



W2B Sections 3 – 11 Microbat Management Plan
2019/20 Annual Monitoring Report

Pacific Complete

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Abbreviations

Abbreviation	Description
CPC	Concrete pipe culvert
DPIE	NSW Department of Planning, Industry and the Environment
ELA	Eco Logical Australia
EPA	Environmental Protection Authority
EPA&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	Commonwealth <i>Environmental Protection and Biodiversity Conservation Act 1999</i>
MCoA	Minister’s Conditions of Approval
MMP	Microbat Management Plan
NBMP	Nest Box Management Plans
PC	Pacific Complete
RCBC	Reinforced concrete box culvert
RMS	Roads and Maritime Services
SSTS	Soft soil treatment sites
W2B	Woolgoolga to Ballina

1. Introduction

1.1 Background

Eco Logical Australia Pty Ltd (ELA) was engaged by Transport for NSW (TfNSW) and Pacific Complete (PC), the delivery partner, to undertake microbat monitoring and management of relevant drainage structures and compensatory microbat habitat associated with the Woolgoolga to Ballina (W2B) Sections 3 – 11 Microbat Management Plan (MMP), prepared by GeoLINK (2015) as part of the Minister's Conditions of Approval (MCoA) for the project.

This 2019/20 Annual Monitoring Report is the second in a series of annual monitoring reports. This report covers five monitoring events representing the autumn, winter, spring and summer 2019 events and the winter 2020 event. Monitoring events were completed between 6 March 2019 and August 2020. The summer 2019 monitoring event was postponed to 23 January and 3 February 2020 due to the severe bushfire season which occurred in 2019-20 preventing access to some of the sites. The project switched to operational phase in the first quarter of 2020 triggering a change in the frequency of monitoring events from quarterly to twice per year in winter and summer for the remainder of the post construction monitoring period. Incorporation of the winter 2020 monitoring event was important to allow for an evaluation of the status of newly created structures containing permanent microbat habitat. The construction of some of the newly created structures containing permanent microbat habitat had not been completed by the end of the construction monitoring period in February 2020.

This report provides an overview of the Woolgoolga to Ballina (W2B) road project and microbat management completed to date, before presenting the methods and results of the 2019-20 monitoring events. The discussion and recommendations in this report are based on information gathered from field investigations and monitoring events. This report aims to inform future microbat monitoring and management within the W2B project, as well as future TfNSW projects involving impacts to microbat habitat, exclusion of microbats and provision of alternative microbat habitat.

1.2 W2B road project

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham, NSW and the Queensland border. This report relates to one component of this Program, namely Sections 3 – 11 of the W2B Highway upgrade project. The W2B project was approved under the NSW *Environmental Planning and Assessment Act 1979* (EPA&A) on 24 June 2014 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 14 August 2014.

The W2B project extends over approximately 155 kilometres (km) from approximately 6 km north of Woolgoolga to approximately 6 km south of Ballina, NSW. The W2B project is divided into 11 sections, with the MMP (GeoLINK 2015b) and this report relating to Sections 3 to 11 (Figure 1 to Figure 11).

Throughout the monitoring period (2019 – winter 2020), the W2B project transitioned from a construction phase to the operational phase.

1.3 Stakeholders and consultation

In compiling this report, a number of key stakeholders have provided advice and comment including:

1. Transport for NSW – responsible for implementing measures in the MMP. ELA have had several meetings with the TfNSW W2B Environmental Officer responsible for ecological monitoring over the duration of the project, and regular contact with the TfNSW Environmental Officer responsible for overseeing the W2B project to discuss issues as they arise, advise on progress and agree upon the approach to actions outlined in the MMP. ELA regularly liaised with the TfNSW Environmental Officer during evaluation of permanent microbat habitat and in the design and installation of replacement microbat habitat where the newly constructed structures were lacking.
2. PC – as the delivery partner responsible for ensuring the W2B project is delivered according to MCoA and contract specifications. ELA consulted with the relevant PC Environmental Officer for each Section at least four times a year during the construction phase and at least twice per year during the operation phase, prior to implementing monitoring of MMP structures. ELA also attended meetings with PC Environmental Officers in the early stages of the project prior to installation of compensatory habitat, provided advice when required, advised on progress throughout each year and discussed issues as they have arisen over the lifetime of the project.
3. Environmental Protection Authority (EPA) – In implementing the MMP, ELA have had several discussions and meetings with Senior Threatened Species Officers from the EPA and TfNSW representatives in regard to the design and installation of alternative microbat habitat required in the vicinity of Section 4 and 5 at Maclean Cut and Section 3A at Glenugie.

1.4 Purpose

This report aims to:

- Outline mitigation measures implemented and actions from the MMP undertaken by ELA during construction to the end of 2019 and into the operational phase of the project up to winter 2020.
- Determine the effectiveness of temporary, alternative habitat installed as a compensatory mechanism, and permanent microbat habitat installed during construction to minimise the impacts to microbats from the loss of medium and high conservation value drainage structures.
- Provide useful information on reproductive status, age class and therefore dynamics and survival of local populations of target threatened microbat species throughout and post-construction.
- Provide results and discussion of the 2019-20 monitoring of drainage structures and alternative habitat identified in the MMP and as well as any additional structures that were identified after production of the MMP, but which are also subject to the provisions of the MMP. Details of additional structures are provided in Section 2.5 below.

This report does not provide results of microbat occupation of bat boxes installed as part of the W2B Nest Box project. Any microbat boxes installed as a requirement of the Nest Box Management Plans (NBMP) for each Section of W2B will be monitored and reported on separately.

2. Overview of microbat management Sections 3 – 11, W2B

2.1 Key elements in the development of the MMP

Key documents in the approvals process for management of threatened microbats and their habitat as part of the W2B Sections 3-11 project are as follows:

- Environmental Impact Statement (Roads and Maritime Services (RMS) 2012)
- Threatened Mammal Management Plan (RMS 2013) –triggered requirement for Project Specific MMP
- Woolgoolga to Ballina Pacific Highway Upgrade Targeted Microbat Surveys, Sections 3 – 11 (GeoLINK 2015a)
- Microbat Management Plan (GeoLINK 2015b)

Key approval dates for the W2B project are as follows:

- Approval under the NSW EPA&A Act on 24 June 2014.
- Approval under the Commonwealth EPBC Act on 14 August 2014.

Key survey dates in the development of the MMP:

- Survey of drainage structures within Sections 4 and 5 undertaken by GeoLINK November 2013 / February 2014 (as part of Sections 4 and 5 soft soil treatment site (SSTS) surveys).
- Survey of 119 drainage structures within Sections 3 – 11, undertaken by GeoLINK in July 2014.
- Re-survey of 62 drainage structures identified as being of high, medium or low conservation value for microbat habitat within Sections 3 – 11, undertaken by GeoLINK in October - November 2014.
- Re-survey of 39 drainage structures identified as being of high, medium or low conservation value as microbat habitat within Sections 3 – 11 undertaken by GeoLINK in February 2015 coinciding with the second Southern Myotis breeding event of the breeding season.

2.2 Microbat Management Plan

In accordance with Section 5.3.5 of the W2B Threatened Mammal Management Plan (RMS 2013), the results from surveys of drainage structures triggered the requirement for a Project Specific Bat Management Plan. Consequently, the *Woolgoolga to Ballina Microbat Management Plan Sections 3-11* (GeoLINK 2015b), herein referred to as the MMP, was prepared.

The objectives of the MMP are to:

- reduce potential for injury or death to microbats
- provide temporary alternative habitat for excluded microbats
- provide permanent replacement habitat for microbats.

Consequently, the MMP includes the following information:

- provision of artificial roosting structures, including designs, numbers required, locations and timing of installation
- timing of construction works
- timing of monitoring
- exclusion procedures (techniques and management) prior to demolition work
- monitoring procedures; pre, during and post-construction
- specifications for the creation of permanent cave-dwelling roosting habitat.
- provisions for delivery of environmental inductions to construction and contract staff.
- requirements for pre-works microbat inspections and works supervision prior to, during and following structure demolition or extension.
- contingency measures for unexpected finds, the capture and release of healthy microbats and management of injured or dead microbats.
- reporting requirements.
- corrective actions and performance measures.

The original MMP applies to pre, during and post-construction phases of the W2B project and included eleven drainage structures within Sections 4 - 7 and Section 10. During the detailed design phase of the project after production of the MMP, nine additional drainage structures located in Section 3A, Section 4, Section 5 and Devil's Pulpit were identified as having medium to high conservation habitat value for microbats and, as such also became subject to the provisions of the MMP (ELA, 2020). Details of when these additional structures were identified and became subject to the provisions of the MMP appear in Table 3 and Table 5.

Figure 1 to Figure 11 shows the mapped locations of bat boxes and drainage structures based on data sourced within the original MMP (GeoLINK 2015b) (labelled as either MMP – Removed or MMP - Retained), structures added to the MMP after it was prepared (labelled as either Additional – Removed or Additional – Retained) and newly constructed features (labelled as New constructions). Figure 1 to Figure 11 were prepared by TfNSW using data points for the drainage structures provided by ELA so that the satellite imagery showing the newly constructed alignment could be included.



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WOOLGOOLGA TO BALLINA - SECTION 3 GLENUGIE LINK

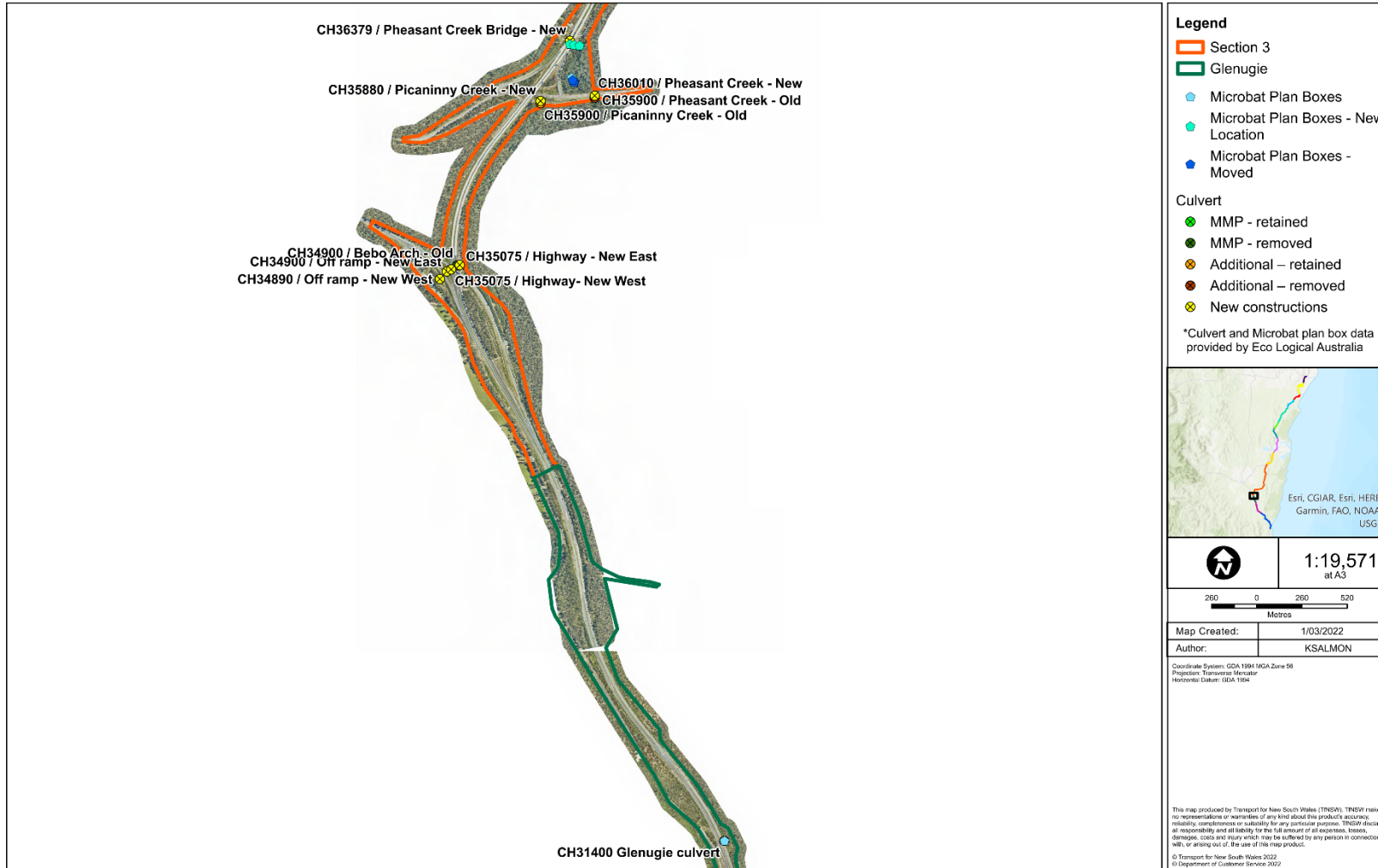


Figure 1: Section 3A Glenugie Link Microbat Monitoring Plan, subject drainage structures and bat box locations.

WOOLGOOLGA TO BALLINA - SECTION 4



Figure 2: Section 4 Greenhill culvert Microbat Management Plan, subject drainage structure and bat box location.



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WOOLGOOLGA TO BALLINA - SECTION 4/5



Legend

- Section 4
- Section 5
- Microbat Plan Boxes - New Location
- Microbat Plan Boxes - Moved

Culvert

- MMP - retained
- MMP - removed
- Additional – retained
- Additional – removed
- New constructions

*Culvert and Microbat plan box data provided by Eco Logical Australia

Esri, HERE, Garmin, FAO, NOAA, USGS, Esri, USGS

1:3,165
at A3

40 0 40 80
Metres

Map Created:	1/03/2022
Author:	KSALMON

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Horizontal Datum: GDA 1994

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Figure 3: Section 4 / 5 Maclean Cut south Microbat Monitoring Plan, subject drainage structures and bat box locations.



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WOOLGOOLGA TO BALLINA - SECTION 5 MACLEAN CUT NORTH



Figure 4: Section 5 Maclean Cut north Microbat Monitoring Plan, subject drainage structures and bat box locations.



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WOOLGOOLGA TO BALLINA - SECTION 5 MORORO BRIDGE



Figure 5: Section 5 Mororo Bridge Microbat Monitoring Plan, subject drainage structures and bat box locations.

WOOLGOOLGA TO BALLINA - SECTION 5 SERPENTINE CREEK



Figure 6: Section 5 Serpentine Creek Microbat Monitoring Plan, subject drainage structures and bat box locations.

WOOLGOOLGA TO BALLINA - SECTION 6 TABBIMBLE CREEK



Figure 7: Section 6 Tabbimble Creek Bridge Microbat Monitoring Plan, subject drainage structures and bat box locations.



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WOOLGOOLGA TO BALLINA - SECTION 6 TABBIMBLE CREEK OVERFLOW

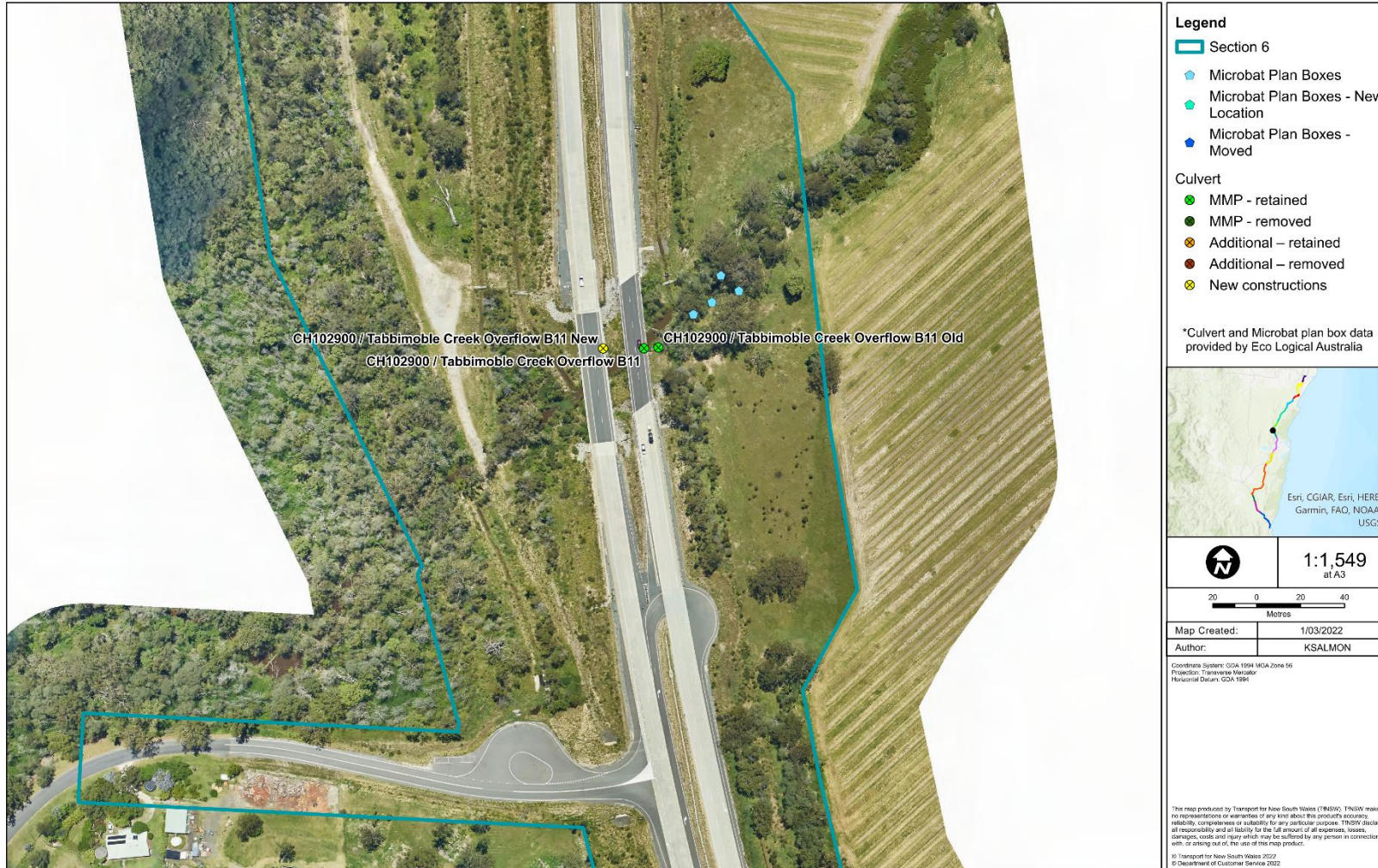


Figure 8: Section 6 Tabbimble Creek Overflow Bridge Microbat Monitoring Plan, subject drainage structures and bat box locations.



Figure 9: Devil’s Pulpit section Microbat Monitoring Plan, subject drainage structures and bat box locations.



Figure 10: Section 7 Oakey Creek Microbat Monitoring Plan, subject drainage structure and bat box location.



Figure 11: Section 10 Saltwater Creek Microbat Monitoring Plan, subject drainage structure location.

2.3 Subject microbat species

There are four subject microbat species identified in the MMP that are listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act), and in the case of the *Chalinolobus dwyeri* (Large-eared Pied Bat) also listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Table 1(GeoLINK 2015b) outlines the conservation status of each species and provides details of their known records in relation to the W2B project, following surveys undertaken by GeoLINK during preparation of the MMP. The Large-eared Pied Bat has not been recorded on site and is considered to be a vagrant that may only ever temporarily utilise structures along the W2B alignment. There are no specific mitigation measures that were required to be implemented for this species and it is considered that the mitigation measures applied would adequately protect this species from impacts associated with the W2B project.

Myotis macropus (Southern Myotis) is the only one of the four species known to use drainage structures as maternity roosting habitat. There are several known maternity colonies located along the W2B project alignment. The largest permanently occupied Southern Myotis roosting site that will not be removed or extended is located within four bat boxes installed under the existing south-bound lane of Mororo Bridge, located over the Clarence River (Figure 5). Another important Southern Myotis roost site that was scheduled for removal was located at Picaninny Creek on Eight Mile Lane at Glenugie (Figure 1). This structure was a culvert not identified in the original MMP but became subject to the provisions of the MMP once it was identified as a Southern Myotis maternity roost site in January 2018 (ELA 2018a). An adjacent culvert on Pheasants Creek, Eight Mile Lane (Figure 1) was also identified as roosting habitat for Southern Myotis in January 2018, was required to be removed and also became subject to the provisions of the MMP (ELA 2018a).

Miniopterus australis (Little Bent-winged Bat) and *Miniopterus orianae oceanensis* (Large Bent-winged Bat) are known from several locations along the W2B highway alignment. Both species tend to form large over-wintering colonies numbering in the hundreds to thousands of individuals within various structures along the Pacific Highway between Halfway Creek and Woodburn, and are present on-site between February / March and September each year. Two key over-wintering roosts for Bent-winged Bats that were not be removed or extended within Sections 3-11 of the W2B project are the bridges over Tabbimoble Creek located in Section 6 (Figure 7 and Figure 8).

Several other key Bent-winged Bat over-wintering roosts that were required to be removed were located within the Bebo Arch in the vicinity of the Glenugie Link (Figure 1) at the southern end of Section 3 (not identified in the original MMP but subject to the provisions of the MMP upon identification in February 2018), and multiple culverts at Maclean cut (Figure 3 and Figure 4). Whilst two of the larger known Bent-winged Bat roost sites at Maclean cut were identified in the MMP, there were five additional culverts that were identified in 2017 (BGC Contracting 2017, GeoLINK 2018a) as having medium to high conservation value or had low conservation value but were in close proximity to high conservation value habitat and therefore became subject to the provisions of the MMP.

Table 1: W2B Subject microbat species, conservation status, roosting requirements and species records

Scientific Name	Common Name	BC Act	EPBC Act	Roosting habitat	Project records
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	Typically requires sandstone escarpments (or occasionally volcanic rock types) to provide roosting habitat that is adjacent to higher fertility sites that are used for foraging. Roosting has also been observed in disused mine shafts, caves, overhangs and disused Fairy Martin (<i>Hirundo ariel</i>) nests. It also possibly roosts in the hollows of trees. The structure of primary nursery roosts appears to be very specific, i.e. Arch caves with dome roofs with indentations (DoE 2014).	Not recorded. However, one record occurs within a 10 km radius of the Project footprint (RMS 2012).
<i>Miniopterus australis</i>	Little Bent-winged Bat	V		Caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings are the preferred roosting habitats (OEH 2012). Maternity colonies are restricted to specific maternity caves (predominantly limestone) (Van Dyck and Strahan 2008). Only five nursery sites /maternity colonies are known in Australia (OEH 2012).	Known. One Little Bent-winged Bat was observed roosting in a lifting point of drainage structure 506006 in Section 4 (SSTS) in July 2014. 262 Little Bent-winged Bats were observed roosting in 17 groups between the jointing gaps of a RCPC in Section 4 in July 2014. 72 Little Bent-winged Bats were also observed roosting between the jointing gaps of a RCPC in Section 5 in July 2014. 553 Little bent-winged Bats were observed roosting in 24 groups between the jointing gaps of the concrete planks of Tabbimoble Creek Bridge (BN7555) in July 2014. 166 Little Bent-winged Bats were observed roosting in 11 groups between the jointing gaps of the concrete planks of Tabbimoble overflow (BN7532). No maternity

Scientific Name	Common Name	BC Act	EPBC Act	Roosting habitat	Project records
					roost sites are known or likely within the Project footprint. 221 records within a 10 km radius of the site (RMS, 2012).
<i>Miniopterus orianae oceanensis</i> (previously known as <i>Miniopterus schreibersii</i>)	Large (Eastern) Bent-winged Bat	V		Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures (OEH 2012, Van Dyck and Strahan 2008).	Known. 131 Large Bent-winged Bats were observed roosting between the jointing gaps of the New Serpentine Creek Bridge in July 2014. 40 Large Bent-winged Bats were observed roosting on rough concrete and in the expansion joints of the Old Serpentine Creek Bridge in July 2014. Individual Large Bent-winged Bats were also observed at Tabbimoble Overflow (BN7532), Saltwater Creek Bridge (BN2167) and the adjacent RCPC on Saltwater Creek (506170) in Section 10 in July 2014. However, no maternity roost sites are known or likely within the Project footprint. 20 records within a 10 km radius of the site (RMS, 2012).
<i>Myotis macropus</i>	Southern (Large-footed) Myotis	V		This species prefers caves, mines, tree hollows, aqueduct tunnels and under bridges/culverts and in dense vegetation (the latter in the tropics) in the vicinity of bodies of slow-flowing or still water (Van Dyck and Strahan 2008). Forages over streams and pools catching insects and small fish by raking their feet across the water surface (OEH 2012).	Known. This species has been recorded from a number of locations within Sections 5, 6 and 7 within the project footprint during GeoLINK surveys in 2014 and 2015. Maternity roost sites located in Section 3A on Picaninny Creek and Pheasants Creek by ELA in 2018. 29 records within a 10 km radius of the site (RMS 2012).

2.4 Subject drainage structures

Drainage structures such as bridges and culverts are known to provide roosting habitat for the four threatened subject microbat species described in **Section 2.3**, along with numerous other non-threatened microbat species. The W2B project required removal, extension or disturbance to existing drainage structures along the alignment. The existing structures have different characteristics and habitat suitability. The drainage structures along the W2B alignment were categorised as being of high, medium or low conservation value as microbat habitat following surveys undertaken by GeoLINK in 2014 and 2015 (Table 2). Placement of drainage structures into each of the three categories was dependent upon historical records of occupation, survey results, availability of roosting space within each structure, microbat species presence or evidence of use by microbats. Table 2 details the criteria used to assign drainage structures to each category and is reproduced from Table 1.3 of the MMP (GeoLINK 2015b).

Table 2: Categories of conservation value microbat habitat and criteria used to assign drainage structures to each category

Conservation / Habitat Value	Criteria
High	<p>Known to provide breeding habitat for threatened species (i.e. Southern Myotis) OR;</p> <p>Known to provide non-breeding roosting habitat for large numbers (i.e. >50) of threatened species (e.g. known to support large numbers of Bent-winged Bats over-winter); OR</p> <p>Supports one or more of the Federally listed Large-eared Pied Bat.</p>
Medium	<p>Does not satisfy high conservation / habitat value category;</p> <p>Provides non-breeding roosting habitat for small numbers (i.e. <50) of threatened species; OR</p> <p>Medium to large guano accumulations and / or stains present indicative of the occurrence of moderate numbers of microbats or medium to long-term usage (threatened / non-threatened status unknown); OR</p> <p>Potentially suitable for breeding Southern Myotis. For example, access under bridge / into culvert >500 mm diameter, presence of large cavities (e.g. >20 mm wide and >100 mm deep), directly adjacent to/ over open water, low inundation susceptibility; OR</p> <p>Supports protected cavities providing good potential long term roosting habitat; however, no bats or evidence of roosting bats present; AND/OR</p> <p>In proximity to open surface water, however provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete), offering limited potential for breeding roosting; AND/OR</p> <p>Supports a breeding colony of non-threatened microbats.</p>
Low	<p>Does not satisfy high or medium conservation/ habitat value categories; AND</p> <p>Individual microbats or very small numbers of non-breeding microbats (e.g. <5) present; OR</p> <p>Small guano accumulations and/ or stains present indicative of the occurrence of small numbers of microbats or short-term usage; OR</p> <p>Provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete) offering limited potential for use as breeding habitat; OR</p> <p>Not in proximity to open water.</p> <p>Roosting habitat of similar value locally is common and would be duplicated by culverts and bridges on the new highway upgrade.</p>

Drainage structures categorised as being of medium or high conservation value as microbat habitat were considered to be the subject drainage structures for the purposes of the MMP and specific mitigation measures and management actions are associated with each of these structures. Low conservation value structures were considered to be locally common and/or would be duplicated by culverts and bridges constructed as part of the new highway (GeoLINK 2015b).

Of the 11 subject drainage structures identified in the original MMP, seven high value and four medium value structures were identified (Table 3). However, at the time of production of the MMP only three of the 11 subject drainage structures were expected to be impacted by W2B construction works through either removal or extension. The remaining eight structures were expected to be retained and would serve as control sites for comparison with impacted sites throughout the monitoring period. At the time of the MMP's preparation detailed designs for the Project had not been completed. In addition, two of the control structures identified in the original MMP actually comprised two separate structures each; Tabbimoble Creek Bridge included the two-lane Old Pacific Highway Bridge as well as the existing two-lane Pacific Highway Bridge (Figure 7) and the same applied to Tabbimoble Creek Overflow Bridge (Figure 8). Effectively there were then 13 subject drainage structures, ten of which would be retained as control sites and three that were impacted.

2.5 Additional drainage structures

Once detailed designs for the W2B project were finalised, several changes to the status of the subject drainage structures were required. Pre-clearing surveys and surveys conducted on new impact areas resulting from project design changes during 2017 and 2018 identified nine additional drainage structures of high or medium conservation value, or of low value but in close proximity to high conservation value structures as microbat habitat which required management under the provisions of the MMP. One structure originally identified as a control site; Devil's Pulpit CH 106190 (Figure 9) became an impact site (GeoLINK 2018c). Seven structures would be retained to act as control sites.

Five of the additional structures were identified during pre-clearing surveys conducted in Sections 4 and 5 in the vicinity of Maclean cut during 2017 (BGC Contracting 2017, GeoLINK 2018a). The pre-clearing reports recommended including these additional culverts and elevating the conservation / habitat value of two other culverts in this area from low to medium because evidence of microbat occupation was found where there had been none previously. Some culverts from the Maclean cut area categorised as low value were recommended to be included in the list of subject drainage structures. The reason for including these low conservation / habitat value structures was because of their proximity to medium to high conservation / habitat value structures and the risk of microbats relocating into them following exclusion from the medium or high conservation / habitat value structures.

Three structures not previously surveyed in the Glenugie Link section were identified as high conservation / habitat value following targeted microbat surveys triggered by design changes in that area (ELA 2018a, GeoLINK 2018b).

The final additional structure to be included in the Plan was a fauna underpass in the Devil's Pulpit tie-in Section at CH 106190. Although not previously listed as medium or high conservation value microbat habitat, ELA recommended inclusion of this structure because of its proximity to a subject drainage structure listed as medium value that will be extended or removed as part of the Project. The additional

structure is a fauna underpass and contained potential microbat roosting sites. There was a risk of microbats relocating to this structure following exclusion from the adjacent medium value structure.

Upon identification of these additional structures, a work program was developed in consultation with PC, EPA, W2B Environmental Representative and TfNSW to identify the quantity and quality of alternative roosting habitat required to be provided temporarily during construction and permanently within the newly created structures, critical timing of exclusion device installation, and monitoring requirements. The status of several the structures identified in the original MMP were also changed from non-impacted to impacted following the detailed design phase of the project which post-dated preparation of the original MMP. The full suite of management measures and recommendations included in the MMP for the original 13 subject drainage structures also applied to the nine additional structures from the date they were identified.

As construction has been completed, several newly created structures were identified as potential receptor sites for the creation of permanent bat habitat and are also subject to MMP monitoring and management measures. The complete list of all structures requiring management and monitoring, including the 13 structures identified in the original MMP, 9 additional structures, 2 existing non-impacted structures that became receptor sites for bat boxes and 22 newly created structures is included as Table 3. There were 13 impact sites and nine control sites. Microbat exclusion occurred at 11 of the 13 impact sites, with the remaining two impact sites not excluded prior to removal. The Bebo Arch in Section 3A Glenugie tie-in was removed during summer 2019 when no Bent-winged Bats were present. There were extenuating circumstances that prevented exclusion of Oakey Creek prior to removal relating to the high-water levels present and the difficulty of keeping any exclusion devices secure and functional. The risk of Oakey Creek being inhabited was very low and a pre-clearance inspection was undertaken prior to demolition with no bats present prior to removal of the structure.

Table 3: Subject drainage structures requiring mitigation and management as part of the W2B 3-11 MMP (includes additional structures and newly created structures and includes new locations for temporary boxes moved into permanent structures).

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed	
	2	31400	N	Glenugie Culvert	Bent-winged Bat Box	Existing - not impacted	High	N/A	Y - Bent-winged Bat Box (with capacity for 2000 bats) installed March 2019 as compensatory habitat for loss of Bebo Arch at CH 34900	1	N	Exclusion required	not
A	Glenugie Link	34900	N	Bebo Arch at southern end of Glenugie Link	Bebo	Remove	High	Impact	N - Bent-winged Bat Box (with capacity for 2000 bats) installed in culvert at CH 31400 March 2019 as compensatory habitat.	0	Y	Not undertaken, demolition during off season February 2019	
A	Glenugie Link	35075	N	Glenugie Link culverts	RCBC	Newly constructed	High	N/A	N	0	N	Exclusion required	not
A	Glenugie Link	35880	N	Picaninny Creek, Eight Mile Lane	RCBC	Newly constructed	Med	N/A	N	0	N	Exclusion required	not
A	Glenugie Link	35900	N	Pheasant Creek, Eight Mile Lane	CPC	Remove	High	Impact	Y - Installed 1 box in a tree March 2018, relocated to Pheasants Creek Bridge June 2021.	1	Y	Internally Jun-18, culvert left open as flyway for Southern Myotis	

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed
A	Glenugie Link	35900	N	Picaninny Creek, Eight Mile Lane	CPC	Remove	High	Impact	Y - Installed 2 boxes in a tree March 2018, relocated to Pheasants Creek Bridge June 2021.	2	Y	Jun-18
A	Glenugie Link	36010	N	Pheasant Creek, Eight Mile Lane	CPC	Newly constructed	High	N/A	N	0	N	Exclusion not required
A	Glenugie Link	36379	N	Pheasants Creek Bridge	Bridge	Newly constructed	High	N/A	Y - 3 boxes relocated from trees, installed June 2021	3	N	Exclusion not required
A	4	76450	N	Greenhill	RCBC	Newly constructed	High	N/A	Y - Bent-winged Bat Box (with capacity for 650 bats) installed in culvert at CH 76400 June 2021 as compensatory habitat for loss of Maclean cut culverts	1	N	Exclusion not required
A	4	75560	N	Greenhill	RCBC	Newly constructed	Med	N/A	N	0	N	Exclusion not required
A	4	81440	N	North of Jubilee Street overbridge	CPC	Newly constructed	Low	N/A	N	0	N	Exclusion not required
A	4	81600	N	North of Jubilee Street overbridge,	CPC	Remove	Low	Impact	N	0	Y	Mar-18

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed
				fauna underpass								
A	4	81645	N	North of Jubilee Street overbridge	CPC 1200 mm	Newly constructed	Low	N/A	N	0	N	Exclusion not required
A	4	81650	N	North of Jubilee Street overbridge	CPC 750mm	Remove	Low	Impact	N	0	Y	Mar-18
A	4	81770	N	North of Jubilee Street overbridge	CPC 2 x 600mm	Newly constructed	Low	N/A	N	0	Y	Mar-19
A	4	81825	N	North of Jubilee Street overbridge	CPC 1000mm	Newly constructed	Low	N/A	N	0	Y	Mar-19
A	4	81825	N	North of Jubilee Street overbridge, CH 81860	CPC 1200mm	Remove	Medium (changed from Low)	Impact	Y - Installed 4 boxes in trees February 2018 (including 2 Hebel)	4	Y	Internally Sept 2017, externally March 2018
A	4	81980	N	North of Jubilee Street overbridge	RCBC / Fauna underpass	Remove	Low	Impact	N	0	Y	Internally Sept 2017, externally March 2018
A	4	82020	Y	North of Jubilee Street overbridge	CPC 1200mm	Remove	High	Impact	Y - Installed 4 boxes in trees September 2017 (including 2 Hebel)	4	Y	Internally Sept 2017, externally March 2018
A	4	82030	N	North of Jubilee Street overbridge	CPC 1200mm	Newly constructed	High	N/A	N – Inadequate capacity for <i>Miniopterus</i> spp. (<650 bats), despite	0	Y	Mar-19

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed
									consistent evidence of use (guano). Bent-winged Bat Box (with capacity for 650 bats) installed in culvert at CH 76400 June 2021.			
B	5	82300	Y	North of Jubilee Street overbridge	CPC 1500mm	Remove	High	Impact	Y-Installed 2 boxes in trees September 2017 (including 1 Hebel)	2	Y	Internally Sept 2017, externally March 2018
A	4	82330	N	North of Jubilee Street overbridge	CPC 1350mm	Newly constructed	High	N/A	N – Inadequate capacity for <i>Miniopterus</i> spp. (<650 bats), despite consistent evidence of use (guano). Bent-winged Bat Box (with capacity for 650 bats) installed in culvert at CH 76400 June 2021.	0	Y	Mar-19
A	4	82610	N	North of Jubilee Street overbridge	CPC 2 x 600mm	Newly constructed	Low	N/A	N	0	Y	Mar-19
A	4	82740	N	North of Jubilee Street overbridge	CPC 675mm	Newly constructed	Low	N/A	N	0	Y	Mar-19

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed	
B	5	82860	N	North of Jubilee Street overbridge	CPC 750mm	Newly constructed	Low	N/A	N	0	Y	Mar-19	
B	5	82860	N	North of Jubilee Street overbridge	RCBC 2200 x 2200mm	Remove	Medium (changed from Low)	Impact	N	0	Y	Mar-18	
B	5	82970	N	North of Jubilee Street overbridge	CPC 900mm	Newly constructed	Low	N/A	N	0	Y	Mar-19	
B	5	89370	Y	Old Serpentine Channel Bridge	Concrete bridge cast in situ	Retain	High	Control	2 boxes previously installed by GeoLINK 2015	2	N	Exclusion required	not
B	5	89400	Y	Serpentine Channel Bridge southbound	PPLNK	Retain	High	Control	4 boxes previously installed by GeoLINK 2015	4	N	Exclusion required	not
B	5	89400		New Serpentine Channel Bridge northbound	Bridge	Newly constructed	Medium	N/A	N	0		Exclusion required	not
B	5	94090	Y	Old Mororo Bridge (was northbound)	STRUS	Retain	High	Control	N	0	N	Exclusion required	not
B	5	94090	Y	Mororo Bridge southbound (now northbound)	PTROG	Retain	High	Control	4 boxes previously installed by GeoLINK 2013	4	N	Exclusion required	not

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed	
B	5	94090	N	Mororo Bridge new (southbound)	Bridge	Newly constructed	Medium	N/A	N	0	N	Exclusion required	not required
B	6	101610	Y	Old Tabbimoble Creek Bridge		Retain	High	Control	N	0	N	Exclusion required	not required
B	6	101610	Y	Tabbimoble Creek Bridge southbound	PPLNK	Retain	High	Control	Y - 8 boxes installed in trees as a precautionary measure due to nearby works February 2017	8	N	Exclusion required	not required
B	6	101610	N	Tabbimoble Creek Bridge northbound	Bridge	Newly constructed	Medium	N/A	N	0	N	Exclusion required	not required
B	6	102900	Y	Old Tabbimoble Overflow Bridge		Retain	High	Control	N	0	N	Exclusion required	not required
B	6	102900	Y	Tabbimoble Overflow Bridge southbound	PPLNK	Retain	High	Control	Y - 4 boxes installed in trees as a precautionary measure due to nearby works February 2017	4	N	Exclusion required	not required
B	6	102900	N	New Tabbimoble Overflow	Bridge	Newly constructed	Medium	N/A	N	0	N	Exclusion required	not required

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed
				Bridge northbound								
	Devil's Pulpit	106170	Y	62.14km south of Ballina, south of Pine Rd	CPC	Extend or remove	Medium	Impact	N - Installed 1 box in adjacent culvert at CH 106230 April 2018.	1	Y	May-18
	Devil's Pulpit	106185	N	New fauna underpass box culvert northbound	RCBC	Newly constructed	High	N/A	N	0	N	Exclusion not required
	Devil's Pulpit	106190	N	Fauna underpass box culvert	RCBC / Fauna underpass	Extend or remove	Medium (ELA)	Impact	N	0	Y	May-18
	Devil's Pulpit	106230	N	Box culvert south bound	RCBC	Existing - not impacted	Medium	N/A	Y - Installed 1 box in culvert as compensatory habitat for loss of culvert at CH 106170 in April 2018	1	N	Exclusion not required
C	7	122190	N	New Oakey Flat culvert	RCBC	Newly constructed	Low	N/A	N	0	N	Exclusion not required
C	7	122280	Y	Oakey Flat # 3 Oakey Creek	RCBC	Remove	Medium	Impact	N - Installed 1 box in a tree November 2016, relocated to culvert at CH 122270 June 2021	1	Y	Not undertaken, low risk of microbat habitation, safety risk to install exclusion devices, letter of justification to RMS

Portion	Section	Chainage	MMP	Location	Feature Type	Construction Action	Conservation Value	Control or Impact	Box installation required	No. of boxes	Exclusion required	Exclusion completed
C	7	122280	N	New Oakey Flat # 3 Oakey Creek	RCBC	Newly constructed	High	N/A	Y - 1 box relocated from tree to culvert June 2021	1	N	Exclusion required not
C	7	122550	N	New Oakey Creek overflow	RCBC	Newly constructed	Low	N/A	N	0	N	Exclusion required not
D	10	157400	Y	Saltwater Creek, south of Coolgardie Road	RCBC	Retain	Medium	Control	N	0	N	Exclusion required not

N/A Structure not part of original MMP, existing or newly constructed.

2.6 Compensatory habitat installation

2.6.1 Temporary habitat

There was a requirement to create temporary replacement microbat roosting habitat prior to commencement of construction and permanent cave-dwelling roost habitat within new culverts and bridges during the construction period, and once construction was complete. The MMP sets out specifications for design, installation, location and monitoring of the temporary and permanent microbat habitat.

Temporary replacement habitat included the installation of a range of bat boxes and box types within vegetation or non-impacted culverts (depending upon the microbat species involved) adjacent to the impacted drainage structures. The number and size of bat boxes to be installed at each location was specified in the MMP and calculated to include a 15% increase on the maximum number of microbats observed at each location. Table 3 and Figure 1 - Figure 11 outline the locations and numbers of bat boxes that were installed at or adjacent to each drainage structure, as well as the months of installation for each of those boxes.

Southern Myotis is known to inhabit a range of bat box types, installed both under bridges and culverts or within trees adjacent to permanent water bodies. Little Bent-winged Bats and Large Bent-winged Bats have never been recorded using bat boxes attached to trees, and only in small numbers or individually in boxes beneath bridges and culverts.

Ten bat boxes that form part of the control sites in the MMP were installed at Serpentine Creek (six boxes installed in March 2015 as part of a separate project) and Mororo Bridge (four boxes installed in 2013 as part of a separate project) prior to the commencement of the W2B highway upgrade project by GeoLINK. Subsequently, and based on the MMP, pre-clearing survey reports and ELA calculations, a further 28 bat boxes were installed as temporary replacement habitat by ELA at sites spread between Glenugie and Oakey Creek (Table 3 and Figure 1 - Figure 11).

Of the 38 boxes required as temporary habitat as part of the W2B MMP, 22 were installed at control locations as a precautionary measure (drainage structures to be retained) and 16 were installed at impact sites (drainage structure to be removed or extended). It is important to note that the control locations were all located within the exiting Pacific Highway upgrade alignment and were subject to varying degrees of vegetation clearance and construction activities for the new highway alignment (within 10-50 m of each structure).

Most (32) bat boxes are 2, 3 or 4-chambered boxes constructed from either timber ply or Cyplas (recycled plastic). Of these, 30 were installed in trees adjacent to the impacted drainage structure (within 200m) and two were installed within culverts, as close as possible to the impacted drainage structure (within 500m). There are six bat boxes constructed from Hebel blocks that were installed to better replicate the darker, more insulated cave-like environments preferred by Little Bent-winged Bats and Large Bent-winged Bats. Five of these six boxes were installed in trees adjacent to the impacted culverts at Maclean Cut.

The remaining Hebel box was designed in a larger style, to accommodate large aggregations of Bent-winged Bats. A prototype multi-chambered Bent-winged Bat box with the capacity to accommodate

approximately 2000 Bent-winged Bats constructed from Hebel blocks was installed in a culvert under the existing Pacific Highway at Glenugie at CH 31400 in early 2019. This Bent-winged Bat box was designed to provide permanent replacement habitat and to replicate the expansion jointing gaps used by Bent-winged Bats in the Bebo Arch at CH 34900 (Figure 1 and Plate 1).



Plate 1: Prototype Hebel box designed to accommodate up to 2,000 Bent-winged Bats, installed in a box culvert at Glenugie CH 31400, March 2019.

2.6.2 Permanent habitat

The MMP describes a range of permanent cave-dwelling microbat roosting habitat that could be created in each new structure built within the vicinity of medium and high conservation value bat roosting habitat structures. The permanently created microbat habitat was to have a minimum carrying capacity equal to or greater than that of the original structure with a 15% buffer. Types of permanent microbat habitat that were considered on the W2B project include:

1. Maximum jointing gaps (15-25mm) between cells of reinforced concrete box culverts (RCBCs).
2. Leaving lift holes uncapped and unfilled in CPCs.
3. Roughened concrete culvert obverts (middle third of drainage structure >900 mm diameter for a width of 300 mm) to be installed. This action was to be enacted once construction of new structures

was completed and if the audit of permanent microbat habitat indicated that the carrying capacity of a new structure was below that required to replace lost microbat roosting habitat.

4. Leaving transport holes unfilled on selected new pre-cast concrete bridges.
5. Installation of bat boxes within drainage structures once construction was complete. This action was to be enacted if the audit of permanent microbat habitat indicated that the carrying capacity of a new structure was below that required to replace lost microbat roosting habitat.

Creation of permanent microbat habitat in the form of recessed chambers, blind culverts, maximum jointing gaps in all fauna underpasses and cavity maximisation and concrete feature replication on new bridges were considered during the detailed design phase of the W2B project. Discussions between TfNSW, PC, ELA, and construction contractors resulted in lift holes being left open and maximum jointing gaps included in some of the new structures located at Glenugie Link (within new culverts at Pheasants and Picaninny Creek and the new culverts that replaced the Glenugie Bebo Arch) and through Maclean cut (new culverts) where appropriate. A permanent microbat roosting habitat audit was undertaken during spring / summer 2019 / 2020 and winter 2020 to provide information on the adequacy of roosting habitat available in newly created structures. This audit could not be completed until construction of all new structures had been completed which was in August 2020.

It was necessary to carry out this audit over both a summer and winter season following completion of construction in order to capture seasonal differences in usage of structures by different microbat species, with Southern Myotis breeding occurring during spring and late summer and peak occupancy by Bent-winged Bats species occurring over winter. Preparation and completion of this report was delayed until the winter audit of newly built structures could be completed (August 2020) when all newly built structures were available for use by microbats. A further delay to reporting was necessary to allow for documentation of the creation and installation of additional permanent habitat within newly built structures that was required following the audit. These additional permanent habitat creation works were completed in June 2021.

A list of all the newly built structures required to be audited for suitability and carrying capacity of microbat habitat is presented in Table 4 below. It includes the actions undertaken to secure permanent microbat habitat and also provides justification for why certain actions were not taken.

Table 4: Newly created structures on the W2B S 3 -11 alignment, the types of permanent microbat habitat contained within them, results of the permanent habitat audit.

Section	Chainage	Location	ID	Feature Type	Dimensions - No. of cells	Options identified in 2018 for creation of permanent habitat features	Bat box installation	Permanent habitat features required after audit of structures
	31400	Glenugie		RCBC	2 cells	Box installation	Yes	1 x Bent-winged Bat box installed in culvert at CH 31400 Mar 2019 with capacity for 2000 Bent-winged Bats as compensatory habitat for Glenugie Bebo Arch at CH 34900.
3A	34665	Glenugie	CL-034665	RCP	1 cell	Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	No tile grout required as new culverts at CH 35075 contain adequate bat roosting habitat.
3A	34825	Glenugie	CL-034825	RCP	1 cell	Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	No tile grout required as new culverts at CH 35075 contain adequate bat roosting habitat
3A	35075	Glenugie	CC-035075	RCBC	8 cells: 2 x 4 box culverts	Leave lift points open (no capping or filling). Application of 300 mm wide strip of tiling grout to central 3rd of cell joints. Maximum jointing gaps (20 mm) in central third of culvert.	No	1 x Bent-winged Bat box installed in culvert at CH 31400 Mar 2019. Maximum joint gaps (20mm) installed in mid-section of all 8 culvert cells at this location (CH 35075), at least 4 expansion joints per cell for a total of 32 expansion joints. No lift points in RCBC. New culverts have capacity in excess of 2000 Bent-winged Bats in expansion joints. No requirement for additional roosting habitat.
3A	35880	Eight Mile Lane	CL-035880	RCBC	5 cells	Leave lift points open (no capping or filling). Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	No lift points in RCBC. No tile grout required. New culvert at CH 36010 contains open lift holes and some wide expansion joints, capacity for 30-50 Southern Myotis. 3 x four chambered bat boxes installed under Pheasants Creek Bridge provide adequate habitat for > 110 Southern Myotis

Section	Chainage	Location	ID	Feature Type	Dimensions - No. of cells	Options identified in 2018 for creation of permanent habitat features	Bat box installation	Permanent habitat features required after audit of structures
3A	36010	Eight Mile Lane	CL-036010	RCP	5 cells	Leave lift points open (no capping or filling). Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	Lift points open. No tile grout required. Culvert contains open lift holes and some wide expansion joints, capacity for 30-50 Southern Myotis. 3 x four chambered bat boxes relocated to Pheasants Creek Bridge provide adequate habitat for > 110 Southern Myotis
3A	36075	Eight Mile Lane	CL-036075	RCBC	5 cells	Leave lift points open (no capping or filling). Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	No lift points in RCBC. No tile grout required. New culvert at CH 36010 contains open lift holes and some wide expansion joints, capacity for 30-50 Southern Myotis. 3 x four chambered bat boxes installed under Pheasants Creek Bridge provide adequate habitat for > 110 Southern Myotis
3A	36379	Eight Mile Lane	Pheasant Creek	BRIDGE	45m (length) 3.6m (height)	Leave lift holes open on Super T's (no capping or filling)	Yes	3 x four chambered bat boxes installed in trees relocated under Pheasant Creek Bridge to assist in providing replacement habitat for >110 Southern Myotis.
4	76400	Greenhill	CL-076400	RCBC	1 cell	Box installation	Yes	1 x Bent-winged Bat box installed in culvert at CH 76450 with capacity for > 650 Bent-winged Bats in June 2021 as compensatory habitat for lack of roosting capacity in new culverts at Maclean cut.
4	81645	Maclean Cut	CL-081645	RCP	1 cell (1200mm)	Application of 300 mm wide strip of tiling grout to central 3rd of cell joints. Maximum jointing gaps (20 mm) in central third of culvert.	No	Lift points open, some maximum jointing gaps. No tile grout required as permanent habitat for >650 Bent-winged Bats created using Bent-winged Bat Box prototype design at CH 76450. Evidence of occasional usage of new culverts at CH 81645 by small

Section	Chainage	Location	ID	Feature Type	Dimensions - No. of cells	Options identified in 2018 for creation of permanent habitat features	Bat box installation	Permanent habitat features required after audit of structures	
								numbers (<50 in total) of bats in the form of light to moderate guano piles beneath most expansion joins.	
5	82030	Maclean Cut		RCP	1 cell (1200mm)	Application of 300 mm wide strip of tiling grout to central 3rd of cell joints. Maximum jointing gaps (20 mm) in central third of culvert.	No	Lift points open, some maximum jointing gaps. No tile grout required as permanent habitat for >650 Bent-winged Bats created using Bent-winged Bat Box prototype design at CH 76450. Evidence of occasional usage of new culverts at CH 82030 by small numbers (<100 in total) of bats in the form of light to moderate guano piles beneath most expansion joins.	
5	82330	Maclean Cut		RCP	1 cell (1350mm)	Application of 300 mm wide strip of tiling grout to central 3rd of cell joints. Maximum jointing gaps (20 mm) in central third of culvert.	No	Lift points open, some maximum jointing gaps. No tile grout required as permanent habitat for >650 Bent-winged Bats created using Bent-winged Bat Box prototype design at CH 76450. Evidence of sustained usage of new culverts at CH 82330 by small numbers (<100 in total) of bats in the form of light to moderate guano piles beneath most expansion joins.	
5	83100	Maclean Cut	Bridge (Koala Drive)	B01	BRIDGE		Leave lift holes open on Super T's South Bound (no capping or filling)	No	Lift points open. No tile grout required as permanent habitat for >650 Bent-winged Bats created using Bent-winged Bat Box prototype design at CH 76450
5	89370	Serpentine Channel	Bridge		BRIDGE		Leave lift holes open on Super T's North Bound (no capping or filling)	No	Lift holes open on Super T's North Bound. Original bridges retained at CH 89370 and CH 89400.

Section	Chainage	Location	ID	Feature Type	Dimensions - No. of cells	Options identified in 2018 for creation of permanent habitat features	Bat box installation	Permanent habitat features required after audit of structures
5	94090	Mororo Bridge, Clarence River		BRIDGE		Leave lift holes open on Super T's South Bound (no capping or filling)	No	Lift holes open on Super T's South Bound. Original bridges retained at CH 94090
6	106185	Devil's Pulpit	CF-106185	RCBC	8 cells	Leave lift holes open (no capping or filling). Consider application of single bat box if lift holes and expansion joints are not adequate. Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	1 x four chambered bat box installed in culvert on southbound at CH 106230 in Apr 2018 remains as permanent habitat. No lift points on RCBC. No tile grout required. New culverts contain adequate bat roosting habitat for 30 bats in expansion joints.
7	122260	Oakey Creek	CC-122270	RCBC	7 cells	Leave lift holes open (no capping or filling). Consider installation of single bat box if lift holes and expansion joints are not adequate. Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	Yes	1 x four chambered bat box relocated to culvert at CH122260 provides adequate habitat for up to 30 Southern Myotis. No lift holes on RCBC. No tile grout required.
7	122550	Oakey Creek	CC-122550	RCBC	3 cells	Leave lift holes open (no capping or filling). Application of 300 mm wide strip of tiling grout to central 3rd of cell joints	No	No lift points in RCBC. No tile grout required. 1 x four chambered bat box relocated to culvert at CH122260 provides adequate capacity for up to 30 Southern Myotis.

2.7 Microbat exclusion

Microbat exclusion was required at subject drainage structures if any direct works (i.e. removal or extension) were undertaken on medium or high conservation value microbat habitat structures. Thirteen of the 22 structures subject to provisions of the MMP required exclusions to be carried out and there were no exclusions conducted during the 2019 / 2020 monitoring period (Table 3). All exclusions were completed prior to 2019. Two of the 13 impacted structures scheduled to be excluded were not excluded to microbats, the Bebo Arch at CH 34900 and Oakey Creek culvert at CH 122280 for reasons outlined below.

The Bebo Arch was occupied each year between late February / March and September by over-wintering Little Bent-winged Bats and occasionally Large Bent-winged Bats. Timing of works at this structure were scheduled to avoid the over-wintering period for Bent-winged Bats, and structure removal occurred in February 2019. Exclusion was not undertaken at the Bebo Arch, as no bats were present immediately prior to its removal. In conjunction with the removal of the Bebo Arch, a prototype Bent-winged Bat box was installed in a nearby culvert at CH 31400 (Plate 1) in 2019, to provide permanent cave-dwelling habitat for Bent-winged Bats prior to the construction of the new culverts that would replace the Bebo Arch at Glenugie Interchange.

Oakey Creek culvert contained a very small amount of shallow and exposed roosting habitat. This culvert contained deep, permanent water (>1.5m) during all inspections, and there were concerns over the practicality of installing and, more importantly, maintaining the integrity of exclusion devices. Due to these concerns and the relatively low risk of microbat habitation, a decision was made to leave the Oakey Creek culvert open to microbats throughout construction of the new culvert provided a pre-clearing survey was conducted on the old culvert before it was demolished (ELA 2018b). This decision was made in consultation with EPA and a W2B environmental representative.

2.8 Microbat monitoring

In accordance with the TMMP and peer review (Schulz 2013), pre-construction monitoring surveys of drainage structures within Sections 3 to 11 and listed in the original MMP were undertaken by GeoLINK to provide baseline data relating to current usage by microbats:

- Winter (July - August 2014)
- Spring (October - November 2014)
- Summer (February 2015).

Pre-construction monitoring surveys of additional drainage structures added after production of the original MMP were also undertaken but owing to time constraints imposed by the construction schedule generally only occurred over a period of less than 12 months. ELA undertook pre-construction microbat surveys of the following drainage structures:

- Section 3A Bebo Arch Glenugie Link (Spring September 2018, Summer December 2018)
- Section 3A Pheasants Creek culvert Eight Mile Lane (Summer February 2018)
- Section 3A Picaninny Creek culvert Eight Mile Lane (Summer February 2018)
- Sections 4-5 Maclean Cut (Summer December 2017 - February 2018)
- Devil's Pulpit tie in Section (Summer December 2017, Autumn April 2018)

This report addresses monitoring of drainage structures, including both impact and control sites, temporary and permanent compensatory habitat. This includes some new drainage structures and bat boxes installed during and post-construction. The MMP sets out the monitoring schedule, including the following specifications:

- Quarterly visual inspections to commence following the exclusion of impacted structures during construction, commencing in 2017 and concluding during 2020 once construction is fully completed.
- Biannual visual inspections post construction for up to six years, commencing in 2020.
- Post-construction biannual monitoring may cease after two years at any particular site, if populations of bats have stabilised at that site.

3. Methodology

A series of monitoring inspections have occurred at the subject drainage structures between December 2017 and August 2020, as determined by the construction schedule and in line with requirements under the MMP (GeoLINK 2015b). In addition to this, a series of opportunistic inspections of some structures were also conducted between August 2020 and June 2021 during investigations for a suitable location for the installation of permanent microbat habitat to augment habitat newly created at Maclean cut. These inspections occurred following completion of the structure audit in August 2020. This report presents the results of all monitoring undertaken during 2019 and 2020, including opportunistic investigations conducted between August 2020 and June 2021 as previous reports have summarised results from 2017 and 2018 monitoring inspections.

Table 5 sets out the details of each subject drainage structure and the date it was identified to be managed in accordance with the MMP (GeoLINK 2015b), as well as dates when monitoring was undertaken during 2019/2020. Table 6 sets out the details of opportunistic inspections conducted between August 2020 and June 2021. Monitoring involved a diurnal visual inspection of the internal and external features of each drainage structure using a torch, binoculars and camera, noting exclusion devices (if present) and compensatory habitat/bat boxes (if present).

In accordance with the requirements of the MMP, the following information was recorded during each monitoring inspection:

- Date and time of inspection.
- Identification code of bat box or subject drainage feature.
- Evidence of microbats (bats, guano, bat bugs and/or staining).
- Number of microbats present.
- Identification of species.
- Indications of breeding activity.
- Occurrence of any pest species such as feral bees.
- Condition of the bat roost / bat box (e.g. any deterioration, structurally unstable) if applicable.
- Roost features present.
- Record of rainfall during monitoring period.

During 2019 / 2020 MMP quarterly monitoring events were split over five separate site visits and included inspections of drainage structures and bat boxes within Sections 2, 3A, 4, 5, 6, Devil's Pulpit, 7 and 10:

- 6th and 7th March 2019
- 3rd and 4th July 2019
- 8th and 9th October 2019
- 23rd and 24th January 2020 (delayed summer monitoring due to 2019-20 bushfires)
- 21st February 2020 (delayed summer monitoring due to 2019-20 bushfires).

As the W2B project transitioned to operational phase during first quarter 2020 there were requirements for a permanent bat habitat audit on new structures to be completed. Monitoring of subject drainage

structures switched from quarterly to a biannual schedule at the completion of construction. It was important to bring post construction monitoring forward from the next scheduled monitoring in 2021 to capture seasonal uptake of bat roosting habitat in any newly constructed structures to inform the permanent habitat audit. This permanent habitat audit would then allow time for the creation of additional permanent habitat and / or relocation of unused bat boxes from tress into culverts prior to contractors handing the W2B project back to TfNSW.

The monitoring event conducted between 20 and 22nd August 2020 included inspections of newly created drainage structures associated with the original subject drainage structures and bat boxes within Sections 2, 3A, 4, 5, 6, Devil's Pulpit, 7 and 10, as well as an audit of the roosting habitat capacity contained within newly built structures.

Furthermore, incidental observations of various structures occurred in the period between August 2020 and June 2021. Although not part of the scheduled monitoring program, these observations allowed for a greater understanding of the uptake of permanently inhabited structures and provided input into the ongoing need for monitoring. As per the MMP, monitoring of structures was to occur for two years post construction. Any further monitoring would be dependent upon an assessment of whether microbats were consistently using newly created structures.

3.1 Compensatory bat box habitat

Compensatory habitat in the form of 38 bat boxes (Plate 2 and Plate 3) constructed from a range of materials and designs were located within Sections 3A, 4, 5, 6, Devil's Pulpit, 7 and 10 (Table 3). All bat boxes were inspected by an ELA ecologist during each quarterly event or during each summer and winter event post construction, unless access to the boxes was prevented for safety reasons related to adverse site conditions or active construction activity in proximity to the boxes. Information on occupancy and box condition was recorded. Any damage to bat boxes was identified, documented and forwarded to PC, for approval of proposed corrective actions. Bat boxes not used by bats since installation were identified to be relocated into newly created culverts where the newly created structures did not contain bat roosting habitat equal to or greater than that available in the original structures.



Plate 2: A single chamber bat box (LHS) and a four-chambered bat box (RHS) constructed from Cyplas in a tree adjacent to the impacted structures in Section 4, Maclean Cut.

Table 5: Full list of drainages structures retained and newly created and dates when monitoring occurred at each location

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	
2	31400	Feb-19	Glenugie Bent-winged Bat Box	Culvert	Existing	No exclusion required	N/A	Yes	Yes	Yes	Yes	Yes
Glenugie Link	35075		Glenugie culverts	Link	Newly constructed	No exclusion required	N/A	No (active construction)	Yes	Yes	Yes	Yes
Glenugie Link	35880		Picaninny Eight Mile Lane	Creek,	Newly constructed	No exclusion required	N/A	No (active construction)	No (active construction)	Yes (audit of habitat)	No (no habitat)	No (no habitat)
Glenugie Link	35900	Jan-18	Picaninny Eight Mile Lane	Creek,	Retained	Jun-18	Impact	Yes (excluded)	Yes (excluded)	Yes (excluded)	Yes (external exclusions removed)	Yes
Glenugie Link	36010		Pheasant Eight Mile Lane	Creek,	Newly constructed	No exclusion required	N/A	Yes	Yes	Yes	Yes	Yes
Glenugie Link	36379		Pheasant Bridge	Creek	Newly constructed	No exclusion required	N/A	No (active construction)	Yes (audit of habitat)	No (not part of MMP)	No (not part of MMP)	Yes (audit of habitat)

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
4	76450	Mar-19	Greenhill Cut	Newly constructed	No exclusion required	N/A	Yes (potential location for Bent-winged Bat Box)	No (not part of MMP)	No (not part of MMP)	No (not part of MMP)	No (not part of MMP)
4	75560	Mar-19	Greenhill Cut	Newly constructed	No exclusion required	N/A	Yes (potential location for Bent-winged Bat Box)	No (not part of MMP)	No (not part of MMP)	No (not part of MMP)	No (not part of MMP)
4	81440	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	No (active construction)	No (active construction)	Yes (audit of habitat)
4	81645	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	No (active construction)	No (active construction)	Yes (audit of habitat)

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
4	81770	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	No (active construction)	No (active construction)	Yes (audit of habitat)
4	81825	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	No (active construction)	No (active construction)	Yes (audit of habitat)
4	82030	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes
4	82330	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes (audit of habitat)

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
4	82610	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes (audit of habitat)
4	82740	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes (audit of habitat)
5	82860	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes (audit of habitat)
5	82970	Mar-19	North of Jubilee Street overbridge	Newly constructed	Excluded during construction of western end	N/A	No (excluded)	No (excluded)	Yes	Yes	Yes (audit of habitat)
5	89370	Mar-15	Old Serpentine Channel Bridge	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
5	89400	Mar-15	Serpentine Channel Bridge southbound	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
5	89400		New Serpentine Channel Bridge northbound	Newly constructed	No exclusion required	N/A	No (not constructed)	No (active construction)	Yes	Yes	Yes
5	94090	Mar-15	Old Mororo Bridge (was northbound)	Early works Dec 2017, temporary jetty Feb 2018, piling Mar 2018, bridge construct May 2018. Structure retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
5	94090	Mar-15	Mororo southbound (now northbound)	Bridge (now northbound) Early works Dec 2017, temporary jetty Feb 2018, piling Mar 2018, bridge construct May 2018. Structure retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
5	94090		Mororo Bridge new (southbound)	Newly constructed	No exclusion required	N/A	No (active construction)	No (active construction)	Yes	Yes	Yes
6	101610	Mar-15	Old Tabbimoble Creek Bridge	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
6	101610	Mar-15	Tabbimoble Creek Bridge southbound	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
6	101610		Tabbimoble Creek Bridge northbound	Newly constructed	No exclusion required	N/A	Yes	Yes	Yes	Yes	Yes

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
6	102900	Mar-15	Old Tabbimoble Overflow Bridge	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
6	102900	Mar-15	Tabbimoble Overflow Bridge southbound	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes
6	102900		New Tabbimoble Overflow Bridge northbound	Newly constructed	No exclusion required	N/A	Yes	Yes	Yes	Yes	Yes
Devil's Pulpit	106185		New fauna underpass culvert northbound	Newly constructed	No exclusion required	N/A	No (not constructed)	No (not constructed)	No (active construction)	No (active construction)	Yes (audit of habitat)
Devil's Pulpit	106230		Devil's Pulpit culvert with bat box	Existing	No exclusion required	N/A	Yes	Yes	Yes	Yes	Yes
7	122190		New Oakey Flat culvert	Newly constructed	No exclusion required	N/A	No (not constructed)	No (not constructed)	Yes	No (active construction)	Yes (audit of habitat)

Section	Chainage	Date added to MMP	Location	Construction dates	Exclusion date	Control or impact	Monitoring March 2019	Monitoring July 2019	Monitoring Oct 2019	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020
7	122280		New Oakey Flat # 3 Oakey Creek	Newly constructed	No exclusion required	N/A	No (not constructed)	No (not constructed)	No (active construction)	No (active construction)	Yes (audit of habitat)
7	122550		New Oakey Creek overflow	Newly constructed	No exclusion required	N/A	No (not constructed)	No (not constructed)	No (active construction)	No (active construction)	Yes (audit of habitat)
10	157400	Mar-15	Saltwater Creek, south of Coolgardie Road	Retained	No exclusion required	Control	Yes	Yes	Yes	Yes	Yes

Table 6: List of drainages structures inspected during searches for suitable locations for permanent habitat installation and dates when monitoring occurred at each location.

Section	Chainage	Date added to MMP	Location	Construction	Audit August 2020	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021	
	2	31400	Feb-19	Glenugie Culvert Bent-winged Bat Box	Existing	Yes	Yes	No (no scheduled monitoring)	No (no scheduled monitoring)	Yes
Glenugie Link	35075			Glenugie Link culverts	Newly constructed	Yes	Yes	Yes	Yes	Yes
Glenugie Link	36010			Pheasant Creek, Eight Mile Lane	Newly constructed	Yes	Yes	No (no scheduled monitoring)	No (no scheduled monitoring)	No (no scheduled monitoring)
Glenugie Link	36379			Pheasant Creek Bridge	Newly constructed	Yes	Yes (permanent habitat design visit)	No (no scheduled monitoring)	No (no scheduled monitoring)	No (no scheduled monitoring)
	4	76450	Mar-19	Greenhill Cut	Newly constructed	No (previously audited)	Yes (permanent habitat design visit)	No (no scheduled monitoring)	No (no scheduled monitoring)	Yes (Bent-winged Bat Box installed)
	4	75560		Greenhill Cut	Newly constructed	No (previously audited)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)	No (not part of MMP)
	4	77200		Service Road N from McIntyres Lane RCBC 4 cell	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)

Section	Chainage	Date added to MMP	Location	Construction	Audit August 2020	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021
4	77500		Service Road RCBC 2 cell	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78200		Service Road opp Causleys Lane 1650 mm RCPC	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78500		Service Road opp Causleys Lane hill RCBC 2 cell	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78600		Service Road RCBC	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78700		Service Road 2400mm x 1500mm RCBC 2 cell	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78800		Service Road RCBC	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	78850		Service Road RCPC	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)

Section	Chainage	Date added to MMP	Location	Construction	Audit August 2020	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021
4	79000		Old Service Station Bridge	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	80000		750 mm RCPC	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
4	80100		Edwards Drain Bridge	Newly constructed	No (not listed to be audited in Aug 2020)	No (not part of MMP)	Yes (permanent habitat design visit)	No (not part of MMP)	No (not part of MMP)
7	122280	Aug-20	New Oakey Flat # 3 Oakey Creek	Newly constructed	Yes (permanent habitat audit)	No (no scheduled monitoring)	No (no scheduled monitoring)	No (no scheduled monitoring)	Yes (Bat box installed)



Plate 3: A single chamber timber bat box (upper feature) and a Hebel bat box with four core holes (lower feature behind tree trunk) installed in a tree adjacent to impacted structures in Section 4, Maclean Cut.

3.2 Control and Impact sites

Control sites were identified as drainage structures classified as medium or high conservation / habitat potential that would not be subject to direct impacts and where construction of the new highway was at least 20 m away from the structure. Some of the original control sites listed in the MMP became impact sites, with detailed design and updates to the project alignment. There were nine control sites, and these are identified in the list of subject drainage structures in Table 3. Control sites occur in Sections 5, 6 and 10 of the W2B project, and consist of the existing Pacific Highway Bridge and old Pacific Highway Bridge over Serpentine Channel on Chatsworth Island, the existing Pacific Highway Bridge and old Pacific Highway Bridge at Mororo over the Clarence River, the existing Pacific Highway Bridges over Tabbimoble Creek and Tabbimoble Creek overflow and a box culvert on Saltwater Creek, Coolgardie in the far northern end of the W2B project.

There were originally four impact sites; two culverts in Section 4/5 at Maclean cut, a culvert in the Devil's Pulpit tie in section and one in Section 7 at Oakey Creek. A suite of additional impact sites was added as the project progressed including new areas at Glenugie Link and Eight Mile Lane (Table 3)

Control sites were monitored to determine microbat utilisation and, if present, record any changes in population dynamics over time. This information is then compared to the population dynamics recorded at the impact sites to assist in assessing the impact of construction on microbat populations.

4. Results

4.1 Permanent Habitat Audit

The results of an audit of newly built structures conducted to evaluate their suitability as permanent microbat habitat during spring / summer 2019/2020 and winter 2020 are provided in Table 4.

The permanent habitat audit found that in most cases there was suitable and adequate microbat roosting habitat available that was equal to, or greater in capacity to that available prior to construction at the locations where subject drainage structures were impacted or in very close proximity to them (< 500m) (Table 4). As already mentioned in Section 2.6.1 above, one larger style Bent-winged Bat box was installed in a culvert at Glenugie (CH 31400) to provide temporary replacement habitat for the loss of the Bebo Arch at CH 34900 while the new culverts were being built. The new box culverts beneath the Glenugie interchange contain roosting habitat for > 2000 Bent-winged Bats in the widened expansion jointing gaps created in the mid sections of each cell of both sets of 4 culverts at this location. These culverts have recorded significant use by Little Bent-winged Bats since their construction with 780+ observed during winter 2020 and 1300+ observed during winter 2021 (Table 9 and Table 10). The Bent-winged Bat box at CH 31400 will remain in place as permanent roosting habitat for a range of microbat species. The Bent-winged Bat box at Glenugie has shown evidence of usage by single bats or by small numbers of bats as evidenced by small guano piles beneath the box or on the walls of the box on numerous occasions.

The results of the permanent microbat roosting habitat audit found that the new culverts at Maclean cut (CH 82030 and CH 82330) did not have the required capacity to accommodate up to 650 Bent-winged Bats and none of the boxes installed in trees had been used. As a result, one additional box was required to be installed post construction that would provide suitable compensatory permanent roosting habitat for up to 650 Bent-winged Bats (2 x the original maximum number of Bent-winged Bats recorded at Maclean cut to allow for growth of the colony). A larger style Bent-winged Bat box was installed approximately 5.5 km south in a box culvert at Greenhill (CH 76400) to augment the existing culvert in June 2021 (Plate 4, Figure 2). A small cluster of Little Bent-winged Bats (8) were recorded roosting within an expansion joint in the box culvert at Greenhill during the installation of the Bent-winged Bat box in June 2021. There was no other structure within the W2B project boundary suitable as a roost site for Bent-winged Bats and capable of hosting the larger style Bent-winged Bat box at Maclean cut or closer than the box culvert at Greenhill.

In addition, some newly built structures at impact sites required additional permanent habitat augmentation in the form of relocated bat boxes. This was either because there was no roosting habitat available in the newly built structure (Oakey Creek) or because the boxes had not been used and a more suitable site for box installation was created with the newly built structure. Where boxes have been relocated into new structures those sites are now treated as permanent bat habitat locations. None of the three bat boxes installed along Pheasants Creek had been used regularly by bats and these boxes were installed beneath the new Pheasants Creek Bridge (CH 36379, Figure 1) in June 2021 where the creek is more open and permanent (Plate 5). The bat box installed in a tree along Oakey Creek to the west of the highway alignment was never used and was installed in the newly built culvert at CH 122266 in June 2021 because it did not contain any roosting habitat (Plate 5).

Some of the unused timber and Cyplas boxes from Maclean cut are proposed to be re-located and installed beneath Mororo Bridge to replace bat boxes at that location that are heavily utilised by a large maternity colony of *Myotis* and in a degraded state.



Plate 4: Large style double chambered Bent-winged Bat box constructed from Hebel blocks with capacity to accommodate hundreds of Bent-winged Bats installed in a box culvert beneath the Pacific Highway at Greenhill (CH 76400) in June 2021.

4.2 Compensatory bat box habitat

There have been multiple instances of microbats recorded occupying bat boxes during the 2019-20 monitoring period, including locations where repeated occupancy has been recorded. Nine of the 38 bat boxes (24%) were occupied by microbats at least once. Tabbimoble Creek (Section 6) was impacted by bushfire before the January - February 2020 inspections and of the 12 boxes in that area, five boxes were burnt. One of those boxes is no longer functional. The loss of these boxes is not critical for continued persistence of the subject threatened microbat species at this location. None of the subject microbat species were ever recorded using these bat boxes. These bat boxes have been used on multiple occasions by another threatened microbat species, *Nyctophilus bifax*. Table 7 provides a summary of the number of boxes per structure and results of monitoring.

At least three species of microbat have been recorded using bat boxes during 2019-20, including the following threatened species listed as vulnerable under the BC Act:

- Southern *Myotis* (Plate 6).
- *Nyctophilus bifax* (Eastern Long-eared Bat) (Plate 7).

- Little Bent-winged Bat.

The occurrence of Eastern Long-eared Bat in a box is notable, because outside of the W2B project, there are few recorded instances of this threatened species roosting within a bat box. During the August 2020 monitoring event, twelve Eastern Long-eared Bats (vulnerable) were recorded in boxes along Tabbimoble Creek in Section 6 (Table 6). This is the same location where this species has been recorded using boxes multiple times during previous monitoring events. During March 2019 it was not possible to identify the *Nyctophilus* spp. present in a box to species level because of the restricted view of bats in the box, so there is potential for two other *Nyctophilus* spp. to have been present; *N. geoffroyi* (Lesser Long-eared Bat) or *N. gouldi* (Gould's Long-eared Bat), neither of which is listed as a threatened species.



Plate 5: Re-located bat boxes at Pheasants Creek Bridge, Glenugie (LHS) and Oakey Creek culvert, New Italy (RHS) on the Pacific Highway.

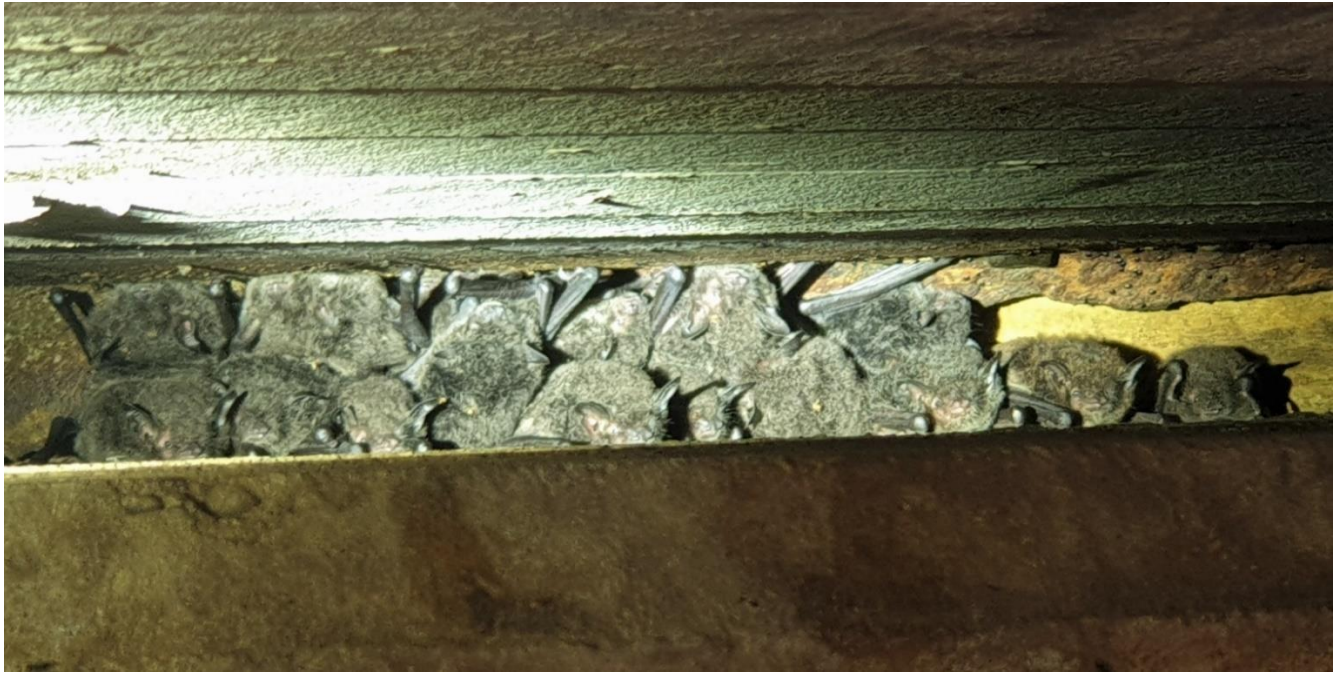


Plate 6: Cluster of 18+ Southern Myotis recorded at Tabbimoble Creek Bridge, January 2020.



Plate 7: Four *Nyctophilus bifax* (Eastern Long-eared Bat) recorded in a Cyplas bat box along Tabbimoble Creek, August 2020.

The Little Bent-winged Bat was recorded once in July 2019 as a single individual in the prototype Bent-winged Bat box, within 3 months of the installation of the box in a culvert at Glenugie CH 31400. This was a very encouraging sign for the prototype Bent-winged Bat box.

Southern Myotis were predominantly located in the four bat boxes beneath Mororo Bridge, a permanently inhabited roost location and maternity site for this species, as well as Serpentine Channel bat boxes. Monitoring results for these control locations are discussed below under Section 4.2.

No microbats were recorded in compensatory bat boxes (Table 7) located at the following sites during the March 2019 – August 2020 monitoring period:

- Section 3A CH 35900 Picaninny and Pheasants Creek bat boxes (3 boxes)
- Section 4/ 5 CH 81900 Maclean cut bat boxes (10 boxes)
- Section 6 CH 106230 Devil's Pulpit bat box (1 box)
- Section 7 CH 122280 Oakey Creek bat box (1 box)

There were few instances of pest species occupying the bat boxes, with occasional instances of spiders, spider egg sacs and mud wasp nests. A leaf nest was recorded in the August 2020 monitoring period, presumed to have been made by *Acrobates sp.* (Feather Gliders). The occurrence of pest species was transitory and present for only one or two consecutive monitoring visits. It was not considered likely that pest species were excluding microbats from using any of the boxes for a sustained period of time, nor is intervention deemed necessary. Overall the compensatory bat boxes remained in good condition throughout the monitoring period.

Table 7: Details of compensatory bat boxes and results of 2019/2020 monitoring

Section	Chainage	Date added into MMP	Location	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring 2020	Jan/Feb	Monitoring 2020	Aug
2	31400	Mar-19	Glenugie culvert bat box (1 x Bent-winged Bat Hebel box)	No bats recorded		1 Little Bent-winged Bat		No bats recorded		No bats recorded		Guano (small amount)	
3	36100	Mar-18	Pheasants Creek bat boxes (3 x Southern Myotis)	No bats recorded		No bats recorded		No bats recorded		No bats recorded		No bats recorded	
4	76450	Jul-21	Greenhill culvert bat box (1 x Bent-winged Bat Hebel box)	Not installed		Not installed		Not installed		Not installed		Not installed	
4	81900	Sep-17	Maclean cut bat boxes (6 x bat boxes, 4 x Hebel boxes)	No bats recorded		No bats recorded		No bats recorded		No bats recorded		No bats recorded	
5	89400	Mar-15	Serpentine Channel bat boxes (6 x Southern Myotis)	No bats recorded		11 Southern Myotis (7 in one box, 4 in another box)		No bats recorded		No bats recorded		1 Southern Myotis	
5	94090	Mar-13	Mororo Bridge North Bound bat boxes (4 x Southern Myotis)	400+ Myotis	Southern	150+ Myotis	Southern	210+ Myotis	Southern	310+ Myotis	Southern	240+ Myotis	Southern
6	101610	Feb-17	Tabbimoble Creek Bridge bat boxes (8 x bat boxes)	No bats recorded		3 Long-eared Bats (species unknown)		No bats recorded		No bats recorded - significant fire and flood damage to some boxes		12 Eastern Long-eared Bats in one box	
6	102900	Feb-17	Tabbimoble Creek Overflow Bridge bat boxes (4 x bat boxes)	No bats recorded		No bats recorded		No bats recorded		No bats recorded - no fire or flood damage		No bats recorded, leaves in box, possible Feathertail Glider nest	
Devil's Pulpit	106230	Apr-18	Box culvert south bound bat box (1 x bat box)	No bats recorded		No bats recorded		Guano (small amount)		No bats recorded		No bats recorded	

Section	Chainage	Date added into MMP	Location	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring Jan/Feb 2020	Monitoring 2020	Aug
7	122280	Nov-16	Oakey Flat # 3 Oakey Creek bat box (1 x Southern Myotis)	No bats recorded		No bats recorded		No bats recorded		No bats recorded		No bats recorded

4.3 Control sites

There were nine control sites inspected regularly during the monitoring period with the addition of four new bridges that were newly constructed added to the list of structures at control sites in 2019 (Table 8). There are some trends forming from the monitoring data gathered at the control sites, but these must be interpreted with caution given;

- the small numbers of bats involved at certain control sites (Serpentine Channel Bent-winged Bats, Saltwater Creek)
- the seasonal patterns of occupation observed prior to construction at many of the control sites,
- the fact that monitoring to date has captured one year of data under construction and one year of data post construction limiting conclusions that can be drawn about bat populations under an undisturbed (non-construction) scenario.
- many of the control sites were in proximity (<20m) to active construction areas which may have caused disturbance to the bat colonies that use these control sites (Serpentine Channel Bridge, Mororo Bridge, Tabbimoble Creek and Tabbimoble Creek Overflow).

Only one location, Mororo Bridge south, has supported a permanent colony of Southern Myotis within four bat boxes installed beneath the bridge from before construction commenced, throughout construction and into the operational phase of the project. Southern Myotis breed in the four bat boxes with maximum colony sizes recorded in Autumn after the second breeding event of the summer. Over 400 Southern Myotis were recorded roosting in the four bat boxes in March 2019, compared to > 150 in July 2019, > 210 during October 2019, over 310 in January-February 2020 and approximately 240 in August 2020 (Table 7 and Table 8), following the expected pattern of occupancy and attaining levels similar to, or exceeding those recorded prior to commencement of works on the W2B project. This result indicates that the Southern Myotis population centred on Mororo Bridge is in good health. Monitoring results from 2018 raised concerns that construction activity adjacent to the bridge may have caused a decline in numbers of Myotis present for the duration of works (ELA 2019). Whether or not the decline in numbers was due to construction activity in close proximity, the decline was only short term as Southern Myotis numbers are now comparable or exceed those recorded prior to construction commencing at this location.

The numbers of Southern Myotis present in the bat boxes and within the old Serpentine Channel Bridge and the existing Serpentine Channel Pacific Highway Bridge fluctuated during the 2019-20 monitoring period, with a trend for steadily increasing numbers of Southern Myotis present (Table 8). There were 17 Southern Myotis recorded roosting in the bridge during March 2019 compared to six Southern Myotis recorded in the bridge and 11 recorded in bat boxes during July 2019, >50 Southern Myotis roosting in the old bridge with a large guano pile beneath, and another old guano pile beneath a roughened section of bridge deck during October 2019, 72 Southern Myotis recorded in the bridge in Jan/Feb 2020 and roughly 100 observed in the Old Pacific Highway bridge in August 2020. A maternity colony of Southern Myotis is now centred on Serpentine Channel Bridge, where none was detected prior to commencement of works. There were also 51 Large Bent-wing Bats recorded using the old Serpentine Creek Bridge in July 2019 (Table 8). The number of Large Bent-winged Bats at this site is characterised by large fluctuations with anywhere between no Bent-winged Bats present and up to 131 (recorded once only during pre-construction surveys). Serpentine Channel Bridges appears to represent temporary roosting habitat for Bent-winged Bats.

The situation at Tabbimoble Creek and Tabbimoble Creek overflow is also encouraging despite the number and species of microbats present at these locations fluctuating between monitoring events (Table 8). The sites are known to be used by hundreds of Little Bent-winged Bats during winter, which was observed again in July 2019 with 298 Little Bent-winged Bats recorded at the Tabbimoble Creek overflow and 656 Little Bent-winged Bats recorded at Tabbimoble Creek (Table 8). These numbers are similar to those recorded in winter prior to commencement of works.

These results contrast markedly with the August 2020 monitoring event where <100 Little Bent-winged Bats were recorded at Tabbimoble Creek and < 10 at Tabbimoble Creek Overflow (Table 8). The number of Little Bent-winged Bats present in August 2020 was the lowest ever recorded during a winter monitoring event. Without more detailed population information from the region it is impossible to know whether this result represents a reduction in the Little Bent-winged Bat population locally. The extreme bushfires that swept through the surrounding forest during the previous summer (2019/2020) and the corresponding damage to the surrounding forested areas is likely to have reduced the availability of insect prey in the area. It is likely that limited local food availability is preventing large numbers of Little Bent-winged Bats from roosting at Tabbimoble Creek or Tabbimoble Creek Overflow bridges. It is assumed that Little Bent-winged Bats that usually roost at these sites over winter have been forced to seek out roosts elsewhere, where less of the surrounding forest was impacted by bushfires and insect prey is more readily available.

Tabbimoble Creek Bridge was used by Southern Myotis as a breeding site during the summer of 2018, and this situation was potentially repeated with the observation of 18+ Southern Myotis present in January 2020 (Plate 6). Low numbers of records of Southern Myotis at either of the Tabbimoble Bridge sites were recorded during March 2019 (6 bats), July 2019 (5 bats) and August 2020 (2 bats) which is a similar pattern to results for Southern Myotis recorded at these locations prior to commencement of works.

The results for Saltwater Creek culvert during the 2019-20 monitoring period indicate greater use of this culvert by bats than has been recorded at any time in the past. Fresh guano was recorded on two occasions (March 2019, January-February 2020) indicating recent occupation by microbats (Table 8). This was followed by 12 Little Bent-winged Bats recorded during July 2019 and one Little Bent-winged Bat recorded during October 2019. A small amount of fresh guano (Plate 8) along with a large pile of old guano (Plate 9) and one dead Little Bent-winged Bat was recorded during the January-February 2020 inspections. There was on old pile of guano but no bats present in August 2020.



Plate 8: Fresh bat guano at control site at Saltwater Creek (Section 10), January 2020.



Plate 9: Mass area of old bat guano at control site at Saltwater Creek (Section 10), January 2020.

Table 8: Results from monitoring inspections at the control sites throughout 2019 and up to winter 2020.

Date added into MMP	Location	Monitoring 2019	March	Monitoring 2019	July	Monitoring Oct 2019	Monitoring Jan/Feb 2020	Monitoring 2020	Aug	Baseline survey results (2014/2015), min and max # bats recorded
15-Mar	Old Serpentine Creek Bridge	17 SM in bridge		6 SM and 51 LgBW in bridge, 11 SM in boxes	50 SM and old large guano pile under roughened section of bridge deck		70 SM (incl pups)	100 SM		Min: No bats Max: 40 LgBW
15-Mar	Serpentine Creek Bridge South Bound	No bats recorded		No bats recorded	1 unknown spp.		2 SM	5 LgBW in bridge		Min: 131 LgBW, 10 SM Max: 131 LgBW, 10 SM
Jun-19	New Serpentine Creek Bridge North Bound	Not constructed		No bats recorded	No bats recorded		No bats recorded	No bats recorded		Newly constructed July 2019
15-Mar	Old Mororo Bridge	No bats recorded		No bats recorded	No bats recorded		No bats recorded	No bats recorded		Min: 1 SM Max: 2 SM
15-Mar	Mororo Bridge North Bound	400+ SM in boxes		150+ SM in boxes	210+ SM in boxes		310+ SM in boxes	240+		Min: 127 SM incl pups Max: 255+ SM
	New Mororo Bridge South Bound	No bats recorded		No bats recorded	No bats recorded		No bats recorded	No bats recorded		Newly constructed
15-Mar	Old Tabbimoble Creek Bridge	No bats recorded		656 LtBW	Guano		18+ SM	2 SM, 85 LtBW		Min: 2 SM Max: 553 LtBW, 10 Nycto, 2 SM, 1 Vsp
15-Mar	Tabbimoble Creek Bridge South Bound	No bats recorded		No bats recorded	No bats recorded		No bats recorded - fire and flood	No bats recorded		Not separated from Old Tabbimoble Ck Bridge in baseline data
	New Tabbimoble Creek Bridge North Bound	Not constructed		No bats recorded	No bats recorded		No bats recorded - fire and flood	No bats recorded		Newly constructed

Date added into MMP	Location	Monitoring 2019	March	Monitoring 2019	July	Monitoring Oct 2019	Monitoring Jan/Feb 2020	Monitoring 2020	Aug	Baseline survey results (2014/2015), min and max # bats recorded
15-Mar	Old Tabbimoble Overflow Bridge	6 SM in bridge		298+ LtBW and 5 SM in bridge	Guano		No bats recorded - fire and flood	9 LtBW		Min: No bats Max: 166 LtBW, 1 LgBW, 1 Nsp, 2 SM
15-Mar	Tabbimoble Creek Overflow Bridge South Bound	No bats recorded		No bats recorded	No bats recorded		No bats recorded - fire and flood	No bats recorded		Not separated from Old Tabbimoble Ck Overflow Bridge in baseline data
	New Tabbimoble Creek Overflow Bridge North Bound	Not constructed		No bats recorded	Guano (fresh)		No bats recorded - fire and flood	No bats recorded		Newly constructed
15-Mar	Saltwater Creek, south of Coolgardie Rodd	Guano (fresh)		12 LtBW	1 LtBW in culvert		1 LtBW in culvert (dead), fresh guano, large pile of old guano	Guano (old)		Min: No bats Max: 1 LgBW

SM = Southern Myotis, ELB = Eastern Long-eared Bat, LgBW = Large Bent-winged Bat, LtBW = Little Bent-winged Bat, Nsp = *Nyctophilus* sp., Vsp = *Vespadelus* sp.

4.4 Impact sites

During the 2019-20 monitoring period there were 29 structures, largely consisting of new structures built at impact sites that were monitored, and they are listed along with results of monitoring events in Table 9. Most of the original 13 impact sites were required to have compensatory bat boxes installed in the adjacent vegetation or a nearby culvert / bridge prior to conducting exclusions of the structures. All exclusions were conducted prior to 2019.

At the end of the 2019-20 monitoring period only one of the 13 impacted structures scheduled to be removed had not been excluded; the Oakey Creek culvert at CH 122280. There were no microbats observed at Oakey Flat # 3, Oakey Creek culvert (Section 7) during inspections conducted in March, July or October 2019 or January-February 2020. Owing to the lack of evidence of microbat occupation at Oakey Creek throughout the monitoring period, and given the practical difficulties in securing exclusion devices, it was decided the Oakey Creek culvert would remain open. New culverts were constructed at Oakey Creek (Section 7) during 2020 and the old culvert was demolished following a pre-clearing inspection for microbats during the last quarter of 2020 (Plate 10). The compensatory bat box that was installed in a tree along Oakey Creek adjacent to the original culvert was installed in the new structure in June 2021, never having been used in its former location in a tree along Oakey Creek (Plate 5).



Plate 10: New Oakey Creek culvert, August 2020.

The Glenugie Link Bebo Arch at (CH 34900) was removed in February 2019 when no bats were present without the need for an exclusion, and compensatory box installation for this structure required the development of a prototype Bent-winged Bat Box based upon replicating the expansion jointing gaps used as roosting habitat within the Bebo Arch. Installation of the prototype Bent-winged Bat box (Plate 1) was completed in March 2019. Subsequent inspections of the Bent-winged Bat box at CH 31400 have provided evidence of use by individuals or small numbers of bats, including a single individual Little Bent-winged Bat roosting within the box in July 2019 (Table 6), and scatterings of fresh guano beneath the box and within the box during incidental inspections in February 2021, March 2021 and June 2021. The site has experienced periodic disturbance from trail bikes passing through the culvert which reduce the attractiveness of the site as an alternative roost location for Bent-winged Bats. There were no other locations that this box could be installed closer to the impacted culverts at Glenugie.

The new culverts built in place of the Bebo Arch at CH 35075 were not operational until the second quarter 2019. During inspections undertaken by TfNSW in June 2019 there was evidence of use with bats recorded as being present, however none were recorded during the monitoring inspections undertaken by ELA that same month. In October 2019 there was significant evidence that Bent-winged Bats had located and begun roosting in the culverts over winter 2019 with several moderate to large guano accumulations recorded beneath widened expansion joints in the central sections of both sets of four culverts. No bats were recorded during January 2020, but none were expected given the summer migration away from winter roosting sites to summer maternity sites by Bent-winged Bats. In addition, there had been flooding rains which washed away much of the evidence of prior use. The August 2020 inspection recorded almost 800 Little Bent-winged Bats, with roughly half in each of the two sets of four culverts. Once again, the bats were recorded in widened expansion joints towards the central section of each of the two sets of culverts. It was also noted that there were several roughened patches of concrete on the obvert of the culverts and from small to moderate guano piles beneath these, it appeared that clusters of Bent-winged Bats had also been roosting on the obvert of the culverts. The new culverts contain roosting habitat with a capacity for >2000 Bent-winged Bats in the expansion joints designed to provide microbat roosting habitat and in roughened concrete patches on the obvert of the culverts.

Opportunistic inspections of these culverts throughout the first and second quarter of 2021 have provided further evidence that Little Bent-winged Bats are utilising the roosting habitat in widened expansion joints in numbers similar to that observed in the original Bebo arch prior to its removal (a maximum of 1000+ recorded in winter 2018). Numbers of Little Bent-winged Bats roosting in the new culverts at Glenugie grew from less than 10 including several dead individuals (4 dead and one injured and taken to WIRES) in February 2021 to over 250 a month later at the end of March, culminating with over 1300+ present in June 2021 (Table 10).

The original culvert at Pheasants Creek CH 35900 was removed during 2019, after partial exclusion (internal only) of the culvert, a pre-clearing inspection prior to demolition and no evidence of microbat usage recorded in 2018. The original culvert at Picaninny Creek a few hundred metres west of Pheasants Creek has remained in place, although excluded (in June 2018) for the duration of construction (Plate 11). Prior to exclusion, this culvert contained roosting habitat for two maternity colonies of Southern Myotis in lift holes in the middle two culverts cells and upwards of 40 individuals. The internal cavities in which bats were roosting at Picaninny Creek were filled with expanding foam during the exclusion process because at the time the culvert was scheduled for removal. Picaninny Creek culvert has been

retained but currently contains no suitable roosting habitat for a maternity colony of Southern Myotis. External exclusions were removed in January 2020. New culverts were installed at Pheasants Creek and Picaninny Creek, Eight Mile Lane, Glenugie Link (Section 3A) during 2020 (Plate 12 and Plate 13).

The new Pheasants Creek culvert is a 5 cell RCPC, with all lift holes left unfilled and uncapped and maximum joint gaps in many of the expansion joints. The permanent habitat audit and recent monitoring inspections (2019-2020), as well as opportunistic inspections undertaken in early 2021 has found that the habitat available within the new Pheasants Creek culvert allows for small groupings of around 10 and potentially up to 20 Southern Myotis to roost communally. The combined requirement for newly constructed structures at Pheasants Creek and Picaninny Creek was for a capacity of up to 100 Southern Myotis (2 x original maximum occupancy) .

The original Pheasants Creek culvert hosted small aggregations of Southern Myotis prior to construction, with two maternity colonies present in the adjacent Picaninny culvert. There have been occasional observations of Southern Myotis utilising the new Pheasants Creek culvert, with 2 Southern Myotis present in March 2019, 5 Little Bent-winged Bats and 1 Southern Myotis present in July 2019, 1 Southern Myotis present in October 2019, and light guano accumulations on the base of the culvert in most cells beneath most lift holes, including bat bug casings within many lift holes during most inspections.



Plate 11: The original Picaninny Creek culvert showing exclusions still semi-intact following flooding in January 2020.



Plate 12: Newly installed culverts at Pheasants Creek, Eight Mile Lane, Glenugie Link, Section 3A, October 2019.

The new Picaninny Creek culvert is a longer but lower box culvert that runs under Eight Mile Lane. Although it is used by bats as evidenced by light guano beneath some expansion joints during the October 2019 inspection, the low height of this culvert makes it unlikely to be used by Southern Myotis. The guano present was representative of *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) guano.

To date there has been no evidence of the re-establishment of a maternity colony of Southern Myotis at Picaninny or Pheasants Creek. The three x four chambered bat boxes installed in trees along Pheasants Creek have never been used. These boxes were installed beneath the new Pheasants Creek Bridge in June 2021. Further summer monitoring is required to evaluate whether the maternity colony of Southern Myotis from Picaninny Creek re-establishes itself beneath Pheasants Creek Bridge or within the newly created culvert at Pheasants Creek.

If no evidence of use of the boxes, or of a maternity colony of Southern Myotis established within Pheasants Creek culvert during summer 2021/22 monitoring, adjustments may need to be made to the original Picaninny Creek culvert which was retained, and further summer monitoring undertaken. It is suggested that the expanding foam / exclusion material be removed from as much of the roosting habitat (lifting holes in culvert cells 2 and 3) in the original Picaninny Creek culvert as soon as possible to allow for Southern Myotis to move through the culvert cells, locate potential habitat and roost within it. There have been changes to the environment outside the original Picaninny Creek culvert which may reduce its suitability as a roosting and breeding habitat location for Southern Myotis in the short to medium term. These changes include the removal of vegetation surrounding the culvert, landform and

drainage changes which reduce levels of water moving through the culvert and reduce levels of protection from the elements.



Plate 13: Newly installed culverts at Picaninny Creek, Eight Mile Lane, Glenugie Link, Section 3A, October 2019.

There were no microbats recorded in the culverts at Maclean Cut by ELA during the 2019/20 monitoring period, however there was evidence of small to moderately sized aggregations having been present between monitoring events in the form of guano piles beneath most exclusion joins and bat bug casings around several of the lift holes of the two main culverts suitable as microbat roosting habitat at CH 82030 and CH 82330 (Plate 14 and Plate 15). The permanent habitat audit however found that the capacity of microbat habitat available in the new culverts was at most two hundred bats. The original culverts at Maclean cut contained up to 300 bats and new structures were required to contain habitat for up to 650 bats to allow for expansion of the colony and errors associated with minimal monitoring of the culverts prior to preparation of the MMP.

These findings led to the requirement for additional permanent habitat for Bent-winged Bats to be installed within a suitable nearby structure. Investigations of culverts located between Maclean cut and Green hills were undertaken during the first quarter 2021 (Table 6 and Table 10). The nearest suitable structure was a box culvert at Green hill CH 76450 and a Bent-winged Bat Box constructed from Hebel blocks was installed within this culvert in June 2021 (Plate 4). During inspections of this culvert in February 2021, it was noted that there were several widened expansion gaps and evidence in the form of guano that small numbers of bats had roosted at the site previously. A small cluster of eight Little Bent-winged Bats were present in one of the widened expansion joints during installation of the Bent-

winged Bat Box in June 2021. The bats did not show any signs of stress during 1 day installation of the Bent-winged Bat Box and were located approximately 8 m from the installation site.

The Devil's Pulpit tie-in section contained two impacted concrete box culverts, one of which was also a fauna underpass. A small amount of microbat guano was observed in the culvert at CH 106170 during October 2019. No other evidence of microbats was recorded at this location during the 2019-20 monitoring period.



Plate 14: Microbat guano beneath an expansion joint of one of the new Maclean cut culverts, August 2020.



Plate 15: Original box culvert (now sealed, lower LHS) and newly constructed culvert (upper, RHS) at Maclean cut, October 2019.

Table 9: Results from monitoring inspections at the impact sites throughout 2019 and up to winter 2020

Section	Chainage	Location	Construction dates	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	Baseline survey results (2014/2015), min and max # bats recorded
Glenugie Link	35075	Glenugie Link culverts	Newly constructed	No construction	(active)	No construction	(active)	Guano (moderate - large) beneath central expansion joins indicating large aggregations of bats have been present over winter.		No bats recorded	780+ LtBW, roughly half in each series of 4 culverts, using widened expansion joins, large guano piles beneath other joins. 3 LgBW in a separate expansion join	Min: no bats (summer) Max: >1000 LtBW/LgBW
Glenugie Link	35880	Picaninny Creek, Eight Mile Lane	Newly constructed	No construction	(active)	No construction	(active)	Guano (light) beneath many expansion joins, likely Eastern Horseshoe Bat due to low height of culvert.		No (flooded)	No (no habitat for Southern Myotis)	Min: 26 SM incl 9 pups Max: 33+ SM
Glenugie Link	35900	Pheasant Creek, Eight Mile Lane	Removed Sept 2019	No bats recorded (internal exclusions only)		Guano (light) (internal exclusions only)		No (removed)		No (removed)	No (removed)	Min: 6 SM Max: 7 SM incl 2 pups
Glenugie Link	35900	Picaninny Creek, Eight Mile Lane	Retained	No bats recorded (exclusions in place)		No bats recorded (exclusions in place)		No bats recorded (exclusions in place)		No bats recorded (external exclusions removed)	No bats recorded	Min: 26 SM incl 9 pups Max: 33+ SM
Glenugie Link	36010	Pheasant Creek, Eight Mile Lane	Newly constructed	2 SM		5 LtBW, 1 SM		1 SM in lift hole, guano (light) beneath many lift holes		No bats recorded (recently flooded)	Guano (light) beneath most lift holes	Min: 6 SM Max: 7 SM incl 2 pups

Section	Chainage	Location	Construction dates	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	Baseline survey results (2014/2015), min and max # bats recorded	
Glenugie Link	36379	Pheasant Creek Bridge	Newly constructed	No construction	(active)	No bats recorded (very limited habitat available - potential location for Southern Myotis bat box)	No	(not part of MMP)	part of	No (not part of MMP)	part of	No bats recorded (very limited habitat available - potential location for Southern Myotis bat box)	Min: 6 SM Max: 35+ SM including pups across two culverts (Pheasants and Picaninny Creek)
4	76450	Greenhill Cut	Newly constructed	No bats recorded - potential location for Bent-winged Bat Box		No (not part of MMP)		No (not part of MMP)		No (not part of MMP)		No (not part of MMP)	Min: Guano (summer) Max: 330+ LtBW
4	75560	Greenhill Cut	Newly constructed	No bats recorded - potential location for Bent-winged Bat Box		No (not part of MMP)		No (not part of MMP)		No (not part of MMP)		No (not part of MMP)	No relevant baseline
4	81440	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No (active construction)		No (active construction)		No bats recorded	Min: No bats Max: No bats
4	81645	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No (active construction)		No (active construction)		No bats recorded	Min: No bats Max: Guano
4	81770	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No (active construction)		No (active construction)		No bats recorded	Min: No bats Max: No bats
4	81825	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No (active construction)		No (active construction)		No bats recorded	Min: No bats Max: Guano

Section	Chainage	Location	Construction dates	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	Baseline survey results (2014/2015), min and max # bats recorded
4	82030	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No bats recorded	Yes		Yes	Min: Guano, bat bugs, heavy staining Max: 330+ LtBW across two culverts at Maclean cut
4	82330	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		Guano (moderate amount) beneath most expansion joints as well as bat bug casings	Guano (moderate amount) beneath most expansion joints as well as bat bug casings	Guano (moderate amount) beneath most expansion joints as well as bat bug casings	Guano (moderate amount) beneath most expansion joints as well as bat bug casings	Min: Guano, bat bugs, heavy staining Max: 330+ LtBW across two culverts at Maclean cut
4	82610	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No bats recorded	Guano (light)		No bats recorded	Min: No bats Max: No bats
4	82740	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No bats recorded	No bats recorded		No bats recorded	Min: No bats Max: No bats
5	82860	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No bats recorded	No bats recorded		No bats recorded	Min: No bats Max: Guano
5	82970	North of Jubilee Street overbridge	Newly constructed	No (excluded)		No (excluded)		No bats recorded	No bats recorded		No bats recorded	Min: No bats Max: No bats
Devil's Pulpit	106185	New fauna underpass box culvert northbound	Newly constructed	No (not constructed)		No (not constructed)	(not constructed)	No (active construction)	No (active construction)		1 LtBW	Min: No bats Max: Guano

Section	Chainage	Location	Construction dates	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	Baseline survey results (2014/2015), min and max # bats recorded
Devil's Pulpit	106190	Fauna underpass box culvert	Structure planned to be removed 31 Jan – 15 Apr 2019.	No (excluded)		No (excluded)		No (active construction)		No (excluded)	No bats recorded (external exclusion removed)	Min: No bats Max: 50+ LtBW/LgBW
Devil's Pulpit	106230	Devil's Pulpit culvert with bat box	Existing	No bats recorded		No bats recorded		Guano (very light) beneath box and on box walls		No bats recorded	No bats recorded	Min: No bats Max: Guano
7	122190	New Oakey Flat culvert	Newly constructed	No (not constructed)		No (not constructed)	(not constructed)	No (active construction)		No (active construction)	No bats recorded (very limited habitat available - potential location for Southern Myotis bat box)	Min: No bats Max: 5 SM incl pup
7	122280	Oakey Flat # 3 Oakey Creek	Removed 2019	No bats recorded		No bats recorded		No bats recorded		No (removed)	No (removed)	Min: No bats Max: 5 SM incl pup
7	122280	New Oakey Flat # 3 Oakey Creek	Newly constructed	No (not constructed)		No (not constructed)	(not constructed)	No (active construction)		No (active construction)	No bats recorded (very limited habitat available - potential location for Southern Myotis bat box)	Min: No bats Max: No bats
7	122550	New Oakey Creek overflow	Newly constructed	No (not constructed)		No (not constructed)	(not constructed)	No (active construction)		No (active construction)	No bats recorded (very limited habitat available - potential location for	Min: No bats Max: No bats

Section	Chainage	Location	Construction dates	Monitoring 2019	March	Monitoring 2019	July	Monitoring 2019	Oct	Monitoring December 2019 - Postponed to Jan/Feb 2020 due to bushfires	Monitoring August 2020	Baseline survey results (2014/2015), min and max # bats recorded
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Southern Myotis bat box

SM = Southern Myotis, LgBW = Large Bent-winged Bat, LtBW = Little Bent-winged Bat

Table 10: Results from opportunistic monitoring inspections at selected impact sites from February 2021 to June 2021.

Section	Chainage	Date added to MMP	Location	Construction	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021	Baseline survey results (2014/2015), min and max # bats recorded	
	2	31400	Feb-19	Glenugie Culvert Bent-winged Bat Box	Existing	Fresh guano on ground and in box, likely only roosting by singles or pairs	No (no scheduled monitoring)	Fresh guano on ground and in box, likely only roosting by singles or pairs	Fresh guano on ground, likely only roosting by singles or pairs	Min: Guano Max: 2000 LtBW
Glenugie Link	35075		Glenugie Link culverts	Newly constructed	7 LtBW incl 4 dead and 1 injured (rescued), large guano piles, bat bug casings and staining on roughened obvert patches	13 LtBW incl 2 dead, two separate clusters in expansion joins, large guano piles, bat bug casings and staining still present	250+ LtBW across 2 expansion joins, incl 1 injured bat hanging from outside expansion join, unable to be rescued, large guano piles, bat bug casings and staining still present	1300+ LtBW using widened expansion joins towards middle of culverts, large guano piles beneath other joins and some beneath roughened patches on obvert	Min: Guano Max: 2000 LtBW (same structure as above)	

Section	Chainage	Date added to MMP	Location	Construction	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021	Baseline survey results (2014/2015), min and max # bats recorded
Glenugie Link	36010		Pheasant Creek, Eight Mile Lane	Newly constructed	2 SM as singles in Cell 3 and Cell 5, guano in all cells beneath grab holes and some expansion joins, Rhino guano as well	No (no scheduled monitoring)	No (no scheduled monitoring)	No (no scheduled monitoring)	Min: 6 SM Max: 35+ SM including pups across two culverts
Glenugie Link	36379		Pheasant Creek Bridge	Newly constructed	No bats recorded	No (no scheduled monitoring)	No (no scheduled monitoring)	No bats recorded	Min: 6 SM Max: 35+ SM including pups across two culverts (same structures as above)

Section	Chainage	Date added to MMP	Location	Construction	Opportunistic Monitoring Feb 2021	Opportunistic Monitoring 25 March 2021	Opportunistic Monitoring 31 March 2021	Opportunistic Monitoring June 2021	Baseline survey results (2014/2015), min and max # bats recorded
4	76450	Mar-19	Greenhill Cut	Newly constructed	Guano, light scattering under several expansion joints	No (no scheduled monitoring)	No (no scheduled monitoring)	8 LtBW using widened expansion joint at E end of culvert, guano pile beneath.	Min: Guano, bat bugs, heavy staining Max: 330+ LtBW across two culverts at Maclean cut
7	122280	Aug-20	New Oakey Flat # 3 Oakey Creek	Newly constructed	No (no scheduled monitoring)	No (no scheduled monitoring)	No (no scheduled monitoring)	No bats recorded	Min: 1 SM Max: 5 SM incl mother and pup

5. Discussion

5.1 2019-20 disturbance events

5.1.1 Bushfire

The extensive, severe bushfire event of 2019-2020 has impacted areas of the W2B study area. During September 2019 to March 2020, the northern parts of NSW experienced extreme fire impacts following persistent drought. In early February 2020, heavy rain extinguished a significant number of fires in the W2B area but caused flooding of many of the W2B Microbat monitoring sites.

The impact of the bushfires on native fauna is subject to ongoing investigation. Besides immediate fire mortalities, further post-fire deaths are expected to occur due to additional indirect impacts (e.g. starvation, reduced shelter and increased feral predator attacks).

Bushfires affected Sections 6, 7, 8, 9 and 10 of the subject area in 2019-20. The wider Tabbimoble Creek area (Plate 16) was impacted by bushfire in 2019-20. A bat box was lost to fire (Plate 17), while a further four boxes were scorched but remained functional. We do not consider it necessary to replace the box that was lost as these boxes were temporary replacement habitat, permanent habitat being available within the adjacent Tabbimoble Creek Bridges.



Plate 16: Burnt section of Tabbimoble Creek showing a tree-mounted bat box (upper central portion of image), 2020.



Plate 17: Burnt section of Tabbimoble Creek showing a fallen tree mounted bat box across the creek line, January 2020.

5.1.2 Microbat monitoring

The transition between construction and operational phases of the W2B project occurred during the 2019-2020 microbat monitoring period along the W2B alignment. The monitoring actions required to be undertaken at each subject drainage structure were completed in the correct sequence; including finalisation of exclusions, quarterly monitoring of structures and boxes throughout the construction period transitioning to twice annual monitoring in winter and summer during the operational phase of the project, completion of the permanent habitat audit and installation of any further permanent habitat required following the audit.

The use of compensatory bat boxes has had poor results at impacted sites with only two boxes out of a total of 16 installed (12.5%) being utilised adjacent to the impacted structures (Pheasants Creek, Picaninny Creek, Maclean Cut, Oakey Creek, Devil's Pulpit). This is in comparison to seven of the 22 boxes (32%) installed at control sites (Serpentine Channel, Mororo Bridge, Tabbimoble Creek and Tabbimoble Overflow) being used. The main reason for this is that of the four target microbat species, only Southern Myotis is known to regularly use bat boxes and prefers to inhabit boxes when installed under bridges or in culverts directly over water. The majority of the bat boxes installed at control sites were for Southern Myotis. All boxes installed at impacted sites have been installed in trees, often along creek lines, but not always over permanent waterways. Although placement of boxes in trees was as

per the MMP, this represented sub-optimal placement of boxes for the target species which are primarily subterranean roosting species, particularly the Bent-winged Bats.

The 2019-20 monitoring period has seen three target species; Little Bent-winged Bats, Large Bent-winged Bats and Southern Myotis inhabiting newly installed structures or bat boxes along the W2B alignment.

It was known prior to construction that large aggregations of Little Bent-winged Bats and some Eastern Bent-winged Bats over-wintered in numerous structures impacted by the W2B project. Sites that can accommodate large aggregations of bats are uncommon in the landscape. Where impacts to roosting habitat cannot be avoided on existing structure upgrades or structure extensions, where possible, careful temporal staging of works under the supervision of a microbat ecologist should be applied to target works when these species are absent from the winter roost sites (late Sept – mid February on the North-coast of NSW). Given that the Bent-winged Bat Box retrofitted into culverts has not yet been proven to be effective to offset construction phase impacts to large aggregations of Bent-winged Bats, this issue requires ongoing investigation into effective mitigation measures when impacts cannot be avoided. It is suggested that the detailed design drawings for newly built structures include at least 4 x widened expansion joins per culvert cell (aiming for minimum width of 20mm) leaving lift holes unfilled and uncapped as standard specifications going forward for any projects where impacts to microbat roosting habitat in structures have been identified.

Significant positive results from this monitoring period include:

- the occurrence of 12 Eastern Long-eared Bats (vulnerable under the BC Act) recorded in a bat box at Tabbimoble Creek in Section 6, being a repeated occurrence for this species at this location,
- establishment of a large maternity colony of Southern Myotis at Serpentine Channel Bridges,
- Southern Myotis maternity population numbers at Mororo Bridge equal to or greater than numbers recorded prior to construction
- first confirmed use of the prototype Hebel Bent-winged Bat Box at Glenugie CH 31400 by a single Little Bent-winged Bat, and regular use of the box by small numbers of bats as evidenced by the presence of fresh guano,
- increasing numbers of Little Bent-winged Bats returning to roost in the new box culverts at Glenugie Link, such that numbers are now equal to, or exceed maximum numbers recorded in original structure that was removed
- installation of a second Hebel Bent-winged Bat Box in Section 4 at Greenhill cut CH 76450 and the presence of a small cluster of Little Bent-winged Bats within an expansion join of the culvert during box installation in June 2021
- completion of the permanent habitat audit and installation of all permanent habitat required.

Of note is the lack of evidence that a maternity colony of Southern Myotis has been able to re-establish within the newly constructed culverts at Picaninny Creek and Pheasants Creek on Eight Mile Lane. Whilst there have been observations of small groups and individual Southern Myotis at the new Pheasants Creek culvert, no evidence of breeding has been observed and the numbers are below those recorded prior to construction commencing. Recent research has indicated that Southern Myotis have very strong site fidelity when it comes to maternity roosts (Gorecki, 2020). This research has also found that there

are significant genetic differences between maternity colonies, even between those located in adjacent culverts and that aggressive behaviours are exhibited by Southern Myotis at roost sites (Gorecki 2020). The implication being that colonies whose roosts are lost will have difficulty integrating into surrounding colonies and require suitable alternatives to be provided prior to loss / disturbance to their original roosts (Gorecki 2020).

It is important that all efforts be made to re-establish a maternity colony of Southern Myotis in the vicinity of Pheasants Creek and Picaninny Creek. Given the original Picaninny Creek culvert remains, it may be possible to re-habilitate this culvert to allow Southern Myotis to roost within it. Currently it has expanding foam applied within all lift holes and expansion joints. It is recommended that this be removed from the original roosting sites in lifting holes in cells 2 and 3 of the culvert in such a way that promotes and facilitates uptake by Southern Myotis. Continued monitoring of the bat boxes installed beneath Pheasants Creek Bridge and the new Pheasants Creek culvert are required to monitor the situation. It is suggested that this be reviewed following summer 2022 monitoring. If there has been no establishment of a maternity colony of Southern Myotis in the vicinity of Pheasants Creek and Picaninny Creek, continued monitoring is likely to be required.

Interpretation of monitoring results is still limited to some degree, given that there has only been two full years of monitoring data collected, one during construction and one post construction. During this period there was also the significant disturbance event of the 2019-2020 bushfire season. Microbat utilisation of a structure often changes throughout the year and a comparison of utilisation rates at similar times of year over many years is more likely to provide useful information on population trends. In addition to this, microbat numbers at a particular location fluctuate in response to climatic conditions, local food availability and the build-up of parasites within roosts. They are also likely to be affected by disturbance from construction activities (noise and vibrations). There was some potential evidence for a short-term disturbance effect from construction observed at the Mororo Bridge Southern Myotis maternity colony which is no longer apparent. For many of the sites, active construction was occurring in close proximity for a large portion of the monitoring period, including designated control sites where construction was occurring within 50 m of the control structure. This raises concerns over the integrity of control sites, however the availability of suitable, alternative control sites outside the alignment remains a limiting factor. It is noted that Southern Myotis appears to be reasonably resilient to construction disturbance events in bridges.

The four boxes underneath Mororo Bridge (south) were also not installed as part of the W2B project. Mororo Bridge is a control site and any existing boxes attached to the bridge whether used or unused should remain where they were originally placed. Significant degradation of these boxes has been noted during monitoring inspections, with the timber permanently coated with excretions (guano and urine) from the bats. The boxes are often at capacity and the local population of Southern Myotis would benefit from installation of at least 6 new boxes of similar size or with a capacity to accommodate up to 500 Southern Myotis at this location.

It is recommended, although not required as part of the W2B project, that the additional boxes be constructed from a mixture of marine grade ply manufactured in a lattice style (proven to be successful for Southern Myotis at numerous sites throughout NSW) and from Cyplas as this material is not likely to react with guano and urine and create an unhealthy environment in the bat boxes. A mixture of

materials is recommended because long term usage of Cyplas boxes by Southern Myotis (or any microbat species) has not been documented as this material is new to the market.

The 8 boxes installed adjacent to Tabbimoble Creek Bridges have had the most success in terms of bat occupation, although not by any of the target species. This is a control sites and boxes were installed as an additional measure to provide compensatory habitat in case bats were displaced by works in proximity to the control roost sites. Given several of the eight Tabbimoble Creek boxes have been used they should remain in place.

The single box installed in a culvert at Devil's Pulpit as compensatory habitat for roosting habitat being lost from an adjacent culvert and fauna underpass has not yet been used. It should remain in place for permanent habitat for the future. The culvert is still the best place for this box to be located as it is catering for unknown bat species with prior evidence of occupation being only in the form of guano.

Remaining MMP activities to be finalised include:

- Summer 2021/2022 monitoring of all structures and bat boxes remaining on the project
- Winter 2022 monitoring of all structures and bat boxes remaining on the project
- Report on the results of summer and winter 2021/2022 monitoring
- Review progress against MMP targets
- Following the winter 2022 monitoring, evaluate whether continued monitoring or adaptive management at any structure is required if the uptake of permanent habitat has not fulfilled requirements of the MMP (GeoLINK 2015b).
- Report on the newly installed prototype Bent-winged Bat boxes at CH 31400 and CH 76450, to ascertain if this type of box can provide an effective alternative habitat for Bent-winged Bats

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