because the repair works have the potential to significantly impact threatened microbats.

## 2. Purpose and objective of MMP

The broad aim of this MMP is to reduce the potential for injury or death to microbats as a result of the proposed works by preventing microbats from roosting within the tunnel prior to and during works and to mitigate long-term impacts on the local populations, by protecting known roosting habitat within the tunnel.

Specifically, this MMP:

- Identifies microbats, including threatened species listed under the BC Act or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), known or considered likely to occur on site that may be potentially impacted by works.
- Reduces the potential for death or injury to the greatest number of microbats by scheduling works for the least sensitive time of year for the Little Bent-winged Bat and Large Bent-winged Bat which are present in the largest numbers and excluding microbats from the tunnel prior to works.
- Provides details of the exclusion procedures and other management measures required to safeguard microbats and minimise impacts to microbats for the duration of the works.
- Identifies risks to construction personnel from working in close proximity to a microbat roost and outlines procedures for mitigating those risks and for dealing with unexpected microbat finds during the proposed works.
- Identifies the monitoring and reporting requirements and responsibilities with respect to the actions outlined in this MMP.

# 3. Species potentially impacted

The SIS identified seven microbat species that may occur within the Balickera Tunnel and surrounding area. These included:

- Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Little Bent-winged Bat
- Large Bent-winged Bat
- Southern Myotis
- Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*).

The ecological attributes of each species are described in Table 3-1.

**Table 3-1: Description of threatened microbat ecological attributes**

| Common name | Scientific name | BC Status | EPBC Status | Roosting | Breeding | Known and potential use on the site | Discussion of Significance | Local Populations |
|---|---|---|---|---|---|---|---|---|
| **Eastern False Pipistrelle** | *Falsistrellus tasmaniensis* | Vulnerable | Not listed | Generally roosts in hollow trunks of eucalypt trees in colonies of 3-80 individuals. Colonies are usually almost entirely male or female groups, although evenly mixed colonies sometimes occur. They occacionally roost in old wooden buildings (Churchill 2008). | Breeding occurs generally in late spring and early summer. A single young is born in December. Lactation continues through January and February | Not captured at the site during surveys, potential presence recorded via ultrasonic recording. May roost in surrounding eucalypt forest. Small number (n = 7) of records occur in the nearby area. | The tunnel is unlikely to support roosting bats, but the species may be indirectly affected by noise and vibration if roostng in surrouding vegetation and may occasionally enter the tunnel. | Move nightly between roosts from 750 – 3500 m apart. Have a large home range of 136 ha. |
| **Eastern Coastal Free-tailed Bat** | *Micronomus norfolkensis* | Vulnerable | Not listed | The species roosts in tree hollows in dry eucalypt forest and woodland on the coastal side of the Great Dividing Range. They usually roost in hollow spouts of large mature trees, but there are also several records from buidlings and in bat boxes (Churchill 2008). | Females give birth in late November or early December. | Not captured at the site during surveys, potential presence recorded via ultrasonic recording. However, the species is known to occur in the local area and can use man-made structures for roosting. | The tunnel does not support a maternity roost, given no captures and few potential ultrasonic recordings were collected during surveys. The tunnel may present a suitable roost site for a small number of individuals however, and exclusion is required before works commence. | Large, overlapping home range (4,099 ha; McConville 2013). |

| Common name | Scientific name | BC Status | EPBC Status | Roosting | Breeding | Known and potential use on the site | Discussion of Significance | Local Populations |
|---|---|---|---|---|---|---|---|---|
| **Little Bent-winged Bat** | *Miniopterus australis* | Vulnerable | Not listed | Individuals use a network of roosts throughout the year. They congregate in the thousands with Eastern Bentwing Bats in a small number of caves in NSW to breed over summer. Non-breeding males often roost alone or in small numbers separate from females. Over winter, will use caves, culverts, abandoned mines, bridges, tunnels, buildings and sometimes tree hollows as hibernation / winter roosts (Churchill 2008). Balickera Tunnel represents one of the most southerly communal roosts known for this species. | Breed in cave systems outside of Sydney / Hunter region. A local population can represent several thousand or tens of thousands of bats. Use the same maternity roost year after year. | Hundreds of individuals captured during current surveys. Current surveys indicate that between 2400 and 5800 individual bats roost within the tunnel at any one time throughout the year. Over 90% of these are Little Bent-winged Bats. Previous surveys indicated between 2700 and up to 15000 bats roosting within the tunnel, the majority being Little Bent-winged Bats. | Communal roost sites particularly maternity and hibernation / over-wintering roost sites should be treated as being of high conservation priority. Disturbance to hibernating colonies can lead to starvation due to loss of energy reserves. The tunnel does not represent a breeding roost but provides significant hibernation roosting habitat as well as non-breeding year round roost habitat for large numbers of this species. Exclusion necessary before works when the species is not hibernating. | Will travel up to 33 km from the roost in a night. with the maximal range being 60 km (Dwyer 1968). |

| Common name | Scientific name | BC Status | EPBC Status | Roosting | Breeding | Known and potential use on the site | Discussion of Significance | Local Populations |
|---|---|---|---|---|---|---|---|---|
| **Large Bent-winged Bat** | *Miniopterus orianae oceanensis* | Vulnerable | Not listed | Individuals use a network of roosts throughout the year. They congregate in the thousands in a small number of caves in NSW, often shared with Little Bent-winged Bats, to breed over summer. Over winter, will use caves, culverts, bridges, abandoned mines and tunnels as hibernation / winter roosts. | Breed in cave systems outside of Sydney / Hunter region. Use the same maternity roost year after year. Females disperse to maternity roosts in limestone caves in late spring / early summer and return to coastal roots in March/April. | No captures during current surveys. Previous surveys indicated between 2700 and up to 15000 bats roosting within the tunnel. Less than 10% of these were Large Bent-winged Bats and this species has been present in greatest numbers over winter, with numbers estimated to be up to 1000 individuals. | Communal roost sites particularly maternity and hibernation / over-wintering roost sites should be treated as being of high conservation priority. Disturbance to hibernating colonies can lead to starvation due to loss of energy reserves. The tunnel does not represent a breeding roost but provides significant hibernation roosting habitat as well as non-breeding year round roost habitat for this species. Exclusion neceassary before works when the species is not hibernating. | Has been recorded travelling as far as 65 km from the roost in one night but more commonly assumed to travel distances between 20 and 40 km nightly (Dwyer 1966). |

| Common name | Scientific name | BC Status | EPBC Status | Roosting | Breeding | Known and potential use on the site | Discussion of Significance | Local Populations |
|---|---|---|---|---|---|---|---|---|
| **Southern Myotis** | *Myotis macropus* | Vulnerable | Not listed | Roosts near water in caves, tree hollows, among vegetation, under bridges, culverts, mines and tunnels and in fairy martin or swallow nests. A single roost can be used historically and occupied year-round, but each colony will have a network of roosts within foraging range. Roost commonly in groups of five – several hundred bats. | They display high fidelity to maternity roost sites, returning year after year. Breeding roosts are over water or within 100 m of it. | Three individuals captured during current surveys. Current surveys indicate that between 2400 and 5800 individual bats roost within the tunnel at any one time throughout the year. Over 90% of these are Little Bent-winged Bats. Previous surveys indicated between 2700 and up to 15000 bats roosting within the tunnel. There were estimated to be between 80 and 100 Southern Myotis present at that time. | Maternity roost sites should be treated as being of high conservation priority. The tunnel continues to represent a breeding/maternity roost. Exclusion neceassary before works. | Forages 10-12 km away from the roost each night. Local populations consist of multiple maternity roosts inhabited by 'colonies' in which a dominant male is associated with a harem of females and young. Colonies can range from a single harem of 8-10 bats to several affiliated harems of more than 120 bats when the colony is at its peak at the end of the breeding season. Three other maternity roosts are known within 10 km of Balickera Tunnel. |

| Common name | Scientific name | BC Status | EPBC Status | Roosting | Breeding | Known and potential use on the site | Discussion of Significance | Local Populations |
|---|---|---|---|---|---|---|---|---|
| **Yellow-bellied Sheath-tailed Bat** | *Saccolaimus flaviventris* | Vulnerable | Not listed | Roosts singly or in groups of usually up to six bats (occasionally up to 30), usually in tree hollows in large open trees i.e. incomplete crown with substantial numbers of dead limbs/ spouts (Clews 2017). Known to also use buildings and in treeless areas they are known to utilise mammal burrows. | Mating occurs in August and a single young is born between December and March. They may be territorial. | Not captured at the site during surveys, or recorded via ultrasonic recording. May roost in surrounding eucalypt forest. Small number (n = 2) of records in the nearby area. | The tunnel does not support roosting bats, but the species may be indirectly affected by noise and vibration if roositng in surrouding vegetation. | Considered a summer migrant to southern Australia. Very little is known about local populations and breeding sites. |
| **Greater Broad-nosed Bat** | *Scoteanax rueppellii* | Vulnerable | Not listed | They roost in tree hollows, cracks and fissures in trunks and dead branches, under exfoliating bark, as well as the roofs of old buildings. | Females congregate in maternity colonies and a single young is born in January. Males appear to be exlcuded from the colony during birth and rearing of the young | Not captured at the site during surveys, potential presence recorded via ultrasonic recording. May roost in surrounding eucalypt forest. Small number (n = 2). | The tunnel does not support roosting bats, but the species may be indirectly affected by noise and vibration if roositng in surrouding vegetation. | Unknown. |

# 3. Microbat survey and roost assessment methodology

Surveys for microbats at Balickera Tunnel and surrounding area were conducted between March 2020 and January 2021 in accordance with the '*Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Methodology* (OEH 2018). The aim of targeted microbat surveys was to determine which microchiropteran bats are currently present within Balickera Tunnel, quantify the number of roosting bats for each species, identify potential alternative roost sites within nightly flying distance of the Balickera Tunnel and assess the potential carrying capacity of any located alternative roosts.

The survey methodologies and data gathered are summarised in the SIS, but included:

- Harp-trapping (1 night per season at either end of tunnel using between 3 and 4 traps at each location)
- Ultrasonic recordings (minimum of 32 nights total, using 1 detector at each end of the tunnel set out for four nights each, four times over the year)
- Thermal imagery (14 hours total across 8 nights, 2 nights per season at either end of tunnel)
- Tunnel inspection (1 day).

Surveys complied with the BC Act survey guidelines (OEH 2018) in being conducted under suitable weather conditions (i.e. within the active temperature range for microbat foraging, with light winds and minimal rain).

# 4. Survey results

The tunnel provided year-round roosting habitat for Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis, as well as Eastern Horseshoe Bats, with these four species of bats being detected in each of the four survey seasons. Harp capture records indicated that Little Bent-winged Bats are the dominant species roosting within the tunnel. The majority of individuals captured were adults. Sex ratios showed that most females are absent from the roost over summer, when they migrate to maternity roosts to give birth and raise young, with a more even distribution of males and females observed over winter and spring. Neither the Little nor Large Bent-winged Bats breed at Balickera Tunnel, but they are likely to mate / copulate at Balickera Tunnel. The peak occupancy for Bent-winged Bats is between autumn and spring with approximately 5500 - 6000 bats counted using thermal camera video recording. During summer numbers of bats roosting in the tunnel were estimated to be 2000 – 3000. The number of Large Bent-winged Bats roosting within the tunnel was estimated at between 300 and 500 bats based on the percentage of ultrasonic calls identified as belonging to this species.

There were few Southern Myotis captured, with two females and a male being trapped at the downstream portal during spring 2020. Despite this, ultrasonic records provide clear evidence that Southern Myotis are roosting within the tunnel and are present in greatest numbers over spring and summer. Presence of Southern Myotis in large numbers during summer outside a suitable roost site has been interpreted as evidence that the site continues to be a maternity roost for this species. The number of Southern Myotis is estimated to be between 50 and 200, depending upon the time of year, based upon the ultrasonic call activity levels recorded.

The inspection of the tunnel using remote IR cameras found two main Bent-winged Bats roost locations within the tunnel that were in approximately the same locations as identified in previous surveys (Pells Consulting 2015 and GHD 2018). There were also numerous small clusters and individuals roosting on the roof as well as in vertical, cylindrical 20 cm diameter holes of the concrete lined sections, predominantly towards the western half of the tunnel. The two main roost areas occur within the first natural rock section from the upstream portal, between chainages 178 and 263 m from the upstream portal. The main roost is estimated to be at approximately chainage 240 m from the upstream portal, with numerous smaller clusters and scattered individuals in the vicinity of this roost. There is a second area where a large cluster of bats is known to roost, and it is located in the second natural rock section between 290 and 370 m.

Southern Myotis predominantly roosts in vertical holes within concrete line sections of the tunnel. There are 106 of these holes spread along the concrete lined sections of the tunnel. A total of 39 of these holes are known to be roosting habitat for bats. The majority of these sites are within the upstream half of the tunnel and, given the assumption that breeding is still occurring within the tunnel, at least some of these are likely to be used for breeding. Those observed to be used regularly are located between chainages 0 to 172 m (22 roosts) and 287 to 304 m (2 roosts). Southern Myotis were also recorded roosting in holes between, 493 to 580 m (6 roosts), 629 to 655 (4 roosts) and 957 to 1010 (5 roosts).

Eight alternative roosts were located within the nightly flight range (33 km) for Little Bent-winged Bats. Four were confirmed to be current Little Bent-winged Bat roosts during this study and included Brookfield Tunnel (19 km to the north west), the M1 Tunnel (27 km to the south west), Pilchers Mountain

Caves (28 km to the north west) and Dungog Water Treatment Plant (WTP) Tunnel (30 km to the north west). The M1 Tunnel was considered to be marginal roosting habitat because of the high light levels, periodic disturbance from human visitors and future development plans. It is only likely to be used by small numbers of Little Bent-winged Bats from time to time. Brookfield Tunnel, Pilchers Mountain Caves and Dungog WTP are also used by Large Bent-winged Bats and have capacity to accommodate large numbers of bats (>1000). It is unknown whether Brookfield Tunnel is suitable as a year round roost. The remaining four known roosts within nightly fight range of Little Bent-winged Bats include Blue Gum Hills Derelict Mine (26 km to the south west). The status of this roost remains unknown with ultrasonic and thermal camera surveys conducted by DPI in autumn 2017 indicating that few Large Bent-winged Bats were using this roost at the time (<50 bats). The three Richmond Vale Rail Tunnels are similar to the M1 Tunnel in that they are exposed to periodic disturbance from human visitors and future development plans. There may be other alternative roost sites within nightly flight range of Little Bent-winged Bats in areas that were not known during this study.

Four other alternative Little Bent-winged Bats roosts are known within a 60 km radius which is within the maximum range of movement recorded for Little Bent-winged Bats and nightly flight range of Large Bent-winged Bats. These roosts include Jesmond culverts (36 km to the south), Yacaaba Headland Sea Caves (37 km to the east), Sugarloaf SCA (46 km to the south west) and Bulahdelah Mountain Alum Mines (48 km to the north east). Bulahdelah Mountain Alum Mines were identified as potential habitat by Ecotone (2000). Recent ultrasonic and thermal camera surveys conducted by DPI in autumn 2017 found no evidence of either Little or Large Bent-winged Bats using this roost at the time, however it is considered that the site could still potentially contain roosting habitat for small numbers of Bent-winged Bats (<50 bats). The status of Yacaaba Headland Sea Caves and Sugarloaf SCA roosts is unknown but given the difficulty of accessing Yacaaba Headland Sea Caves that roost is unlikely to have been disturbed and is presumed to remain viable. Several of these roosts are capable of accommodating a further 500 -1000 additional bats combined and would be suitable as year round (non-breeding) roost sites. Although not accessible by Little Bent-winged Bats in a single night's flight from Balickera, these roosts are easily reached within a couple of nights by using one of the other alternative roosts as a stepping stone, or within a single night's flight by Large Bent-winged Bats.

There were also a number of smaller alternative roost sites identified within nightly flight range (60 km) of the tunnel for the Large Bent-winged Bat. Many of these were located in bridges or culverts and would only be suitable for individuals or small numbers of bats.

There are three known alternative maternity roosts for Southern Myotis within nightly flight range (10 – 12 km), being at the Pacific Highway Bridges over Twelve Mile Creek and Grahamstown Drain and at Clarencetown Bridge over the Williams River. Grahamstown Drain and Clarencetown Bridge are both known to have capacity to accommodate an additional 50 - 100 Southern Myotis. There are also a number of other roosts within culverts reported from Clarencetown, but the status of these roosts has not been confirmed.

# 5. Microbat habitat categorisation

A means of categorising microbat roosts into low, medium and high conservation value is provided in Table 5-1, and is based upon an assessment process used by Transport for NSW on the Pacific Highway upgrades (GeoLINK 2015). Under this categorisation, Balickera Tunnel is considered to represent high conservation value roosting habitat for three threatened microbat species; Large Bent-winged Bat, Little Bent-winged Bat and Southern Myotis. All three species are known to roost within the tunnel in large numbers (>50).

Little Bent-winged Bats use Balickera Tunnel as roosting habitat in the largest numbers (>2000 individuals) year round. The tunnel serves as a significant communal roost, an important winter / hibernation roost, is likely to be where mating occurs and is one of the most southerly roosts known for this species.

Large Bent-winged Bats are also present at the tunnel throughout the year but in lower numbers than the Little Bent-winged Bat (<1000 individuals). The tunnel serves as a significant communal roost and is also a significant winter / hibernation roost site for Large Bent-winged Bats. It is unknown whether mating occurs at this site but is assumed to occur.

Southern Myotis use Balickera Tunnel as roosting habitat throughout the year and are present in numbers between 80 and up to 200 bats. The tunnel serves as a maternity / breeding roost for this species and as a winter hibernation roost.

**Table 5-1: Conservation Habitat Value categories for subterranean microbat roosts in culverts and bridges**

| Conservation Value | Criteria |
|---|---|
| **High** | Known to provide breeding habitat for a threatened species<br>Known to provide non-breeding roosting habitat for large numbers (>50) of a threatened species |
| **Medium** | Does not satisfy high conservation value category<br>Provides non-breeding roosting habitat for small numbers (<50) of a threatened species<br>Medium to large guano accumulations and/or stains present indicating the occurrence of a moderate numbers of microbats or medium to long-term usage<br>Suitable as breeding habitat for Large-footed Myotis with access under a bridge / tunnel, >800 mm diameter with large cavities (>20 mm wide and >100 mm deep) and directly over / adjacent to open water, with low inundation susceptibility<br>Supports protected cavities providing good potential long-term roosting habitat, however no bats or evidence of roosting bats present<br>In proximity to open water however provides mainly exposed surface roosting opportunities (cavities <50 mm deep or roughened concrete only), offering non-breeding roosting sites only<br>Supports a breeding colony of non-threatened microbats |
| **Low** | Does not satisfy medium or high conservation value categories<br>Individual microbats or very small numbers of non-breeding microbats present (<5)<br>Small guano accumulations and / or stains present indicative of the occurrence of small numbers of microbats or short term usage<br>Provides mainly exposed roosting opportunities (cavities <50 mm deep or roughened surfaces only), offering non breeding roosting sites only<br>Not in proximity to open water<br>Similar roosting habitat locally common |

# 6. Impacts to microbats

The works have the potential to impact microbats in the following ways:

- Death / injury of individual bats during works – roosting bats can be easily overlooked during the day and will often remain in a roost when threatened during daylight hours rather than risk predation by flying and searching for other roosts during daylight
- Loss of roosting habitat – reduction in the amount of suitable roosting habitat locally available may lead to increased competition / overcrowding of remaining roosting resources
- Disruption of reproductive behaviour – reduced breeding success if unable to locate a suitable alternative breeding roost or to successfully raise young within the tunnel (Southern Myotis) and disruption to mating which occurs in the tunnel (Little and potentially Large Bent-winged Bats as well as Southern Myotis)
- Disturbance during works – excessive noise (especially high pitched), dust and vibrations above the general background levels will cause bats to arouse more often during daylight when they would normally be resting, reducing energy reserves, and possibly ultimately leading to starvation and death.

There will be a reduction of water levels through the tunnel as a result of the requirement to dewater Balickera Canal from 200 m downstream of the tunnel to allow remediation works to occur. This will not affect microbats. This is because water levels within the canal fluctuate from extreme lows of no flowing water and a few standing pools to a maximum of 300 m of the tunnel being submerged with no significant effect on roosting microbats. The majority of microbat roosting habitat is located within the upper 500 m of the tunnel, well above the maximum water level height.

# 7. Management actions

## 7.1 Prior to works

A suitably qualified project ecologist will be appointed to ensure the MMP is delivered according to specifications outlined here. A suitably qualified ecologist is considered to be an individual with:

- A minimum of seven years of experience in microbat ecology and management.
- Extensive experience undertaking microbat field surveys, has carried out targeted field surveys for microbats and their roost sites on more than twenty occasions in the past five years and has undertaken roost searches for Little and Large Bent-winged Bats and Southern Myotis, harp trapping at large roost sites, ultrasonic recording, thermal camera recording, radio tracking, emergence surveys and roost counts.
- Demonstrated industry experience in implementing MMPs.
- Demonstrated experience in undertaking successful microbat exclusions.

The project ecologist must also hold an NPWS Scientific Licence, a relevant Animal Research Authority issued by an approved Animal Care and Ethics Committee that includes the approval to undertake radio tracking of microbats and have a current Australian Bat Lyssavirus (ABLV) vaccination.

### 7.1.1 Compensatory habitat installation

Prior to all works commencing, compensatory habitat in the form of bat boxes will be installed in suitable locations for the affected species. Compensatory habitat can be provided for the threatened Southern Myotis because it is known to be a successful technique. Provision of purpose-built compensatory habitat has not been proven to be effective for large numbers of either the Little or Large Bent-winged Bat species, despite there being a couple of examples of large numbers (1000-2000 bats) of both Bent-winged Bat species roosting in the expansion joints of large road culverts in northern NSW. There are no suitably large road culverts within nightly flight range of Little Bent-winged Bats capable of accommodating >2000+ bats for the duration of the exclusion. There are numerous examples of successful colony establishments of Southern Myotis following exclusion from impacted roosts to bat boxes installed in carefully selected locations (ELA 2011, Marshall 2011, Rueegger 2016).

Bat boxes will be installed within the nightly foraging range of Southern Myotis from Balickera Tunnel (Table 7-1). Bat boxes should be installed in late winter / spring to allow time for the boxes to be discovered prior to exclusion of the tunnel and at least one month prior to the exclusion. The recommended site for box installation is beneath the Pacific Highway Road Bridge over Balickera Canal, approx. 800 m downstream from Balickera Tunnel. Approval from TfNSW will be required prior to box installation involving attachment to the bridge at this site. It is noted that a frame may be required to be installed to support bat boxes if TfNSW will not approve attachment to the bridge. A total of ten, four-chambered bat boxes will be installed as compensatory habitat for the colony of up to several hundred Southern Myotis estimated to roost within the tunnel. The bat boxes are to be purchased from a reputable supplier such as Hollow Log Homes. Hollow Log Homes produce timber boxes that will last upwards of ten years when installed beneath a bridge. They also supply recycled plastic (Cyplas) boxes that are predicted to last upwards of 30 years but have not been in existence for long term studies to quantify longevity. For this reason, it is recommended that half the boxes be supplied as timber and the other half as Cyplas. Each four-chambered bat box has capacity to accommodate approximately 50 Southern Myotis.

### 7.1.2 Pre exclusion monitoring of alternative roost sites / control sites and bat boxes

The bat boxes must be monitored once during spring and once during summer prior to exclusion, then daily during exclusion to record any potential relocations from the tunnel to the bat boxes. Monitoring of these boxes will also be incorporated into the post construction monitoring plan.

Monitoring of alternative roost sites / control sites for all three species (minimum of Brookfield Tunnel, Pilchers Mountain caves, Dungog WTP Tunnel, Twelve Mile Creek, Grahamstown Drain Bridge, Clarencetown Bridge or alternative if access to Clarencetown Bridge is prohibitive) will also occur in conjunction with monitoring of the bat boxes at least twice prior to exclusion, once during spring and once during summer to obtain baseline data. If the exclusion is delayed, monitoring is still to be conducted at the alternative roost sites / control sites once during each season prior to works. Methodology for monitoring will involve a single diurnal visual inspection using spotlights and binoculars (except at Balickera Tunnel where internal tunnel access is prohibited), a minimum 1.5 hour emergence survey accompanied by ultrasonic recording, and thermal video recording for larger roosts (Brookfield Tunnel, Dungog WTP and Pilchers Mountain caves). Ultrasonic recording is also to be conducted for 4 nights at each location during each monitoring event. These surveys will provide an estimate of activity levels to allow for comparison of activity levels of the target bats before, during and after the exclusion at the tunnel.

Monitoring of all the above structures during the exclusion process (as described above) will be conducted daily in conjunction with radio-tracking and will be undertaken for a minimum of seven days, and up to the point that radio tracking ceases.

Monitoring of known alternative roost sites within nightly flight range and the bat boxes will continue once every quarter for two years after tunnel remediation has been completed, to determine usage and monitor box condition (Table 7-1). Bat boxes require regular maintenance to continue to provide habitat (Rueegger 2016; Griffiths et al. 2020) and regular inspections have been scheduled for the operational phase of works. Once remediation works in the tunnel have been completed it is expected that Southern Myotis will return to roost within the tunnel. However, if the bat boxes provide suitable habitat, they may continue to be used by Southern Myotis indefinitely and will be the responsibility of Hunter Water to maintain.

### 7.1.3 Pre-exclusion monitoring of the tunnel

The exclusion of microbats from the tunnel is required to avoid the risk of injury and death to microbats during tunnel remediation works. There are prohibitions upon entering the tunnel for safety reasons and therefore the project ecologist will be unable to obtain a clear view into all potential roost spaces within the tunnel. The project ecologist will not be able to enter the tunnel to check that the tunnel is bat free during the exclusion process.

For this reason, the exclusion will be undertaken gradually and in a staged manner with only one entrance excluded at a time. Sections of the tunnel entrance will be incrementally sealed up each night over a four to six night period, which may need to be extended depending upon the behaviour of the bats. If distressed bats are observed in the 30 minutes immediately following closure of a section of curtain then the curtain will be raised to its former level and another attempt will be made once activity levels reduce to the accepted limits provided in Section 7.1.4 below for curtain closure. Evidence that bats are distressed will include bats regularly flying into the curtain, bats falling to the ground and repeated or ongoing social chatter. Numbers and activity levels will be monitored for over at least two seasons prior to construction – during spring (September) and during early summer (early December). If the exclusion is delayed, monitoring is still to be conducted at the tunnel once during each season prior to works. Methodology for monitoring will involve a minimum 1.5 hour emergence survey accompanied by ultrasonic recording, and thermal video recording. Ultrasonic recording is also to be conducted for four nights at each location during each monitoring event. These surveys will provide an estimate of activity levels to allow for comparison during exclusion at the tunnel.

An emergence survey at each tunnel portal using thermal video cameras for a minimum of 1 hour from sighting of first bat to emerge from the tunnel (equipment and staff to be in place and ready to record from sunset) will be conducted the night before exclusion to establish an approximate number of emerging / entering bats and obtain a net estimate of the number of bats present within the tunnel at the time of exclusion. This survey will be conducted in conjunction with ultrasonic recording at the both tunnel portals for the entire night.

The surveys prior to construction will establish baseline activity levels at 1) the tunnel entrance, 2) the installed nest boxes and 3) alternative roost sites / control sites with known bat activity (Brookfield Tunnel, Pilchers Mountain Caves, Dungog WTP Tunnel for Little and Large Bent-winged Bats and Twelve Mile Creek, Grahamstown Drain and potentially Clarencetown for Southern Myotis. Alternative roost sites / control sites will be chosen that best represent the habitat and species present at Balickera Tunnel. These sites will be used to compare activity levels and ensure that if no bats are emerging from Balickera Tunnel during exclusion surveys, that this is not simply an artefact of low bat activity on the survey nights due to environmental conditions.

### 7.1.4 Timing of Exclusion

Exclusion and works are recommended to be conducted during the time of year assessed in the SIS as being the least sensitive for the Little and Large Bent-winged Bats because they represent the two species with the highest risk of the greatest impacts, locally, regionally and nationally. Exclusion will be timed to coincide with the period of lowest Bent-winged Bat activity in December. Unfortunately, this coincides with the breeding period for Southern Myotis and goes against recommendations to conduct exclusions outside the breeding / birthing / lactation period. An exclusion during December – April avoids the overwintering periods (June to August) for the affected microbat species.

The most suitable period for conducting an exclusion at Balickera Tunnel must be balanced between the risks to each of the three affected threatened species roosting within Balickera Tunnel. The optimum time to conduct an exclusion for the two Bent-winged Bat species would be mid – late December. At this time of year the number of Little and Large Bent-winged Bats present at the tunnel is at the lowest point. The majority of females, including any pregnant females have migrated to the maternity roosts.

However, the maternity season for Southern Myotis falls between October and March and this species is known to breed within the tunnel. Southern Myotis has two birthing events in this region; October / November and January / February. Females generally lactate for 8 weeks (Churchill 2008) meaning that pups are weaned sometime in December prior to the second birthing event in January / February. There is a very small window to in late December to minimise pup / juvenile deaths as a result of the exclusion if carried out as the juveniles are becoming independent. As discussed above, Southern Myotis will readily inhabit bat boxes if placed within suitable locations. There are at least three other Southern Myotis maternity roosts within 10 km of the tunnel. Compensatory habitat, in the form of bat boxes, is also proposed to be installed beneath the Pacific Highway Bridge over Balickera Canal, subject to approval from TfNSW. This location is, less than 1 km from the downstream portal of the tunnel and less than 2 km form the upstream portal of the tunnel, minimising the distance that potentially immature young born in October / November will have to travel to find an alternative roost.

The remediation works at Balickera Tunnel, if completed as a single event are proposed to be completed within a five month window. As such, we propose that works will commence in December, with microbats excluded from the tunnel for a maximum of five months between December and early May. This will ensure that the Bent-winged Bats will be excluded at a time of the year when they are already leaving for maternity and summer roosts. It also means that when Bent-winged Bats are returning to the tunnel from summer and maternity roosts in February / March the tunnel will continue to be blocked off at a time when the bats are already in a transitional period. It will be summer / early autumn when insect availability is still high and the Bent-winged Bats will be best equipped to cope with the need to find alternative winter roosts and have ample time to do so before winter.

The exclusion is to be planned for a period of mild temperatures (warmer evenings, little or no wind, no rain) with a view to providing ideal foraging conditions for microbats. Progressive closure of exclusion curtains will not be undertaken during weather / climatic extremes such as when daily maximum temperatures exceed 35°C or when daily minimum temperatures drop below 12°C, when heavy rainfall is predicted (>20 mm in a 24 hour period), when strong winds are predicted (>35 km/hr) or when bushfires are burning within 20 km of the subject site. Exclusions will be planned to avoid periods of forecast weather that could reduce the success of the exclusion. However, there is a risk that adverse weather may occur during the multi night exclusion process. In this case the exclusion process will not occur on nights when the weather is unsuitable as described above. Microbats can remain in a roost and in torpor for more than 2 weeks during winter and up to 5 days during summer (Geiser and Kortner 2010) but are likely to emerge to forage every night or every few nights when the weather conditions are favourable. The staged exclusion will occur when bats are likely to be foraging to allow any bats in torpor to wake naturally and exit the roost before it is excluded to them.

### 7.1.5 Roost Exclusion Methodology

The methodology used to exclude all microbats from Balickera Tunnel aims to minimise the risk of injury or death to all individuals and ensure no microbats remain within the tunnel prior to works commencing. As such, microbat numbers and behaviour will be monitored throughout the exclusion process at the tunnel entrances, and at the alternative roost sites / control sites and nest boxes for comparison. Monitoring of microbat activity shall be conducted using ultrasonic recording devices and thermal cameras. Additional monitoring will occur at the tunnel throughout the exclusion process via emergence surveys, harp trapping, radio tracking (as outlined below) and thermal camera counts of emerging bats. The emergence surveys are to be conducted so that an ecologist with experience in conducting emergence surveys at microbat roosts is present every evening of the exclusion.

The emergence surveys, including ultrasonic and thermal camera recording, must be undertaken outside the tunnel portals from the same place each night, recording the number of microbats exiting the tunnel, their general direction of travel and their behaviour upon exiting. Locating a single ultrasonic detector approximately 5 m inside the upstream portal during the final few nights of exclusion will also be required. This detector will be left in place following the complete exclusion to monitor for bat activity inside the tunnel and assist with determining whether all bats have been excluded from the roost. Emergence surveys will commence 30 minutes prior to sunset and continue until the lead ecologist is satisfied that all bats have emerged from the roost, or until there has been a period of sustained inactivity or dramatic reduction in activity (60 – 90 minutes). Specific activity level targets for commencing closure of exclusion curtains is provided below.

The exclusions will be undertaken gradually and in a staged manner with sections of the tunnel entrances incrementally blocked off each night over a four (minimum) to six-night period (Table 7-1). Exclusion will be undertaken first at the quieter downstream portal (stage 1), followed by the busier upstream portal (stage 2). For both portals, this will involve progressive closure of the tunnel portals via a thick plastic curtain draped over portions of the portals at night after the majority of bats have emerged to forage (for which the time may vary each night). The curtain will only be dropped into place after emergence activity has fallen to a level where there has been no bats emerging for a 10 minute period or where there is consistently only 1 or 2 bats entering / exiting within a 10 minute period, as it is unlikely that there will be an extended period of no bats exiting / entering the tunnel. This method will encourage bats to find roosts elsewhere, limiting the number of bats left without a roost once the exclusion devices are installed over the entire portal.

During each evening of Stage 1, once microbat activity has fallen to the prescribed level, the curtain will be incrementally dropped in the following sequence:

- One half of the portal closed off on the first night
- Closed to have only a 50 cm gap remaining
- Closed to have only an 18 cm gap remaining
- *Optional step: Closed to have only a 10 cm gap remaining (if ecologist feels that bats need more encouragement)*
- Closed completely on the final night.

During Stage 2, on each evening, once microbat activity has fallen to the prescribed level, the curtain will be incrementally dropped in the following sequence:

- One half of the portal closed off on the first night
- Closed to have only a 1 m gap remaining
- Closed to have only a 50 cm gap remaining
- Closed to have only an 18 cm gap remaining
- Closed to have only a 10 cm gap remaining
- Closed completely on the final night.

This sequence will be completed first for the downstream portal and then for the upstream portal. If at any time large numbers of bats are in distress, as evidenced by repeated flying into the curtains or falling to the ground, the exclusion effort will be halted. At this time the most recent curtain drape will be lifted and bats in distress rescued from ground, held and examined for injuries and released on site. The same curtain drape will be attempted the following night and this process will be repeated until no bats are in distress and the curtain drape can remain in place. On the final evening of each stage of the exclusion, the ecologist must remain on site for at least one hour after complete closure to monitor bat behaviour using thermal cameras.

Harp trapping is to be conducted over two nights at the upstream portal once the portal has been at least 50% closed in order to capture up to 30 emerging bats (preferably at least 20 Little Bent-winged Bats, with the remainder being Large Bent-winged Bats or Southern Myotis), fit them with radio transmitters and track their movements during the subsequent 19 days during which the transmitter will remain active (Table 7-1). Radio-tracking will aim to obtain fixes on the tagged bats nightly from a number of high points and known alternative /control roost sites (Brookfield Tunnel, Pilchers Mountain caves, Dungog WTP Tunnel, Twelve Mile Creek, Grahamstown Drain Bridge, Clarencetown Bridge) within a 50 km radius of the tunnel, as well as diurnally during visits to known alternative /control roost sites. Radio tracking will occur for a minimum of four hours on the first night transmitters are fitted to observe whether transmitter attachment could be affecting bat behaviour.

If a bat is tracked following release and not found to be in flight, this could be an indication that the transmitter is affecting the bat. If this occurs during the four hours post release, the bat will be observed for 15 minutes whilst stationary if roosting off the ground. If the bat remains stationary after 15 minutes, a decision will be made by the project ecologist on whether it is then safer to hand capture the bat (if possible) and remove the transmitter by carefully clipping hair to release the transmitter or cutting the attachment harness. If the bat has had the transmitter removed, has been checked for any signs of injury and appears healthy, active and alert, it will be released at point of capture. If the bat flies away before it can be captured, it will be tracked for the remainder of the four hours, or for at least one hour (whichever is the longer time period) to ensure it is flying and foraging as expected.

Any bat with a transmitter found on the ground during radio tracking must be hand captured and have the transmitter removed immediately by carefully clipping hair to release the transmitter or cutting the attachment harness. The bat will be checked for signs of injury and taken to a wildlife rehabilitator / veterinarian if injuries are detected. If no injuries are detected and the bat appears healthy, active and alert and ready to fly, it will be released immediately (if found at night) or held during the day in a cool, dark, quiet and well ventilated space until it can be released at point of capture after dark that evening.

Following final closure of a portal, ecologists must then conduct a pre-dawn survey at the excluded portal on the morning following complete closure of each portal (Table 7-1). These pre-dawn surveys will take place over a 1.5-hour period, concluding at sunrise. These surveys aim to monitor microbat behaviour, identify and rescue any microbats roosting in unsafe places outside the entrance to the tunnel (if safe and practical to do so), and assess the integrity of the exclusion devices. Any microbats roosting in unsafe places that are able to be captured by hand will be held in a calico bag (one bat per bag) in a cool, dark, quiet and well ventilated place for the day until they can be released at the point of capture on the canal after dark. Any breaches of the exclusion devices will be noted and marked for repair later that evening.

Following the closure of the upstream portal (stage 2), ecologists will need to return to the upstream portal each evening for tunnel release to lift a small portion of the curtain for 5 evenings or until no bats have been observed emerging for three consecutive nights (Table 7-1). The ecologists will need to lift a small portion of the curtain to allow any bats remaining inside the tunnel to exit safely, whilst attempting to ensure no bats enter again. Tunnel release will begin at sunset and the small portion of curtain will remain open for 45 minutes, or until no activity can be heard aurally or on the detector from within the tunnel. The opening will be supervised by an ecologist at all times so that it can be closed quickly if other bats from outside the tunnel are detected flying in the canal, or closed once a bat(s) has exited. An ultrasonic detector left inside the tunnel prior to its complete closure will be used to assist in determining whether any bats are left inside the tunnel and will be checked daily.

Once the ecologists are satisfied that there are no bats left roosting in the tunnel, the tunnel inspection platform is to be run through the tunnel to confirm that no bats are roosting within the tunnel (Table 7-1). If bats still remain in the tunnel, a small portion of the exclusion curtain will be lifted nightly for another 5 nights or until no bats have been observed / recorded emerging for three consecutive nights and a second run through of the tunnel inspection platform will be undertaken (Table 7-1). A contingency plan has been prepared in the event that bats continue to remain within the tunnel following a repeat of the tunnel release process (see section 8 below)

Ultrasonic recording at the tunnel, which may be supplemented with thermal camera recordings, will continue for up to 14 days post-exclusion and will only cease 5 days after the tunnel has been declared bat free. Construction may only commence once the project ecologist confirms that the tunnel is either bat free or has engaged the contingency plan required if bats remain in the tunnel after two weeks post closure of the tunnel.

Once the exclusion has been completed, the exclusion curtains must then be secured in such a manner that will allow them to remain in place until a barrier that can be used during construction is installed or throughout tunnel remediation works. Once exclusion is complete, an annexe will be built around the tunnel portal which will also be impermeable to microbats and that will create a second available barrier to microbats. Works will then be able to progress with less risk 24 hours a day (see section 9). This will allow one exclusion device to always be in place at a given time, and prevent microbats breaching during works. The outer exclusion barrier on the annexe will only be required to be closed from one hour before sunset each night until sunrise each morning during construction.

The ecologist will need to conduct periodic inspections of the exclusion devices (one week after install, one week during the first week of construction and then each month during works or following any change to the devices or annexe) to ensure the exclusion devices continue to function as intended. The installed bat boxes and control sites will be monitored ultrasonically and inspected / checked during this time.

#### 7.1.6 Contingency Plan

If bats continue to remain in the tunnel following the second application of the tunnel release procedure and second run through by the Tunnel Inspection Platform, an amendment to the planned works program and contingency plan will be enacted (Table 7-1). The contingency plan involves a delay to commencement of works at the upstream portal until all bats have left the tunnel. Works can commence at the downstream portal as it is assumed that the noise and disturbance involved will provide the final encouragement bats need to leave the tunnel. The contingency plan requires nightly attendance at the tunnel by ecologists to open a small portion of the exclusion curtain to allow bats to leave. If dead bats are discovered at the tunnel entrance during this process, or discovered by construction personnel during works, works must cease until the situation can be evaluated by the project ecologist. Under this scenario, works may be restricted to certain times, such as night works only until all bats have vacated the tunnel. Additional deterrents may be required to be installed such as high powered lighting of the internal tunnel, to encourage bats to vacate the roost and select alternative roosts.

### 7.1.7 Exclusion devices

There are a number of materials that can be used to exclude microbats from a roost and the choice of suitable materials will be dependent upon whether the exclusion is permanent or temporary, the shape and location of the roost entrances and the substrate material to which the exclusion device must be fitted. In the case of the Balickera Tunnel, the exclusion is temporary during remediation works.

There is no access to the roosting features within the tunnel and as a result the exclusion devices will be fixed temporarily over the tunnel portals. The suggested material that would be appropriate to use as an exclusion device is a heavy duty plastic sheeting that can be cut to shape and draped across the upstream and downstream portals (Figure 19).

The exclusion devices will be draped over the tunnel portals like curtains and secured in place from above so that they will not become dislodged in the event of heavy rainfall. The sheeting will allow some air flow through the structures via tiny holes in the plastic, a thin gap at the base and gaps between the strips / flaps of the plastic sheeting which will not be large enough to allow microbats to return.

An email is to be sent to the project manager following completion of the exclusion process confirming that the exclusion is complete and providing photos and descriptions of the exclusion devices that have been installed. An action log will be kept during the exclusion process and for any monitoring inspections conducted between the exclusion and commencement of works. This log will be submitted to the project manager upon completion of the project as part of the reporting requirements. The exclusion log will contain the following information:

- Action undertaken
- Date
- Personnel involved
- Results / outcomes against performance measures
- Effort / time on site
- Adaptive / alternative procedures required / recommended.

Exclusion devices would need to be monitored one week after installation, and then monthly by the project ecologist during works to ensure they remain effective in excluding bats, especially following any high rainfall, high wind or flood events, or changes to the design of the annexe or exclusion devices themselves.

It will be critical that contractors ensure the exclusion devices remain secure throughout tunnel remediation works.

**Figure 19. Example of exclusion device using heavy duty plastic sheeting across a culvert**

## 7.2 Actions during construction

### 7.2.1 Construction requirements

During remediation works within the tunnel, where it can be avoided, no shotcrete or rock bolting is to be applied to the natural rock surface within a 1 m radius of the edges of the two main roosting areas at 240 m and between 290 and 370 m (Figure 5-5 and Figure 5-6). The exact location and chainage to be determined during geotechnical inspections of the tunnel prior to commencing works. There have been several internal tunnel studies completed and the chainages do not line up. A final reference point and cross check of chainages against bat roost locations will be required as part of the geotechnical inspections completed prior to works. Detailed drawings and measurements (area and countours, depth, width, length) will be taken of roosting habitat that cannot be avoided during remediation works during the geotechnical inspections of the tunnel prior to commencing works. Contouring and shaping of the shotcrete applied to the location of the impacted microbat roosting habitat will aim to replicate the features of the impacted microbat roosting habitat and remain within the structural integrity limits of the shotcrete. The resultant surface must be approved by the project ecologist once it is safe to do so and before contractors hand the site over to Hunter Water.

The 106 vertical cylindrical 20 cm diameter holes within the concrete lined sections are identified by numbering from 1 to 106, starting at the upstream portal. There are 39 holes known to be used by bats as roosting habitat (Ecotone 2000). These 39 holes, along with an additional hole within the second concrete lined section making up a total of 40 holes, will be retained in original format, wherever possible. Where impacts to these holes cannot be avoided, the holes must be recreated in exact dimensions using shotcrete, provided the integrity of shotcrete will not be compromised.

### 7.2.2 Site induction

All staff and contractors participating in tunnel remediation works will be made aware of the environmental sensitivity of the site and the potential presence of threatened microbat species prior to commencing work through undertaking an environmental induction led by the contractors OH&S representative and prepared by the project ecologist (Table 7-1). Pictures of microbats (provided by the project ecologist) will be placed in the crib room as a reference and the location of potential microbat roosts marked on site maps / design drawings displayed on site. Staff will be briefed on what to do in the event of unexpected finds of microbats. Some microbats carry diseases that can be lethal to humans if untreated, and unexperienced/unvaccinated people must never handle bats unless absolutely necessary (See Section 8.2and Section 8.3 for the unexpected finds procedure).

All staff will be made aware of how to identify roosting microbats or signs of microbats. Microbats or evidence of their presence can manifest in a range of ways and works staff will be made aware of these signs as part of the site induction process. A set of visual aids on microbats for use in the induction process will be prepared by the project ecologist. Evidence of or potential for microbat occupancy includes the following:

- Visual (diurnal) observations of singles or clusters of roosting microbats hanging from the obvert (ceiling or roof) or walls, or lying within horizontal crevices in structures such as bridges, culverts, derelict mines, tunnels, old buildings, chimneys.
- Visual (nocturnal) observations of bats flying from or returning to a structure at dusk and dawn, respectively.
- Audible sounds made by roosting bats include a chattering clicking type noise often heard around dusk and dawn or if bats are disturbed in a roost. Any suspicion of unusual noises within the tunnel will be investigated further by the project ecologist with a handheld ultrasonic call recorder.
- Guano (bat dung / scats) will be present if bats are utilising a roost, even just for a couple of days. Often guano collects immediately under the roost site or sticks to the structure walls under the roost or around the entrances to a roost.
- Any Welcome Swallow or Fairy Martin nests – mud and earth constructed bird nests are relatively common on bridge and culvert structures and will be investigated as some bat species will utilise disused nests as roost sites.
- No works will commence if roosting bats are found or heard within a work area or bats are observed flying from a roost or around the works site during daylight. Unexpected finds of microbats will be reported immediately to onsite environmental staff, project manager and the project ecologist who will advise the best course of action. Photographs will be taken and then sent to the project ecologist to identify the microbats and to determine what actions are required.

### 7.2.3 Daily Inspections of exclusion devices

Twice daily checks of the exclusion devices are to be undertaken by the site supervisor at the start of every day and no later than 1 hour prior to sunset and records kept of these checks (Table 7-1). If the exclusion devices are unsecure the site supervisor must contact onsite environmental staff, the project manager and the project ecologist immediately so that the breach can be inspected and repaired as soon as possible. No works are to commence in the tunnel if there is a chance that bats have been able to enter the tunnel during the period of the breach. If no bats have had a chance to enter the tunnel, the breach must be repaired prior to dusk. If the breach cannot be repaired until the following day, a temporary fix must be put in place under the supervision of the ecologist so that no bats can enter the tunnel during evening works.

If a breach of the exclusion device has occurred and microbats are found to be roosting in the tunnel, the project ecologist may attempt to capture the bat(s), hold in a calico bag in a cool, dark, quiet place until nightfall and release at the site; if safe to do so. It is presumed that if any bats are located it would be in a completed works area, the active works area, or the area immediately surrounding it, all of which will have been made safe for workers to access. If the bat(s) cannot be captured, an exclusion zone will be set up by the ecologist within which no works can occur. The exclusion methodology of lifting a small section of the curtain shortly after dark to release any bats will then be followed until the bat makes its way out of the tunnel.

The project ecologist or an ecologist experienced in handling microbats and vaccinated against Lyssavirus (approved by the project ecologist if the project ecologist is unable to attend) will be on call at all times during the remediation works in case any microbats are sighted. If any microbats or signs of microbats (see below) are observed, an exclusion zone will be set up around the roost site and all works ceased within that area until the project ecologist can collect and relocate any roosting bats (if it is safe to do so).

In the instances that an exclusion device is required to be moved or opened during the day to conduct works, the project ecologist must be notified and it will be the responsibility of the site supervisor to re-instate the exclusion device(s) over the tunnel portals no later than 30 minutes prior to sunset at the conclusion of the work day.

### 7.2.4 Construction monitoring

The objectives of construction monitoring are to:

- Ensure no microbats are harmed during construction.
- Identify the need to adjust the construction methodology to minimise impacts to microbats, if required.
- Document microbat activity levels at alternative roost sites / control sites and bat boxes.

One week after the tunnel has been declared free of bats, ultrasonic monitoring will be conducted over four nights at both tunnel portals, bat boxes and outside the identified alternative roost sites / control sites. Bat boxes will also be visually inspected once during the day.

Monitoring will be conducted following the methodology described above once each month during the construction period.

## 7.3 Post-construction monitoring and site rehabilitation

The objectives of monitoring and site rehabilitation are to:

- Ensure no microbats have been harmed by the construction works.
- Identify the need to adjust the exclusion methodology to minimise impacts to microbats on future projects.

- Identify whether the microbat management actions have been implemented and gauge their success.
- Identify and manage any remaining threats to microbats and their habitat within the study area.
- Provide further recommendations for consideration on future projects with similar impacts on threatened microbats.

Following the completion of tunnel remediation works and providing the roosting habitat for bats has been preserved during works, microbats should return to roost within the tunnel. Monitoring microbat activity levels will continue for a minimum of two years in order to document and determine the success or otherwise of the remediation works and the exclusion process. Monitoring at bat boxes and the selected key alternative roost sites, also serving as control sites will also be conducted over this time period. The monitoring program will commence within one month of the tunnel being open for use by microbats, then conducted quarterly for two years as follows:

- Ultrasonic detection at each tunnel portal for four nights per season.
- Ultrasonic detectors at known alternative roost sites for four nights per season in parallel with tunnel surveys.
- Thermal camera video recording at each tunnel portal for two nights each season in conjunction with ultrasonic recording.
- Diurnal inspection of bat boxes once during each quarter.
- An internal paddle through / TIP run of the tunnel once during May or June and once during December or January in each year of monitoring to check roost locations.
- Harp trapping of both tunnel portals for a single night once during autumn each year of ongoing monitoring.

If after two years microbat numbers and species present within the tunnel do not return to levels observed prior to construction, and the same pattern is not observed at the control sites, this will trigger the offset payment scheme to be enacted to account for the loss of threatened microbat roosting and breeding habitat. Thresholds for triggering the offset payment scheme will be as follows;

- If less than 75% of the maximum pre-construction winter occupancy of bats (5807 based upon thermal camera counts conducted for this study) are recorded roosting within the tunnel by the second winter.
- If less than 75% of the maximum pre-construction summer occupancy of bats (2370 based upon thermal camera counts conducted for this study) are recorded roosting within the tunnel by the second summer.
- If < 75% of the bats recorded roosting within the tunnel are Little Bent-winged Bats during each autumn, winter and spring monitoring event, and when the results of all monitoring events are combined.
- If Southern Myotis has not established a breeding colony of at least 50 bats within the tunnel that has successfully bred within the tunnel at least once during the two year monitoring period.

There may be other scenarios where the application of the offset scheme will be required depending upon the results obtained during monitoring such as if the numbers show a decreasing trend from first to second year despite being above the thresholds provided above. There may also be scenarios where the thresholds above can be adjusted to reflect significant increasing trends in numbers or the presence of certain species even when results are below thresholds provided above.

The application of this scheme will need to be developed in consultation with Hunter Water, the Department of Planning, Industry and Environment (DPIE), Biodiversity Conservation Division (BCD) and a suitably experienced microbat ecologist prior to commencement of works. Under Section 8.6.1 of the current Biodiversity Assessment Method (BAM), an optional offset may be proposed when the impacts to habitat within human-made structures cannot be mitigated. If the tunnel remediation works have long term impacts on the suitability of the structure for microbats, and therefore the prescribed impacts have not been avoided, minimised or mitigated, then the agreed optional offset will be enacted.

Rehabilitation of the cleared areas previously containing native vegetation is required to replace lost microbat foraging habitat around the tunnel. Cleared areas will be replanted with native plant species recorded on site. Management of weeds around the tunnel portals should also be undertaken via manual means using a cut and paint technique (no herbicide spraying). Overgrowth of weeds promotes the presence of predators in close proximity to the tunnel portals and obstructs access for bats.

## 7.4 Operational Monitoring

Regardless of whether microbats have returned to the tunnel within two years post construction, operational microbat monitoring is required to be conducted once every two years for the following eight years, and then every five years thereafter at Balickera Tunnel to document microbat activity, record fluctuations in the number and species of roosting microbats, record any changes to the roosting locations being used by microbats within the tunnel and potentially to document the re-uptake of roosting habitat within the tunnel. The same level of monitoring should be applied to Brookfield Tunnel, Dungog WTP Tunnels and any installed bat boxes given there are no existing monitoring programs for these sites.

Operational monitoring will consist of the following:

- Ultrasonic detection at each tunnel portal for four nights per season
- Thermal camera video recording / counts at each tunnel portal for a single night each season in conjunction with ultrasonic recording
- Diurnal inspection of bat boxes once during each quarter
- An internal paddle through / walk through / TIP run of each tunnel once during May or June and once during December or January in each year of monitoring to check roost locations
- Harp trapping of both tunnel portals for a single night once during autumn each year of operational monitoring.

Ongoing weed management of rehabilitated areas and at the tunnel portals should continue with annual inspections / weed control using the cut and paint technique described above.

**Table 7-1: Summary of actions required to implement the MMP**

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| **Pre exclusion** | | | | | |
| Compensatory habitat | Install 10 x bat boxes for Southern Myotis | Spring and at least one month prior to commencing exclusion | 10 x 4 chambered bat boxes installed | Install boxes on frame beneath bridge if TfNSW doesn't approve installation on bridge | Project ecologist, Hunter Water, installation contractor |
| Site inspection / meeting | Project inception | Commencement of project | | | Project ecologist, site supervisor, project engineer / supervisor |
| Environmental induction | Discussion of risks involved and safety procedures | Commencement of project | | | Project ecologist, site supervisor, project engineer / supervisor, contractors and all site personnel |
| Action log | Commence logging actions | Commencement of project | Action log completed | | Project ecologist |
| Pre-construction surveys – baseline alternative roosting habitat | Diurnal visual, emergence, thermal camera and ultrasonic surveys | Spring and summer prior to exclusion, once per season if works are delayed | Four nights of ultrasonic survey all sites, two nights of thermal camera per season at tunnel, single night thermal camera emergence at Brookfield, Dungog, Pilchers, single diurnal inspection of bat boxes, Twelve Mile Creek, Grahamstown Drain Bridge and Clarencetown Bridge or culverts each season. | | Project ecologist |
| Procure exclusion materials | Purchase suitable materials | At least two weeks prior to exclusion | Exclusion materials procured | | Project ecologist |
| Exclusion device site prep | Complete framing / support installation for exclusion curtains | Week prior to commencing exclusion | Exclusion devices in place and ready to be dropped into place | Contractor under project ecologist supervision | |
| Pre-exclusion survey – bat box inspection | Visual diurnal bat box inspection | Day prior to commencing exclusion | Visual inspection completed | | Project ecologist |

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| Pre-exclusion survey - tunnel | Emergence, thermal camera, ultrasonics and emergence survey at tunnel entrances | Night before commencing exclusion | Count of bats and species of bats known prior to exclusion | | Project ecologist |
| Pre-exclusion survey – other sites | Ultrasonic monitoring of alternative roost sites and bat boxes | Conducted in parallel to exclusion stage 1 and stage 2 | Record of activity levels at alternative roost sites | | Project ecologist |
| **Exclusion** | | | | | |
| Stage 1 exclusion (downstream portal) | Emergence survey with thermal camera | 30 mins prior to sunset until activity reduces to pre-determined levels each night of exclusion | Defined time reached when exclusion device can be dropped into place | Conduct only if weather suitable, meets conditions described in MMP | Project ecologist |
| Stage 1 exclusion | Installation of partial exclusion device | After emergence survey | Exclusion device installed | | Project ecologist |
| Stage 1 exclusion | Continued incremental closure of exclusion device | Nights 2 – 4 or 5, dependent upon how well the bats react | Exclusion device installed with minimal distressed behaviour from bats | Conduct only if weather suitable, meets conditions described in MMP | Project ecologist |
| Stage 1 exclusion – bat box inspection | Visual diurnal bat box inspection | Daily during exclusion | Visual inspection completed | | Project ecologist |
| Stage 1 exclusion | Pre-dawn survey | Morning after final closure of exclusion device | No breaches of exclusion device, no bats roosting in unsafe places | | Project ecologist |
| Stage 2 exclusion (upstream portal) | Emergence survey with thermal camera | 30 mins prior to sunset until activity reduces to pre-determined levels each night of exclusion | Defined time reached when exclusion device can be dropped into place | | Project ecologist |
| Stage 2 exclusion | Installation of partial exclusion device and internal ultrasonic detector | After emergence survey | Exclusion device installed | | Project ecologist |
| Stage 2 exclusion | Continued incremental closure of exclusion device and downloading of ultrasonic detector from inside tunnel | Nights 2 – 6, dependent upon how well the bats react | Exclusion device installed with minimal distressed behaviour from bats | | Project ecologist |

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| Stage 2 exclusion – harp trapping and radio tracking | 1-2 nights of harp trapping to fit radio transmitters | When upstream portal is greater than 50% closed but not on the final closure night | Capture of up to 30 bats and fitting of radio transmitters | | Project ecologist |
| Stage 2 exclusion – radio tracking of bats | Track bats for at least four hours following attachment of transmitters on first night | Night that transmitters are attached | Bats flying and foraging with no indication of compromised behaviour due to transmitter attachment | | Project ecologist |
| Stage 2 exclusion – bat box inspection | Visual diurnal bat box inspection | Daily during exclusion | Visual inspection completed | | Project ecologist |
| Stage 2 exclusion | Pre-dawn survey at upstream portal and downloading of ultrasonic detector | Morning after final closure of exclusion device | No breaches of exclusion device, no bats roosting in unsafe places | | Project ecologist |
| Stage 2 exclusion – diurnal radio tracking | Conducted at upstream portal during pre-dawn surveys then diurnally at alternative roost sites | Day after transmitters are attached | Fixes obtained on tagged bats | | Project ecologist |
| **Post exclusion** | | | | | |
| Post-exclusion surveys - other sites | Emergence surveys with thermal cameras at Brookfield, Pilchers, Dungog WTP, diurnal visual inspections of Twelve Mile Creek, Grahamstown Drain Clarencetown Bridge or culverts | Day and evening after full exclusion and daily for 7 days or until radio tracking ceases, whichever is the longer | Count of bats present at alternative / control sites | | Project ecologist |
| Post exclusion surveys – tunnel releases | Targeted partial opening of exclusion device at upstream portal to release any bats still roosting in tunnel and download ultrasonic detector, | Between sunset and approx. 45 minutes after sunset, on evenings 1 – 5 in suitable weather following complete exclusion | Bats remaining in tunnel released until there is no activity recorded either visually or on ultrasonic devices placed inside tunnel portal, no bats allowed back into tunnel | | Project ecologist |

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| | thermal camera and ultrasonic detectors | | | | |
| Post exclusion surveys – bat box inspection | Visual diurnal bat box inspection | Daily during post exclusion period until no bats remain in tunnel | Visual inspection completed | | Project ecologist |
| Post exclusion surveys – Tunnel Inspection Platform TIP) | Diurnal run of tunnel inspection platform to check for roosting bats | On the advice of the ecologist, proposed to be approx. one week after full exclusion of the tunnel | Complete visual of the internal surface of the tunnel | | Project ecologist / Abyss Solutions |
| Post exclusion surveys – tunnel release and TIP | Repeat of the above three steps if bats are found roosting in the tunnel following the TIP run | Immediately following TIP run for up to five nights | Bats remaining in tunnel released until there is no activity recorded either visually or on ultrasonic devices placed inside tunnel portal, no bats allowed back into tunnel | | Project ecologist |
| Notification | Email to PM to confirm exclusion complete | Day that exclusion is completed | Tunnel does not contain any bats | | Project ecologist |
| Post exclusion surveys – diurnal radio tracking | Locating roost sites of tagged bats | Daily from Day 1 after transmitters attached until battery life of transmitters is exceeded (up to 19 days) | Fixes obtained on tagged bats daily | | Project ecologist |
| Pre-construction | | | | | |
| Annexe and double barrier install | Install annexe effecting a double barrier system prior to commencement of works | Once all bats have been cleared from the tunnel | Double barrier in place to exclude bats from tunnel during works | | Contractor under project ecologist supervision |
| **Construction** | | | | | |
| Confirm roost locations, measure roost habitat | Geotechnical inspections confirm chainages and bat roost locations | Following exclusion and prior to commecment of works | Measurements of precise location, area, size, contours) of bat roosting habitat prepared and transferred to detailed design draawings for avoidance / recreation during works | | Geotechnical engineer in collaboration with project ecologist |
| Construction monitoring - tunnel | Inspect exclusion devices, monitor bat activity levels using ultrasonic detectors and | One week following declaration that the tunnel is bat free, during the first week of tunnel remediation works, monthly during tunnel remediation works, four nights ultrasonic recording | Exclusion device secure | | Project ecologist |

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| | email results to project manager | | | | |
| Construction monitoring – other sites | Ultrasonic monitoring of alternative roost sites and bat boxes | Conducted in parallel to tunnel monitoring, one week following bat free declaration, during the first week of construction then monthly throughout construction, four nights ultrasonic recording and single visual diurnal bat box inspection each monitoring event. | Record of activity levels at alternative roost sites | | Project ecologist |
| CONTINGENCY PLAN IF REQUIRED: Tunnel release of bats during construction | Targeted partial opening of exclusion device at upstream portal to release any bats still roosting in tunnel and download ultrasonic detector, thermal camera required | Between sunset and approx. 45 minutes after sunset, nightly in suitable weather conditions until all bats have left the tunnel. | Bats remaining in tunnel released nightly until there is no activity recorded either visually or on ultrasonic devices placed inside tunnel portal, no bats allowed back into tunnel | | Project ecologist |
| Daily works inspection | Inspect exclusion devices twice daily and inform project ecologist if action required | Twice daily during works, early am and no later than 1 hour before sunset | Exclusion devices secure | | Site supervisor |
| Remove exclusion devices | Remove exclusion devices to allow access to bats | Immediately following demobilisation of site | Tunnel open for use by bats within 2 weeks following completion of internal tunnel works | | Contractor under project ecologist supervision |
| **Post construction** | | | | | |
| Post-construction monitoring | Monitor activity levels at tunnel, key alternative roost sites and in bat boxes after construction finishes as directed in MMP | Within one month after tunnel open to bats and then quarterly for two years | Number of roosting bats returns to pre-construction levels | | Project ecologist |
| Reporting | Prepare a report outlining actions undertaken | Within two months following completion of exclusion works | Written outcome of exclusion process provided | | Project ecologist |

| Management Measures | Details | Timing | Performance Indicators | Contingency Measures | Responsibility |
|---|---|---|---|---|---|
| Ongoing operational monitoring | Biennial monitoring of the microbat colony in the tunnel, and at Brookfield and Dungog WTP Tunnels | Four nights ultrasonic recording at each tunnel portal each season, 1 night thermal camera recording at each tunnel portal each season, single diurnal bat box inspection each season, single night harp trapping at each tunnel portal during autumn, single paddle through / walk through / TIP during May or June and December or January | Information on tunnel microbat population | | Hunter Water / Contract Microbat Ecologist |

# 8. Contingency measures

Wild animals can display unpredicted and unexpected behaviours, therefore this MMP must be flexible in its application so that a range of potential outcomes can be dealt with in accordance with OEH NPWS scientific licencing and Animal Care and Ethics Committee approvals.

## 8.1 Adaptive procedures

The procedures of this plan may be adapted in response to factors such as microbats remaining in the tunnel and not emerging to forage during the exclusion process which, would have implications for the length of time it takes to exclude microbats from the tunnel. As there is an identified window of time when impacts to bats can be minimised, any longer delays may create additional impacts that will need to be managed.

The aim is to facilitate the identification of the best course of action for the particular situation, including time and logistical constraints, as well as the biological constraints posed by the microbats. This would require open communication between the work supervisor, project manager, onsite environmental staff and the project ecologist.

Microbats are wild animals and do not always behave in the ways we expect or predict. Management plans need to be adaptable enough to react to situations as they arise and deal with a range of possible outcomes. Modifications to the procedures outlined in this plan may be undertaken provided there has been consultation with the project ecologist and agreement by all relevant parties (project ecologist, Hunter Water and DPIE). The aim of this clause is to allow for the identification of the best course of action to facilitate construction given time and logistical constraints as well as ecological constraints imposed by the affected microbat species.

## 8.2 Capturing and releasing healthy microbats

If healthy microbats are discovered during works or observed flying from a roost site or around the works site during daylight, works will stop immediately and the site supervisor, onsite environmental staff, project manager and project ecologist will be informed. This is the responsibility of all site personnel.

The project ecologist may elect to retrieve isolated bats (if possible) that are alive and healthy from the work area, hold them in a calico bag (no more than 5 microbats of the same species to be held in a single bag) during the day in a cool, dark, well ventilated place and release them at the point of capture once the work area is secured. This will only be undertaken if microbats can be safely released on the night after they were captured. Bats will not be held for more than 12 hours.

If it is not possible to capture and remove the bats, a suitable exclusion zone will be set up by the project ecologist and no works will be undertaken within that zone until specifically directed by the project ecologist.

Bats will not be handled by unvaccinated (for Australian Bat Lyssavirus, ABLV) and inexperienced persons. Some microbats carry diseases that can be lethal to humans if untreated and restrictions on handling is to minimise any potential for possibility of serious disease transmission. Photos are the first and best course of action to help identify microbats and will be supplied to onsite environmental staff and the project ecologist. If a non-vaccinated person does come into contact with a microbat, they must seek immediate medical attention. A post ABLV exposure vaccine is available and highly effective and will be administered as quickly as is reasonably possible after exposure (see Section 9.1 for further information).

Any evidence of a roosting microbat will be documented, photographed and actions recorded with onsite works staff, and then immediately directed to the project ecologist for further action.

## 8.3 Injured or dead microbats

If microbats are found injured or dead in a works area, all works in the immediate area will cease and the site supervisor, onsite environmental staff, project manager and project ecologist must be informed. Any injured or dead microbats will be documented, photographed and actions recorded with onsite works staff and directed to the project ecologist for further action. A suitable exclusion zone will be set up by the project ecologist and no works will be undertaken within that zone until specifically directed by the project ecologist.

Injured bats will be removed by the project ecologist and transported to a local veterinarian or wildlife carer experienced in the care and handling of microbats. Options for treatment and future release would be decided on in consultation with the veterinarian/carer and then documented by the project ecologist. Costs for treatment would be the responsibility of the contractor. Dead microbats will be collected by the project ecologist (using gloves and a plastic bag) and retained for lodgement with the Australian Museum.

# 9. Health and safety risks

Some of the procedures detailed within the plan pose various risks to human safety. The key risks include:

- Contact with microbats
- Working near a waterbody
- Working at night
- Working at heights via being in close proximity to steep slopes.

These risks are to be addressed by the project ecologist through preparation of a Safe Work Method Statement (SWMS) that outlines control measures required to eliminate or reduce the risks to acceptable levels. Controls to eliminate or reduce the key risks identified in this section are commonly encountered on construction projects and will be adequately addressed in the SWMS prepared by the project ecologist.

## 9.1 Exposure to diseases such as Australian Bat Lyssavirus

Some microbats carry diseases that can be lethal to humans if untreated. Bats will not be handled by people unvaccinated for ABLV or by inexperienced persons. This is to minimise the potential for serious disease transmission. Photos are the first and best course of action to help identify microbats and will be supplied to onsite environmental staff and the project ecologist.

Even if previously vaccinated against ABLV, if personnel are bitten or scratched by a bat anywhere, you should:

- Immediately wash the wound thoroughly with soap and water for at least five minutes - proper cleansing of the wound is considered to greatly reduce the risk of infection
- Apply an antiseptic with anti-virus action such as povidone-iodine, iodine tincture, aqueous iodine solution or alcohol (ethanol) after washing (suitable antiseptics are to be present on site at all times)
- Seek medical attention as soon as possible to care for the wound and to assess whether you are at risk of infection.

If you are at risk of infection, you may require treatment consisting of a combination of rabies immunoglobulin and rabies vaccine. If you have not been vaccinated previously, you will require an injection of rabies immunoglobulin as soon as possible after exposure and a series of either four or five rabies vaccine injections over one month. If you have been vaccinated before with a full course of vaccination, you will require two further doses of vaccine. In NSW, Public Health Units will work with your doctor to assess your risk and where indicated, will arrange for rabies vaccines and immunoglobulin to be delivered to your GP or hospital.

It is important to stress that the likelihood of exposure is considered to be extremely low and the presence of this disease has been recorded in only a few microbats ever. It is also important to note that the treatment process is simple to administer and, if commenced within a few days of any exposure, is considered to be 100% effective. This risk of the disease needs to be taken seriously, but panic or overreaction resulting from an unexpected exposure to bats or their habitat is likely to represent as serious a risk to workers in this situation given the confined spaces and heights that occur in this work environment.

The project ecologist and any other ecologists working on site must be vaccinated against Australian Bat Lyssavirus and wear gloves if handling microbats. The equipment and procedures for dealing with potentially infected persons outlined above must be detailed within the SWMS. Appropriate bat rescue equipment/ PPE must be available on site before works commence (cotton bags, gloves, soap and water to wash hands).

## 9.2 Actions to minimise exposure to White Nose Fungus

White-nose syndrome (WNS) is a fungal disease that has caused significant declines in insectivorous bat populations in the eastern United States and Canada. White-nose syndrome has not been identified in Australian bats despite testing of a number of cave dwelling bat species. A risk assessment concluded that there is a high likelihood that the fungus will enter Australia in the future. White-nose syndrome is not known to infect humans or other animals following exposure or to cause any health risks but it can be transmitted by humans carrying the spores on clothing and equipment.

It is important that cavers returning or entering Australia from overseas be aware of the risk of carrying the fungus into Australia on their clothing, footwear and caving gear and take appropriate precautions to disinfect their equipment and clothing prior to entry into the country. People who come in contact with insectivorous bats in Australia should be aware of the disease and report any suspect cases.

The causative agent of WNS is the fungus *Pseudogymnoascus destructans* (formerly Geomyces destructans). *P. destructans* is psychrophyllic, meaning it grows best at low ambient temperatures. In vitro studies have found that optimal temperatures for growth are between 12.5 and 15.8 °C, with cessation of growth above 20°C. While the fungus grows best at humidity levels above 90% it is able to survive prolonged periods of low humidity and is capable of growth on a range of environmental substrates.

Transmission is by direct contact from infected bats to healthy bats and by direct contact between bats and the cave substrate. The worst affected bat species tend to cluster tightly together in large colonies, thus facilitating fungal spread. Airborne transmission has not been demonstrated. Humans have also been implicated in the spread of the disease.

In North American bats infection is often associated with abnormal behaviour such as increased arousal from hibernation, increased grooming behaviour and flying during the day which, in turn, has resulted in mass mortalities. Increased arousal frequency consumes additional energy reserves, so affected bats have little or no identifiable fat stores. Wing damage results in increased evaporative water loss leading to electrolyte depletion and dehydration. Many, but not all, affected bats have a grossly visible white or grey fungal growth on muzzles, ears and wing membranes, which can lead to scarring and necrosis. Affected wings may become thinner, discoloured, have a flaky appearance and develop erosions and ulcers. Folded surfaces of severely affected wing membranes adhere to each other, tear easily, and appear to lose tone, tensile strength and elasticity. An estimated one million hibernating bats have died, with populations in some hibernacula decreasing by 90 to 100%. WNS can thus have a significant impact on bat populations.

While the large-scale mortalities seen in North America are considered less likely to occur in Australia due to its milder climate, bat species living in southern Australia could still be affected, particularly the critically endangered southern bent-winged bat, due to the additive effect of existing threatening processes, and thefact that the entire population lives within the preferred temperature zone of P. destructans (Holz et al.2016).

In the context of working within known subterranean bat roosts in Australia, during the site induction process workers must be made aware of the possibility of transmission of WNS if they have visited caves overseas and notify onsite environmental represetnatives. Where decontamination of clothing and equipment is required, the items should first be cleaned of all mud and debris. Clothing and other suitable items should then be submersed in hot water maintained at a temperature of at least 55 °C for a minimum of 20 minutes. Equipment that cannot be immersed in water can be treated by disinfection. Disinfectants that have been shown to kill *P. destructans* include chlorine bleach, 60% ethanol, 60% isopropanol and 3% hydrogen peroxide.

People who come in contact with insectivorous bats in Australia should be aware of the disease and report any suspect cases.

Information on how to recognise and report a suspect case of WNS is available on the Wildlife Health Australia (WHA) website:

www.wildlifehealthaustralia.com.au/Portals/0/Documents/ProgramProjects/How_to_report_a_suspect_case_of_WNS.pdf.

# 10. Roles and Responsibilities

The construction personnel, project ecologist, project manager and environmental officer form a team that work together to achieve short-term management of microbats at the Subject site through delivery of the MMP

The project engineer /supervisor is responsible for:

- Notifying the project ecologist if there are any changes to the scope of works or works schedule.
- Including the actions outlined in the MMP in the Construction Environmental Management Plan (CEMP) or Site Environmental Management Plan (SEMP).
- Ensuring the location of potential microbat roosts are marked on site maps or drawings.
- Notifying the project ecologist of the proposed date for commencement of remediation works.
- Notifying the project ecologist of the proposed date for works within a 5 m area either side of a known roost site.
- Immediately notifying the project ecologist in the event of any unexpected finds of microbats during works (alive and healthy, injured or dead).
- Covering the costs associated with rehabilitation and release of any microbat injured during the course of works.
- Ensuring monitoring of any new microbat habitat (if required) is undertaken and reported on with any recommendations for future improvement forwarded to Hunter Water.

The project ecologist is responsible for:

- Providing basic information and pictures of microbats to be included in the environmental induction and to be kept in the crib room and available to all site personnel.
- Preparing a SWMS and ensuring daily Toolbox Talks are completed for the ecology team when ecologists are on site as outlined in the program above during the implementation of the MMP.
- Procuring exclusion material.
- Maintaining an action log in relation to activities related to the implementation of the MMP.
- Monitoring and installing / directing the installation of exclusion devices (may require assistance from construction personnel).
- Providing regular updates to the Hunter Water project manager and contractor site supervisor on the progress of the implementation of the MMP, and particularly the exclusion and monitoring works conducted prior to, during and post construction.
- Dealing with any unexpected finds of microbats on site, including provision of advice, attendance at site at short notice, rescue, handling, and release of healthy bats, transfer of injured bats to an appropriate wildlife carer and lodgement of dead microbats with the Australian Museum.
- Reporting on the outcomes of the MMP within two calendar months of completion of works.
- Undertaking and reporting on monitoring of the tunnel and associated control sites post remediation works.

 

The project ecologist is to provide guidance to the project engineer / supervisor such that the aims of the MMP are achieved and impacts to microbats are minimised. Any decision involving a change to the procedures outlined in this document would be discussed or referred to the Hunter Water project manager and environmental officer in the earliest instance and may need to be discussed or referred to DPIE for concurrence.

The site supervisor is responsible for:

- Conducting environmental inductions for all personnel working on site.
- Providing the relevant materials on site to deal with the immediate care of bites and scratches from microbats.
- Marking off any sensitive areas to prevent access to all non-essential personnel during works.
- Conducting twice daily checks of the exclusion devices during the works period (early morning and no later than 1 hour prior to sunset).
- Notifying the project ecologist if the exclusion devices are not secure.
- Notifying the project engineer / supervisor of the proposed date for works.
- Notifying the project engineer / supervisor of the dates when work is expected to come within 5 m of the two main bat roost sites.
- Stopping works on site in the event of any unexpected finds of microbats during works (alive and healthy, injured or dead).
- Notifying the project engineer / supervisor of any unexpected finds of microbats during works (alive and healthy, injured or dead).
- Maintaining a suitable exclusion zone around any unexpected finds on the advice of the project ecologist.

Construction staff and contractors are responsible for:

- Undertaking site inductions including the environmental induction.
- Avoiding any sensitive areas marked off within the work site.
- Assisting the project ecologist with installation and maintenance of exclusion devices (if required).
- Stopping works immediately and notifying the site supervisor, project manager and environmental officer in the event of any unexpected finds of microbats during works (alive and healthy, injured or dead).
- Notifying the site supervisor if it is considered that any of them have been exposed or potentially exposed to the ABLV.

# 11. Reporting and Communication

The project engineer / supervisor and contract site supervisor will be kept informed via regular email and phone updates of progress and key milestones throughout the implementation of the MMP by the project ecologist. An action log summarising all site works undertaken will be maintained by the project ecologist. The action log will be a record of the actions taken, personnel responsible, timing, results as measured against performance measures and decisions made regarding adaptive measures (if required) during the installation and monitoring of exclusion devices. The action log will be included in the final project report.

A final project report outlining the actions taken in implementing the MMP and the success or otherwise of the MMP in mitigating impacts to microbats including recommendations for improvements to the process that could be employed on future projects will be submitted two months following completion of MMP works. This report will not include MMP monitoring actions undertaken after works have been completed.

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# Appendix K Abyss Solutions Tunnel Inspection Report

# Inspection of the Bat Colonies in Balickera Bulk Water Transfer Tunnel

*Inspection report*

Prepared for
Eco Logical Australia

By

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## Disclaimer

This document has been prepared in good faith based on data collected at the Balickera Bulk Water Transfer Tunnel site using Abyss Solutions' Tunnel Inspection Platform, information supplied by Eco Logical Australia and information available at the date of publication. The information contained herein, to the best knowledge of Abyss Solutions Pty. Ltd. is complete and accurate. Estimates are provided on a best endeavor basis only and Abyss Solutions cannot be held responsible for unforeseen costs, events or outcomes.

## Confidentiality



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# Table of Contents

# 1 Document Details

## 1.1 Document History

| Date | Version | Description |
|---|---|---|
| **30.06.2020** | **0.1** | **First Draft** |
| **03.07.2020** | **1.0** | **Client Submission** |
| **09.04.2021** | **1.1** | **Chainage Correction** |

# 2 Introduction

Abyss Solutions conducted a remote above water inspection of the Balickera Bulk Water Transfer Tunnel to determine the locations of major microbat colonies on the tunnel crown. This was the fifth inspection conducted by Abyss Solutions, with the inspection taking place on June 17-19, 2020.

Abyss Solutions captured imagery of the full length of the 1200m long tunnel. To conduct the inspection, Abyss Solutions utilised a custom-built Tunnel Inspection Platform (TIP) equipped with high fidelity infrared light cameras & illumination, to which the resident bat colonies were insensitive. A video showing the complete tunnel crown was produced with chainage and the locations of bat sightings recorded on this. The data gathering, processing & findings of the inspection are detailed herein.

# 3 Inspection Overview

Abyss Solutions was engaged by Eco Logical Australia to deliver an above water inspection of the Balickera Bulk Water Tunnel (see Figure 1 and Figure 2) to identify and record the locations of resident bat colonies and major defects on the tunnel crown, while avoiding disturbance to the bats. Locations were recorded in the form of chainages as measured from the downstream portal.


**Figure 1 Satellite view of the Balickera Bulk Water Tunnel showing its approximate path.**

**Figure 2 Upstream (left) and downstream (right) portals of the Balickera Bulk Water Tunnel.**

Abyss Solutions conducted similar inspections on four occasions, in December 2017, April 2018, September 2018 and April 2019. Abyss Solutions designed and built a Tunnel Inspection Platform (TIP) for the initial inspection which relied on red light imaging and illumination. This was subsequently modified to include infrared imaging and illumination as well as a more streamlined chassis for the subsequent inspections. The changes aimed to further reduce the impact of the platform on the bat colonies and mitigate the risk of entanglement with underwater vegetation and obstacles.

The TIP consisted of a needle shaped floating platform with infrared illumination and a set of three cameras with adjustable orientation (See Figure 3). The TIP was operated by applying tension to two lines attached to the TIP, from the tunnel ends. The lines were fed through the tunnel prior to the inspection using water flow through the tunnel.


**Figure 3 The Tunnel Inspection Platform with infrared illumination and imaging cameras.**

The TIP was initially deployed at the downstream end of the tunnel and pulled through the full length of the tunnel, before being retracted from the same end. Data was collected in both directions along the length of the tunnel. The tunnel crown was captured using imagery from 3 cameras to provide maximum coverage.

# 4 Analysis Methodology

The data processing involved the following:

- **Video Processing:**

The video clips were extracted from the three imaging cameras. The videos were time synced with a perspective adjustment and aligned spatially to produce a single continuous view of the tunnel crown. This ensured features crossing the boundaries between images were of the same scale and aligned spatially. An excerpt from the footage is shown in Figure 4. The footage is orientated such that the south-western wall appears on the left and the north-eastern wall on the right.

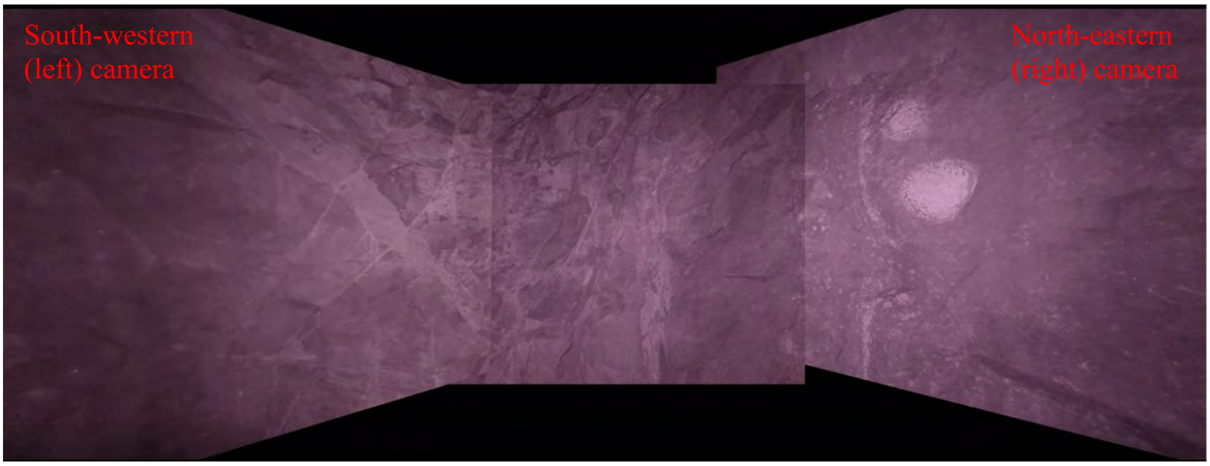



**Figure 4 Excerpt from combined video footage showing the perspective adjustment and spatial alignment of the 3 cameras.**

Examination of the video revealed that bat sightings were concentrated at the centre of the tunnel crown. Hence a cropped version of the video was produced focusing on this region. This video is intended to facilitate easier identification of bats. An excerpt of this footage is shown below.


**Figure 5 Excerpt from cropped video footage focusing on the centre of the tunnel crown where all bat sightings were concentrated. This video is intended to facilitate easier identification of bats.**

- **Video Analysis:**

The video footage was analysed to identify and locate major sightings of bats. The sightings were classified as either (i) *isolated* sightings in which 1-2 bats were found in a sequence of frames with no other surrounding bats, or (ii) *clustered* sightings of 3 or more bats appearing in successive frames together. Examples of this are shown in Figure 6 and Figure 7. Approximate numbers of bats in each sighting were also recorded.

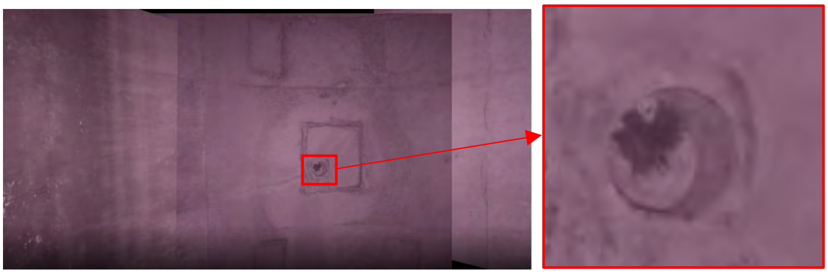


**Figure 6 Example of *isolated* bat sighting in which 1-2 bats were found in a sequence of frames with no other surrounding bats**

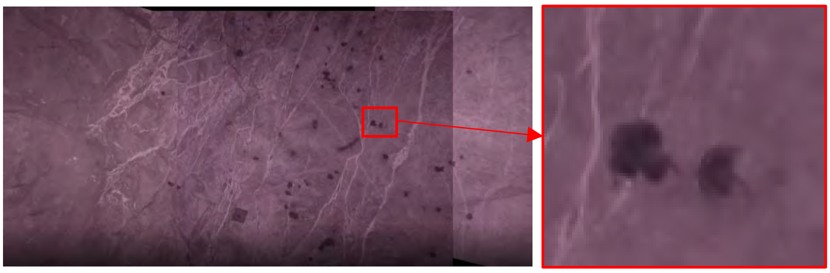


**Figure 7 Example of *clustered* bat sighting in which more than 3 bats were found in a sequence of frames together**

# 5 Interactive Video Deployment

The combined video footage and analysis results have been integrated onto Abyss Solutions' interactive video analysis platform, *SeqView*. The platform allows the user to review the video footage with bat sightings annotated on a timeline of the video. The user can jump through the video by moving from one sighting to the next on the timeline with the chainage (measured from the downstream portal), estimated number of bats and general comments displayed beside the video.

**Figure 8 Screenshot of the SeqView platform which provides an interactive view of the video footage and analysis results.**

The platform is accessible through the following link and login credentials provided below:

**Table 1 SeqView platform access details for viewing combined video footage and analysis results**

| | |
|---|---|
| Platform Link | https://ecologicalaus.cctv.abyss.solutions/sv/ |
| Username | eco |
| Password | blitz-divisible-scorebook2 |

To review the video footage and results the user should select a video (first) and annotation file (second) by click these in the left-hand pane. The video and annotations will load in the centre pane. The user can use the video playback buttons on the video screen including play, pause and full screen. To speed up playback hold down the 'shift' key. To jump between bat sighting the user simply clicks on the timeline, moving between sighting using the left and right arrow keys. To change categories from *Isolated* to *Cluster* sightings the up and down arrow keys. When the user moves between sightings the estimated bat count, chainage and notes are displayed in the right-hand pane.

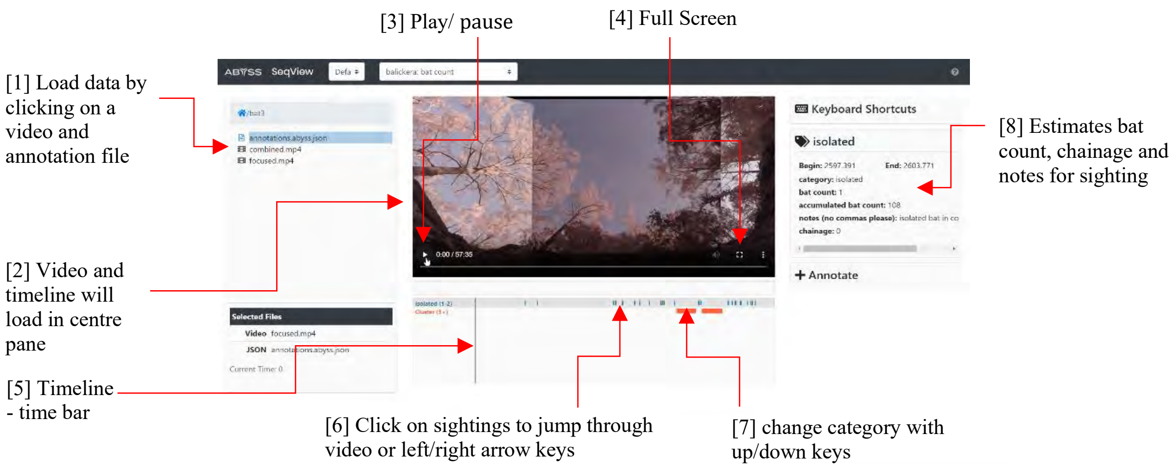



**Figure 9 Explanation of the use and layout of SeqView for reviewing video footage and analysis.**

A tabular summary of the analysis can also be obtained pressing ‘h’ on the keyboard. The user can view video segments for each entry in the table by clicking on the time stamp and playing the video in the right pane. Pressing ‘h’ again returns to the original view.

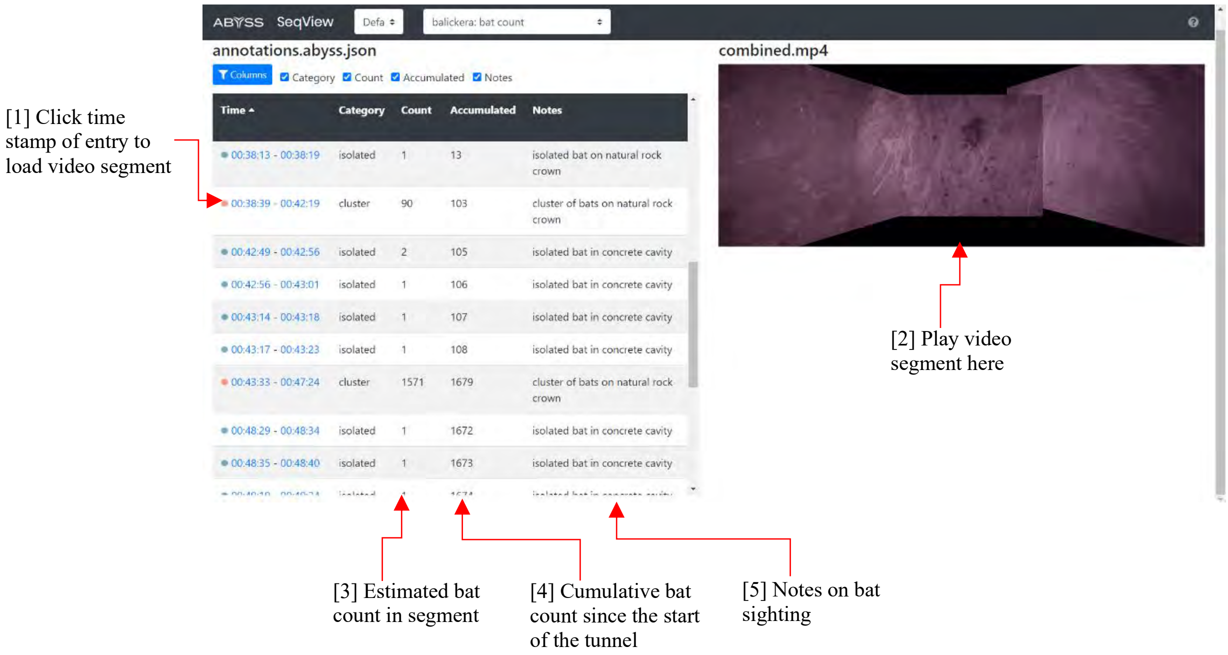



**Figure 10 Tabular summary of the bat count analysis that can be obtained by pressing ’h’ on the keyboard.**

Full resolution still imagery can also be obtained from frames in the video. The user simply pauses a particular frame, right clicks and selects frame. The user can then download images from the left, right, centre or combined view.

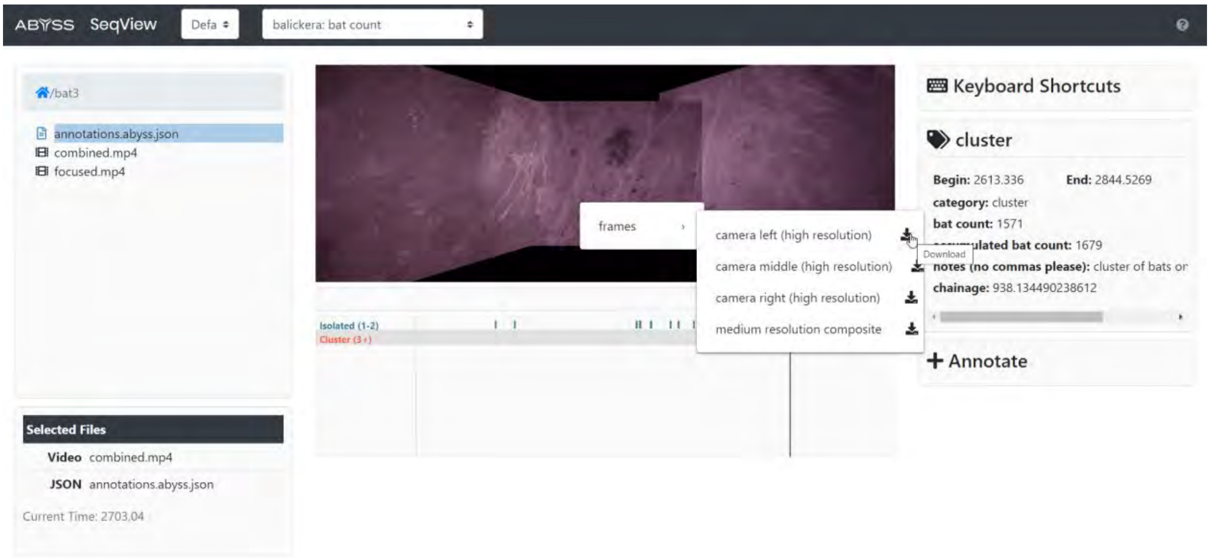
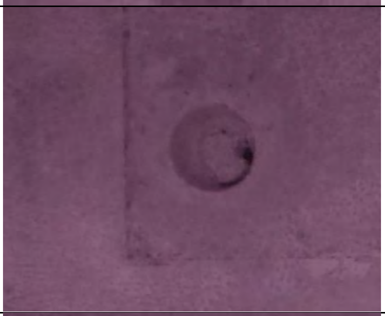
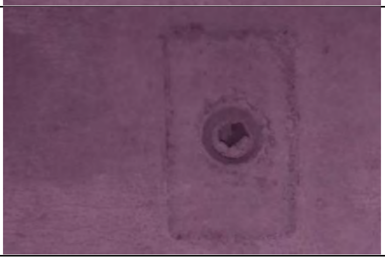


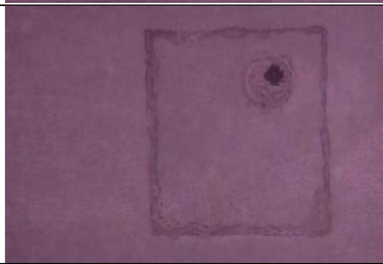
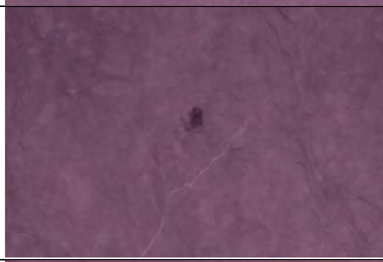

**Figure 11 Full resolution still imagery can be downloaded for any frame in the video.**

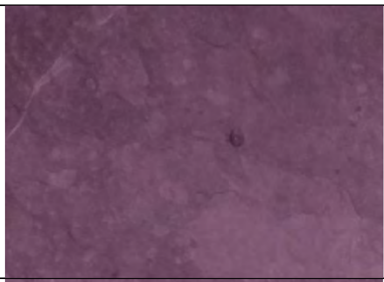
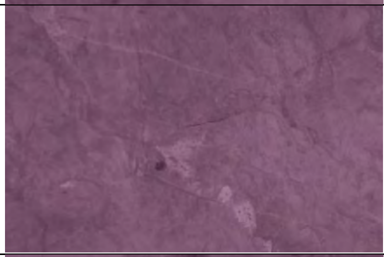
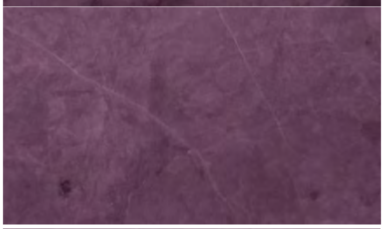
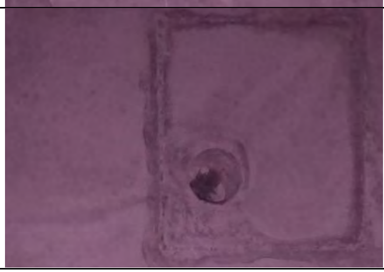
# 6 Findings

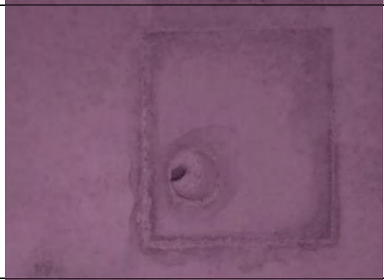
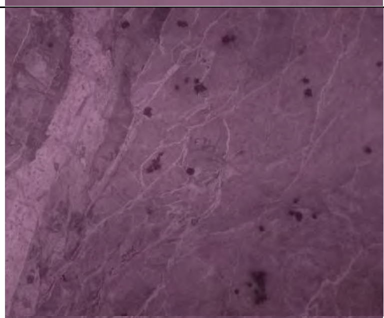
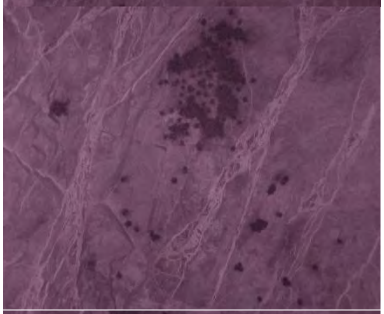
This section presents the findings of the above water inspection of the Balickera Bulk Water Transfer Tunnel. Major bat sightings are tabulated in Table 2. Each sighting is categorized as either an isolated or clustered bat sighting with start and end times in the video and chainages measured from the downstream end of the tunnel.

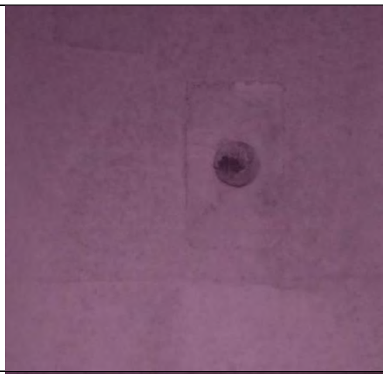
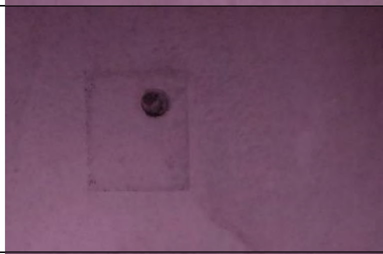
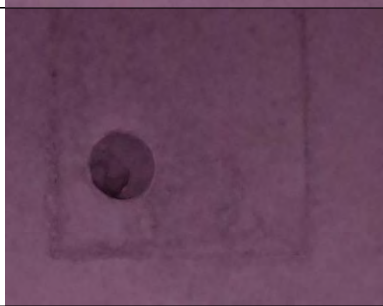
**Table 2 Summary of major bat sightings and tabulation of estimated number of bats counted.**

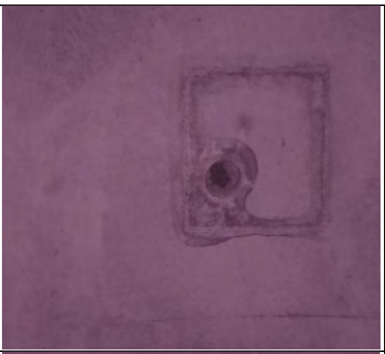
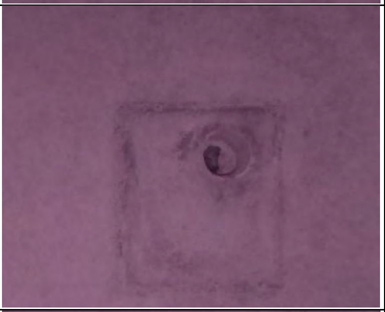
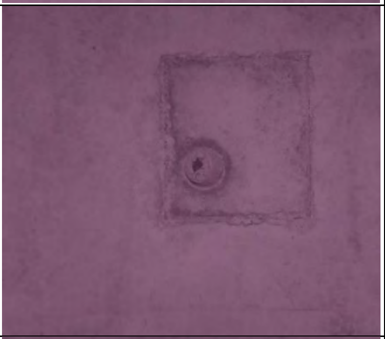
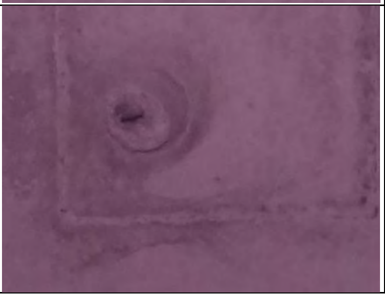
| Time | Chainage | Category | Count | Cumulative | Imagery | Notes |
|---|---|---|---|---|---|---|
| 00:09:28 - 00:09:35 | 207m | Isolated | 1 | 1 |  | Isolated bat on natural rock crown. |
| 00:11:47 - 00:11:53 | 233m | Isolated | 1 | 2 |  | Isolated bat in concrete cavity. |
| 00:26:26 - 00:26:35 | 579m | Isolated | 1 | 3 |  | Isolated bat in concrete cavity. |
| 00:26:51 - 00:26:56 | 588m | Isolated | 1 | 4 |  | Isolated bat in concrete cavity. |
| 00:26:55 - 00:27:01 | 589m | Isolated | 1 | 5 |  | Isolated bat in concrete cavity. |

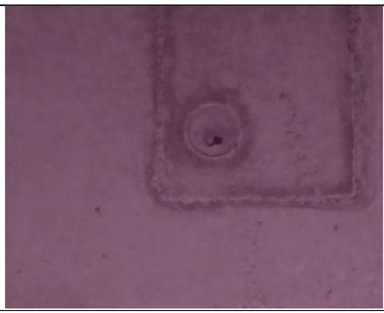
| | | | | | | |
|---|---|---|---|---|---|---|
| 00:28:10 - 00:28:19 | 616m | Isolated | 1 | 6 |  | Isolated bat on natural rock crown. |
| 00:30:32 - 00:30:39 | 668m | Isolated | 1 | 7 |  | Isolated bat in concrete cavity. |
| 00:31:29 - 00:31:37 | 690m | Isolated | 1 | 8 |  | Isolated bat in concrete cavity. |
| 00:33:22 - 00:33:27 | 731m | Isolated | 1 | 9 |  | Isolated bat in concrete cavity. |
| 00:35:36 - 00:35:42 | 780m | Isolated | 1 | 10 |  | Isolated bat on natural rock crown. |
| 00:35:54 - 00:36:00 | 787m | Isolated | 1 | 11 |  | Isolated bat on natural rock crown. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 00:36:11 - 00:36:17 | 792m | Isolated | 1 | 12 |  | Isolated bat on natural rock crown. |
| 00:38:13 - 00:38:19 | 837m | Isolated | 1 | 13 |  | Isolated bat on natural rock crown. |
| 00:38:39 - 00:42:19 | 847m - 927m | Cluster | 90 | 103 |    | Cluster of bats on natural rock crown. |
| 00:42:49 - 00:42:56 | 937m | Isolated | 2 | 105 |  | Isolated bat in concrete cavity. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 00:42:56 - 00:43:01 | 940m | Isolated | 1 | 106 |  | Isolated bat in concrete cavity. |
| 00:43:14 - 00:43:18 | 946m | Isolated | 1 | 107 |  | Isolated bat in concrete cavity. |
| 00:43:17 - 00:43:23 | 948m | Isolated | 1 | 108 |  | Isolated bat in concrete cavity. |
| 00:43:33 - 00:47:24 | 954m - 1039m | Cluster | 1571 | 1679 |    | Cluster of bats on natural rock crown. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 00:48:29 - 00:48:34 | 1062m | Isolated | 1 | 1680 |  | Isolated bat in concrete cavity. |
| 00:48:35 - 00:48:40 | 1064m | Isolated | 1 | 1681 |  | Isolated bat in concrete cavity. |
| 00:49:19 - 00:49:24 | 1080m | Isolated | 1 | 1682 |  | Isolated bat in concrete cavity. |
| 00:49:53 - 00:49:57 | 1092m | Isolated | 1 | 1683 |  | Isolated bat in concrete cavity. |
| 00:49:55 - 00:49:59 | 1093m | Isolated | 1 | 1684 |  | Isolated bat in concrete cavity. |
| 00:50:02 - 00:50:07 | 1095m | Isolated | 1 | 1685 |  | Isolated bat in concrete cavity. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 00:50:52 - 00:50:59 | 1114m | Isolated | 1 | 1686 |  | Isolated bat in concrete cavity. |
| 00:51:04 - 00:51:09 | 1118m | Isolated | 1 | 1687 |  | Isolated bat in concrete cavity. |
| 00:52:16 - 00:52:21 | 1145m | Isolated | 1 | 1688 |  | Isolated bat in concrete cavity. |
| 00:52:56 - 00:53:00 | 1159m | Isolated | 1 | 1689 |  | Isolated bat in concrete cavity. |
| 00:53:10 - 00:53:17 | 1164m | Isolated | 1 | 1690 |  | Isolated bat in concrete cavity. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 00:53:46 - 00:53:52 | 1177m | Isolated | 1 | 1691 |  | Isolated bat in concrete cavity. |

# 7 Conclusion

Abyss Solutions has successfully completed the above water inspection of the Balickera Bulk Water Transfer Tunnel using its TIP for the fifth time. High fidelity video of the tunnel crown was captured using infra-red illumination. The imagery was used to locate major sightings of bat colonies. The inspection found:

- 30 isolated bat sightings between:
    - 207-837m,
    - 937-948m, and,
    - 1062-1177m.
- 2 clustered bat sightings containing:
    - 90 bats between 847-927m, and,
    - 1571 bats between 954-1039m.

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