Melbourne Water Corporation

Sugarloaf Pipeline Project Toolangi Habitat Linkage Monitoring

Effectiveness of Glider Pole Linkages

May 2017

Acknowledgements

The following individuals or groups have assisted in the preparation of this report. However, it is acknowledged that the contents and views expressed within this report are those of GHD Pty Ltd and do not necessarily reflect the views of the parties acknowledged below:

- The Department of Environment, Land, Water and Planning (DELWP) for allowing access to records in the VBA database
- Melbourne Water Corporation staff including Andrea Burns, Paul Evans, Alex Sneskov, Anna Zsoldos, Mark Scida, Warren Tomlinson and Steve McGill for providing assistance, support and advice throughout the project

Abbreviations

DELWP	Victorian Department of Environment, Land, Water and Planning (formerly DEPI)
DEPI	Victorian Department of Environment and Primary Industries (now DELWP)
DSE	Department of Sustainability and Environment (now DELWP)
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EVC	Ecological Vegetation Class
EWP	Elevated Work Platform
FFG	Flora and Fauna Guarantee Act 1988
GHD	GHD Pty Ltd
ROW	Right of Way
MW	Melbourne Water Corporation
Spp.	More than one species
TSF	Toolangi State Forest

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

The Sugarloaf Pipeline Project (the Pipeline) was completed in February 2010 to enable the transfer of water from the Goulburn River in Yea to the Sugarloaf Reservoir, Christmas Hills. The Pipeline received State Government approval and Federal approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2008, subject to conditions. The conditions included the obligation to undertake works in accordance with an Environmental Management Strategy (EMS), which identified and documented particular actions and requirements for the project before, during and after pipeline construction.

One of the post-construction requirements was to establish habitat linkages across sections of the newly-cleared pipeline route. Habitat linkages were implemented within Toolangi State Forest (TSF), aiming to restore habitat connectivity for both arboreal and ground-dwelling fauna. Three types of habitat linkages were established for the project:

- Glider poles
- Coarse woody debris (CWD)
- Culverts

The requirement that forms the basis of this report and this Melbourne Water Corporation (MW) project is included in Attachment 7 of the EMS (Mitigation Plan for EPBC Act and FFG Act Listed Fauna Species), and is stated as follows:

> "*For a period of at least two years, the use of the habitat linkage crossings that have been installed within the Toolangi State Forest will be monitored for their effectiveness and usage by native fauna".*

This report covers the monitoring of the glider poles habitat linkages only.

Glider poles were installed along the construction corridor in Toolangi State Forest in a post-construction effort to help gliding (volant) mammals (e.g., Greater Glider, Sugar Glider) cross the treeless corridor more safely. Greater Gliders and Sugar Gliders were seen in Toolangi by Sugarloaf Alliance ecologists during pre-construction surveys (spotlighting). In February 2009, catastrophic bushfires burned the Toolangi forest. The numbers of gliders that persisted or that have since recolonised is unknown.

The glider pole habitat linkages monitoring program (the Project) was established in November 2014.

1.2 Study site

The study site occurs within the Toolangi State Forest, Victoria, approximately 80 km to the northeast of Melbourne. The study site is located across the Highlands-Northern Fall (HNF) and Highlands-Southern Fall (HSF) Bioregions and is comprised of a mixture of Heathy Dry Forest, Damp Forest, Lowland Forest and Shrubby Foothill Forest Ecological Vegetation Classes (EVCs).

The pipeline follows a newly cleared easement (Right of Way, ROW) through Toolangi State Forest on the eastern side of the Melba Highway. For the purpose of this Project, Toolangi State Forest has been divided into three sections: north, central and southern (see section 2.1 and Figure 1). Glider Pole habitat linkages have been installed in all three sections, but only the northern and central sections were included in the monitoring.

1.3 Objective

The objective of this project is to develop and implement a scientifically rigorous habitat linkage monitoring program for two years. The program is to be based on the requirements set out in the EMS and as determined and agreed in consultation with the Department of Environment, Land, Water and Planning (DELWP) (2012).

1.4 Limitations

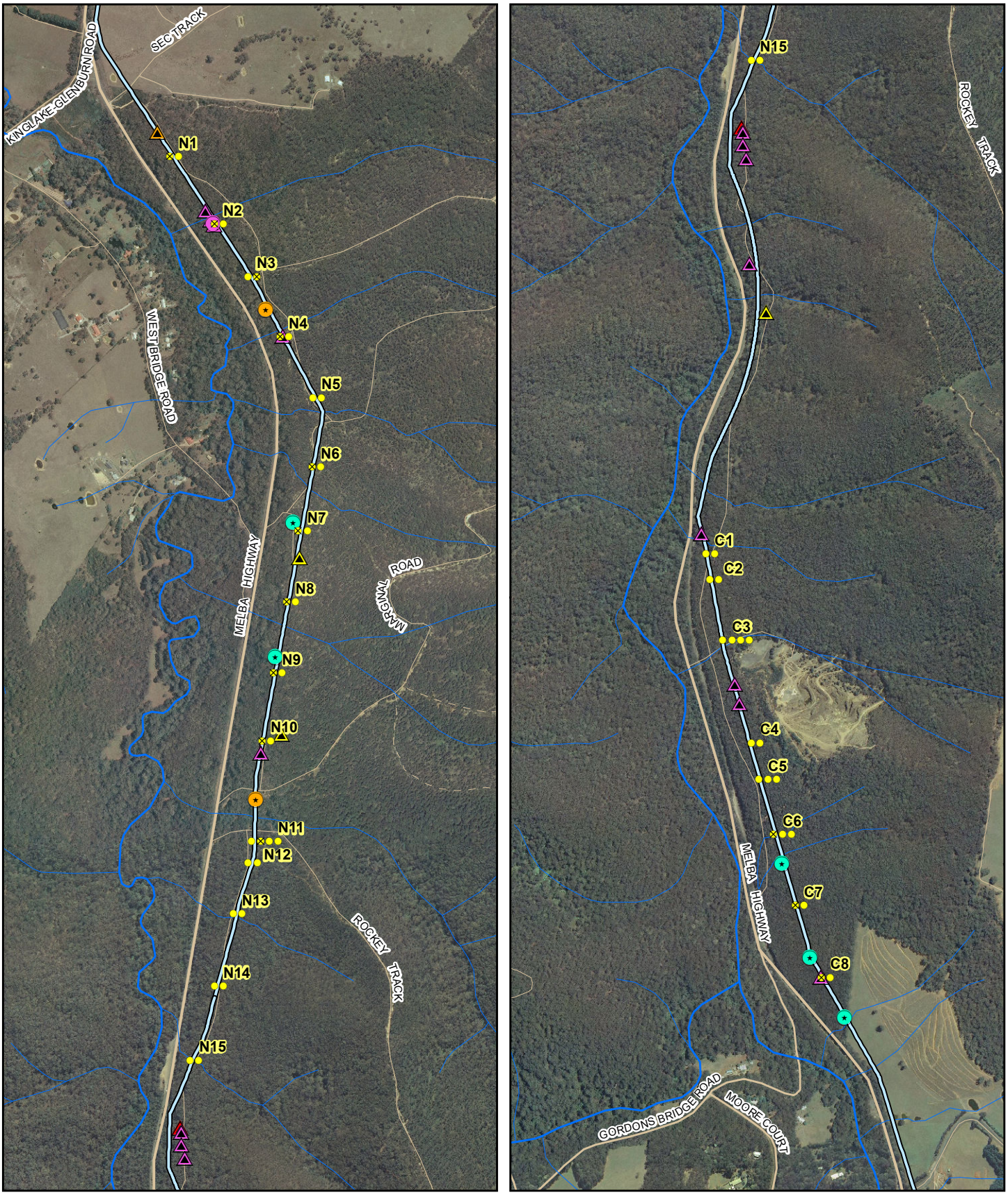
This report has been prepared by GHD for Melbourne Water Corporation and may only be used and relied on by Melbourne Water Corporation for the purpose agreed between GHD and the Melbourne Water Corporation as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person/entity other than Melbourne Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.



LEGEND

- Camera Locations
- Glider Pole Locations
- Pipeline

Glider Locations

Preliminary Spotlighting

- Greater Glider
- Sugar Glider
- Yellow-bellied Glider

Control Spotlighting

- Brushtail Possum
- Common Ringtail Possum
- Greater Glider
- Yellow-bellied Glider

1:15,000 @ A4

0 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Melbourne Water
Toolangi Habitat Linkages Monitoring

Job Number 31-29843
Revision A
Date 05 Apr 2017

Preliminary Glider Mapping

Figure 1

G:\31\29843\GIS\Maps\Working\3129843_004_GliderMapping_A4P.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Melbourne Water - Imagery (2007). VICMAP - Roads, Waterways, Pipeline (2007). GHD - Glider Poles (2017). Created by: CI, CM

2. Methods

2.1 Approach

The approach used for this project had three parts:

1. Preliminary spotlighting surveys to locate arboreal fauna and thus inform appropriate placement of cameras along the alignment.
2. Establishing wireless cameras on a subset of the poles to monitor the use and effectiveness of glider pole linkages.
3. Ongoing spotlighting surveys during the two-year camera deployment period to provide supporting information for camera results and potentially to determine the need for stopping points for the project. (Stopping points were ultimately not required so have not been described below.)

Methods for these three parts are described below.

2.1.1 Preliminary spotlighting

Given the devastation of the forest caused by the 2009 fires, preliminary spotlighting surveys were undertaken in the Toolangi forest to assess whether the numbers of fauna living in the forest warranted glider pole monitoring, and if sufficient animals were detected, to inform the best locations for glider pole monitoring so that the chances of success and cost-effectiveness were maximised.

Spotlighting was undertaken along the ROW in the sections of forest that contain glider poles i.e. north, central and southern sections, to provide baseline information on i) the presence of arboreal mammals, and ii) the relative abundance of arboreal mammals (particularly gliders). This information assisted in determining suitable locations for glider pole cameras.

Spotlighting involves the use of hand-held or head mounted, focussed light beams to locate nocturnal fauna by their movement and/or by their eye-shine. This technique is a standard and widely-used method for detecting nocturnal mammals and birds.

Spotlighting was done on foot (walking). The entire length of alignment through the Toolangi State Forest was assessed by spotlighting on three separate occasions (rounds). The information gathered during all three surveys was then combined, and used to inform placement of cameras.

Each round of preliminary spotlighting was conducted by two GHD ecologists over two consecutive survey nights (i.e., four person-nights) to enable the entire study area to be assessed, and was undertaken under favourable conditions for detecting gliders. Surveys were undertaken between 30 January 2013 and 28 February 2013 (Table 1).

All fauna detected were identified to species (where possible) and recorded with a GPS location.

The location of gliders was not taken into consideration during the installation of glider poles for this project however based on the likely glider species present, the distance between glider poles was taken into account, and glider poles were placed at intervals no larger than 15 m apart across the ROW. Preliminary spotlighting was then undertaken to inform which poles to monitor based on the known presence of gliders in the surrounding area.

2.1.2 Establishing cameras

Following construction of the pipeline, 83 glider poles were established in 37 linkages along the ROW through Toolangi. Because each linkage has multiple poles, the unit of replication for this project was considered to be the linkage, not the pole. A representative sub-sample (at least 30%) of linkages were monitored. In total 13 linkages were monitored, with one camera established at each. This number factored in contingency, such that the failure of up to two cameras (but no more) would still result in 30% or more of linkages being monitored, thereby satisfying the DSE standard referred to by the independent reviewer.

The location of the 13 linkages chosen for monitoring was determined by the location of gliders detected during the preliminary spotlighting. As a result cameras were set up in the north and central sections only. No gliders were found in the southern section so this area was not included in the camera monitoring.

The following linkage locations had cameras installed (refer Figure 1):

North Section – N1, N2, N3, N4, N6, N7, N8, N9, N10 and N11

Central Section – C6, C7 and C8

Motion-triggered cameras were used, which provide colour pictures during the day and infrared (greyscale) pictures at night with no visible flash. To reduce maintenance over the course of the monitoring program, solar panels were installed and connected to cameras, and cameras were operated with wireless data retrieval technology. Thus, the wireless cameras provided constant survey effort. Circumferential glider diversion devices (tree collars) were used to direct pole-climbing mammals into the camera's field of view. Tree collars were placed below the downward-facing camera, and the single break/gap in the collar allowed animal passage up or down the pole in full view of the camera. The purpose of tree collars is not to restrict the movement of gliders to certain poles, but to direct gliders into the field of view for the camera.

At each of the 13 camera locations the following were set up:

- Custom arboreal fauna pole surveillance system, based on BuckEye Cam X7D Covert IR wireless surveillance camera (AU frequency) with standard antenna. Includes focus and IR calibration modifications to suit application
- Customized adjustable camera strut and circumferential glider diversion device
- BuckEye Cam solar panel for X7D camera

At select linkages within the alignment the following additional equipment was installed in conjunction with the camera equipment described above, to allow the photos from the cameras to be downloaded remotely via the mobile phone network.

- BuckEye Cam X Series Next-G CellBase kit. Consisting of LAN and cellular modems (AU frequencies), weatherproof housing, standard antenna, PC Base software and configuration assistance
- Monocrystalline 40 or 80 watt solar panel, regulator and heavy duty pole mounting system, 33 amp-hour SLA battery and pole mounting cradle
- Element 6 dBd Yagi antenna and cable to suit X series cameras, with tree mounting brackets
- X Series hi-gain omni-directional repeater antenna

Each glider pole camera and associated apparatus was set up in situ with the use of an elevated work platform (EWP) (see Plate 1 and Plate 2).

Cameras were in installed over three days in late 2014 (27, 30 and 31 October) and retrieved more than two years later on the 24 November 2016. All cameras were operational for the duration of this period, with the exception of N1, which had been shot at with a firearm and was no longer operational from approximately March 2016, and C6, which lost power in approximately August 2016.

All cameras were set to take a single photo (still image) per trigger.

Plate 1 Setting up with EWP

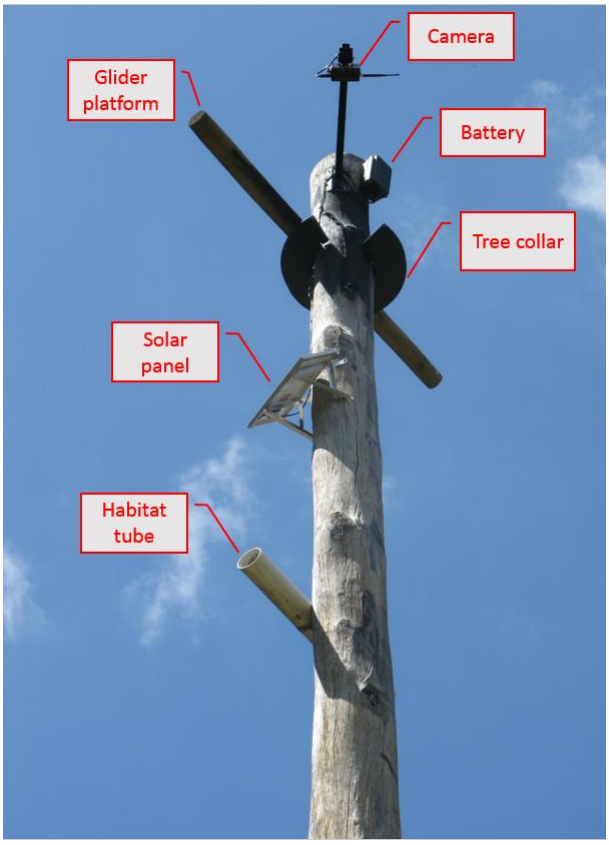


Plate 2 Camera set up

2.1.3 Control spotlighting

To provide a scientific control for the glider pole camera results, periodic spotlighting surveys (control spotlighting) were undertaken in the habitat surrounding glider pole cameras. Information gathered during control spotlighting surveys could provide important supporting information that could be compared to glider pole camera results, enabling more informed conclusions about glider activity in the study area (i.e. glider activity levels in surrounding habitat against glider activity recorded on poles). Control spotlighting is an important component of the monitoring program, allowing more robust data and informed outcomes.

Control spotlighting was undertaken approximately every three months throughout the two-year monitoring period (total of eight control spotlight rounds). Spotlighting effort included walking the length of the ROW in the areas that glider pole cameras were set up (i.e. north and central sections). Both the north and central sections were covered on each of the two nights of spotlighting per round. Sections were typically surveyed in the opposite direction on the two nights to avoid time-of-evening bias.

Surveys were undertaken in a range of weather conditions but were typically planned for weather considered favourable for arboreal mammals. Each control spotlighting survey took four person-nights (two people, two evenings) to complete.

2.2 Timing

As a result of the Black Saturday fires of 2009 there was little habitat for gliders present after the installation of the pipeline. Therefore, there was a lull of several years between the installation of the poles and the commencement of the monitoring program to allow time for gliders and other fauna to return to the forest.

Spotlighting surveys and camera monitoring were conducted between January 2013 and November 2016 (Table 1).

Table 1 Survey Timing

Type	Round	Dates	Season	Sections Surveyed
Preliminary Spotlighting	1	30 & 31 Jan 2013	Summer	North, central and southern
	2	14 & 18 Feb 2013	Summer	
	3	27 & 28 Feb 2013	Summer	
Control Spotlighting	1	21 & 22 Jan 2015	Summer	North and central
	2	15 & 16 April 2015	Autumn	
	3	19 & 20 Aug 2015	Winter	
	4	18 & 19 Nov 2015	Spring	
	5	25 & 29 Feb 2016	Summer	
	6	22 June 2016 & 6 July 2016	Winter	
	7	21 & 22 Sept 2016	Spring	
	8	16 & 17 Nov 2016	Spring	
Camera Survey	NA	27-31 Oct 2014 to 24 Nov 2016	All	North and central

2.3 Data analysis

2.3.1 Downloading and management of data

Using the mobile phone network, cameras were set up to send photos wirelessly to a computer while they were in situ. After they were retrieved, cameras were checked for additional photos that may have been saved internally.

Every image from every camera was assessed for animals. Where an animal was found, the species, number of individuals and corresponding camera number, linkage location, photograph number, time, date and other metadata were recorded.

Some preliminary screening was conducted on the total images captured over the course of the project. Because the cameras are motion-sensing, animals that spend longer in front of cameras are likely to result in more photos being taken than animals that spend less time in front of cameras. This can skew results, because the numbers of photos do not reflect the numbers of individuals, and the numbers of photos per individual varies. Therefore, for some analysis, multiple triggers of the same individual were removed where possible on the basis of the timestamp of the photo. Repeated detection of the same animals at different poles, at broader time intervals or on different days cannot be eliminated.

All photographs have been retained on disc (even if no animals were present) for future reference.

All data were managed within Microsoft Excel.

Weather data were sourced from Coldstream weather station accessed from the Bureau of Meteorology[1] (temperature, relative humidity, wind speed and direction) and on-ground observations (cloud cover and precipitation).

Species Groupings

It was expected that habitat linkages would be used more by some animal groups than others, so some species were grouped for some analyses. Additionally, if an animal in a photo was not identifiable to species (e.g. when only part of an animal was visible) but the animal could confidently be assigned into a faunal group then these images were also used. Groupings are shown in Table 2.

Table 2 Fauna groupings used for analysis

Group name	Fauna included in group
Small Mammal	Agile Antechinus, Eastern Pygmy Possum
Glider	Sugar Glider, Greater Glider, Feathertail Glider
Bird	Australian Magpie, Crimson Rosella, Australian Raven, Grey Shrike-thrush, Honeyeater spp., Laughing kookaburra, Pied Currawong, Red-browed Treecreeper, Tawny Frogmouth, Treecreeper spp., White-throated Treecreeper, bird spp.
Bat	All micro bats (not identified to spp).
Unknown	Animal could not be identified even to group level

Species grouped as ‘unknown’ were removed from analyses of photos with the exception of total numbers of images that contained an animal.

[1] Accessed via Eldersweather.com.au during each survey.

3. Results

3.1 Preliminary spotlighting

For the project to progress to the glider pole camera stage, three or more glider sightings/detections were required across the three preliminary surveys. Over the course of the three rounds three glider species were confirmed on site: Greater Glider (*Petauroides volans*), Yellow-bellied Glider (*Petaurus australis*) and Sugar Glider (*Petaurus breviceps*). These were heard or observed during the second spotlighting event on 14 and 18 February 2013, within the central and northern sections of the study area (as mapped in Figure 1). Five arboreal species were detected during the preliminary spotlighting (Table 3). Both Yellow-bellied Gliders and the Sugar Gliders were detected from calls only. The location of these gliders informed the location of the glider pole cameras.

A full list of species recorded during the preliminary spotlighting trips is summarised in Appendix A.

Table 3 Summary of preliminary spotlighting results (arboreal species only)

Common Name	Species Name	No. of individuals
Greater Glider	*Petauroides volans*	1
Yellow-bellied Glider	*Petaurus australis*	2
Sugar Glider	*Petaurus breviceps*	5
Common Ringtail Possum	*Pseudocheirus peregrinus*	6
Common Brushtail Possum	*Trichosurus vulpecula*	1

3.2 Control spotlighting

Four species were observed over the eight control spotlighting rounds (Table 4). All individuals were seen, with the exception of the Yellow-bellied Glider, which was heard only. There was a notable absence of Sugar Gliders detected during these rounds.

A full list of species recorded during the control spotlighting trips is summarised in Appendix A. Additional data collected during each survey event are summarised in Appendix C.

The location of these individuals are mapped in Figure 1.

There is no ROW (and therefore no glider pole linkages) between N15 and C1 as the pipeline was installed via tunnel between these two areas. Spotlighting was still conducted between the "portals" along a 4WD track that links the two sections (north and central). Four Greater Gliders, two Common Brushtail Possums and a Common Ringtail Possum were all observed between the portals. Gliders and Possums were reasonably spread out along the alignment though a small cluster of Great Gliders was evident between the portals (Figure 1).

Table 4 Summary of control spotlighting results (arboreal species only)

Common Name	Species Name	No. of individuals
Greater Glider	*Petauroides volans*	16
Yellow-bellied Glider	*Petaurus australis*	1
Common Ringtail Possum	*Pseudocheirus peregrinus*	6
Common Brushtail Possum	*Trichosurus vulpecula*	2

3.1 Glider pole cameras

A total of 3728 images were taken over the course of the project; 1912 photos that contained vertebrate animals[2] were included in analysis (Table 5).

Image numbers were further reduced for some analysis by eliminating multiple pictures of the same individual. Subsequently, a total of 776 photos comprising 782 individuals were retained (Table 5).

Table 5 Total no. of photos

Parameter	No. of photos
Total no. of photos captured	3728
Total number of photos with no animals	1803
Total no. of photos of unknown animals that could not be grouped (eliminated from all analysis)	13
Total no. of photos with animals (excluding unknown)	1912
Total no. of photos with animals (excluding unknown and replication of individuals)	776
Total no. of individual animals (this may include repeated sightings of individuals at different location or times)	782

On average, more than twice the number of photos and individuals were observed per pole in the north section compared with the central section (Table 6). Fewer individuals were photographed at the two ends of the study site (N01 and C08). At these locations, the extent of the forest ends and gives way to cleared paddocks. Despite the discrepancy in numbers of individuals, on average similar numbers of species were captured in each of the two sections per pole (North – 5.7 species, Central – 5 species) (Table 6).

[2] Pictures with nothing or invertebrates were not included in the analysis.

Table 6 Photos per Pole Location

Pole Number	No. of photos with animals (incl. multiple triggers of same individual)	No. of photos with animals (excl. multiple triggers of same individual)	No. of species	No. of poles in crossing	Is the linkage near a forest edge?
North Section					
N01	14	7	4	2	Yes – linkage is at north edge of forest
N02	188	80	7	2	No
N03	152	67	8	2	No
N04	190	91	6	2	No
N06	116	64	4	2	No
N07	74	36	5	2	No
N08	127	62	6	2	No
N09	340	87	7	2	No
N10	100	39	5	2	Yes – linkage is adj. Marginal Road
N11	391	157	5	4	Yes – linkage is adj. Marginal Road
Total	**1692**	**690**	**13**		
Average	**169.2**	**69**	**5.7**		
Central Section					
C06	94	46	7	3	No
C07	71	21	4	2	No
C08	55	19	4	2	Yes – linkage is at south edge of forest
Total	**220**	**86**	**9**		
Average	**73**	**29**	**5**		
Grand Total	**1912**	**776**	**16**		

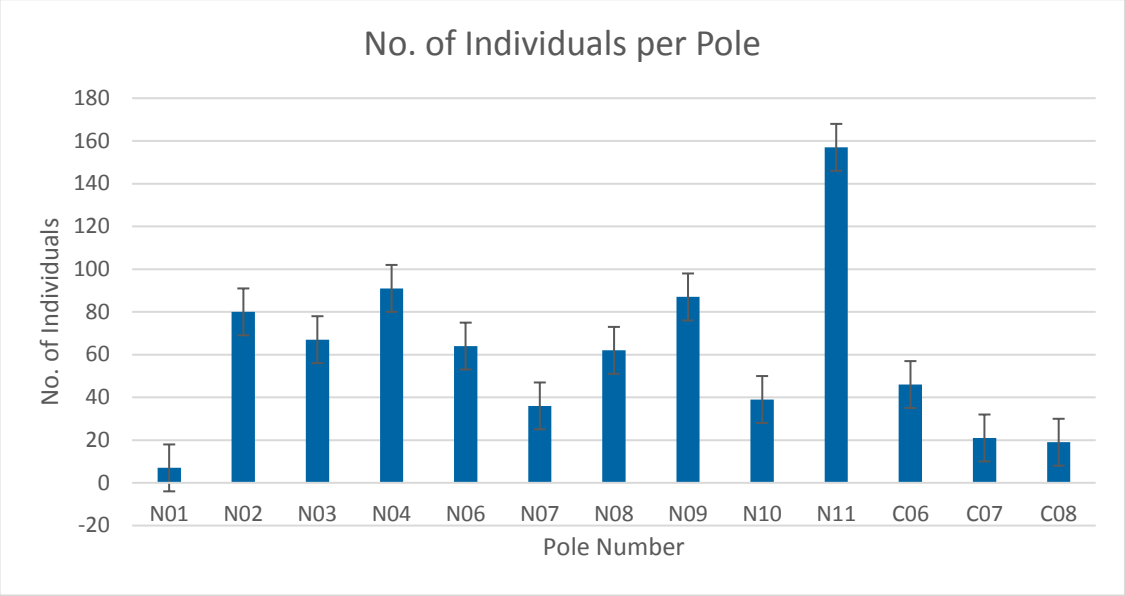


Figure 2 No. of Individual Animals per Pole

In the northern section there appears to be a low point in the number of individuals detected at pole N07 (< 40 animals). The numbers of individuals then increases similarly to the north and south of this pole, to peaks of more than 80 animals at N04 and N09 (Figure 2). This pattern is not reflected in all faunal groups but is evident in the gliders group (Figure 3 and Figure 4).

There is a notable peak in the number of individuals of all animals, individual gliders and individual birds at pole location N11 (Figure 3 and Figure 4); activity here is almost double that at any other pole location.

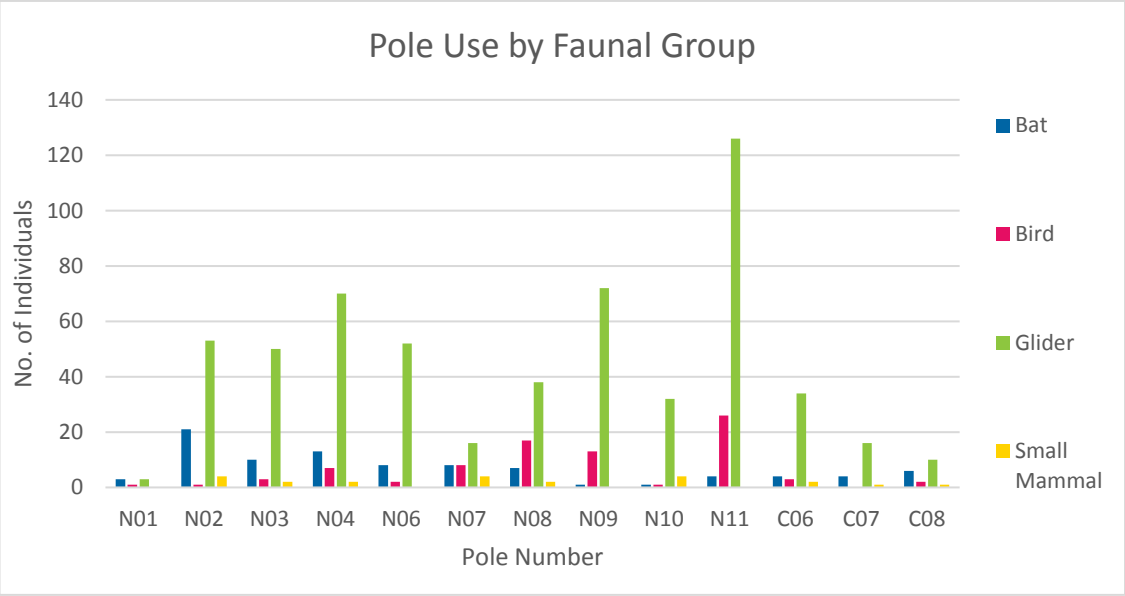


Figure 3 Pole Use by Faunal Group

Pole use was dominated by gliders compared to other faunal groups. For all fauna groups, numbers of individuals were lowest at the geographic ends of the study site; N01 and C08 (Figure 3).

Gliders were more common per pole in the northern section than in the central section (Table 7 and Figure 4). At both ends of the forest (N01 and C08), glider numbers increased with geographic distance from the end, at least for the first few cameras (Figure 4). Large numbers of Sugar Gliders were detected at pole N11 (Table 7 and Figure 4). Three glider species were captured by the cameras including Feathertail Gliders which were not observed during spotlighting.

Table 7 No. of Individual Gliders per Pole

Row Labels	Greater Glider	Sugar Glider	Feathertail Glider	Total
N01		1	2	3
N02	2	28	18	48
N03	3	34	2	39
N04	2	46	18	66
N06		21	31	52
N07		8	8	16
N08		14	23	37
N09	2	39	26	67
N10		26	5	31
N11	1	120	4	125
C06	2	22	8	32
C07		9	7	16
C08		3	6	9
Total	**12**	**371**	**158**	**541**

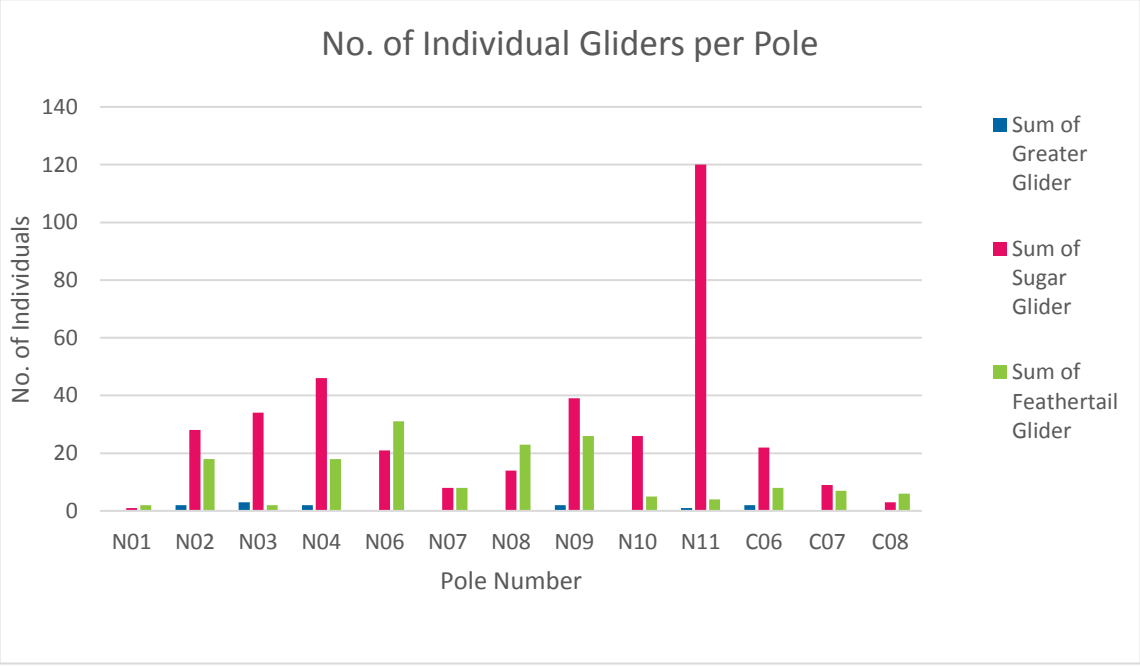


Figure 4 No. of Individual Gliders per Pole

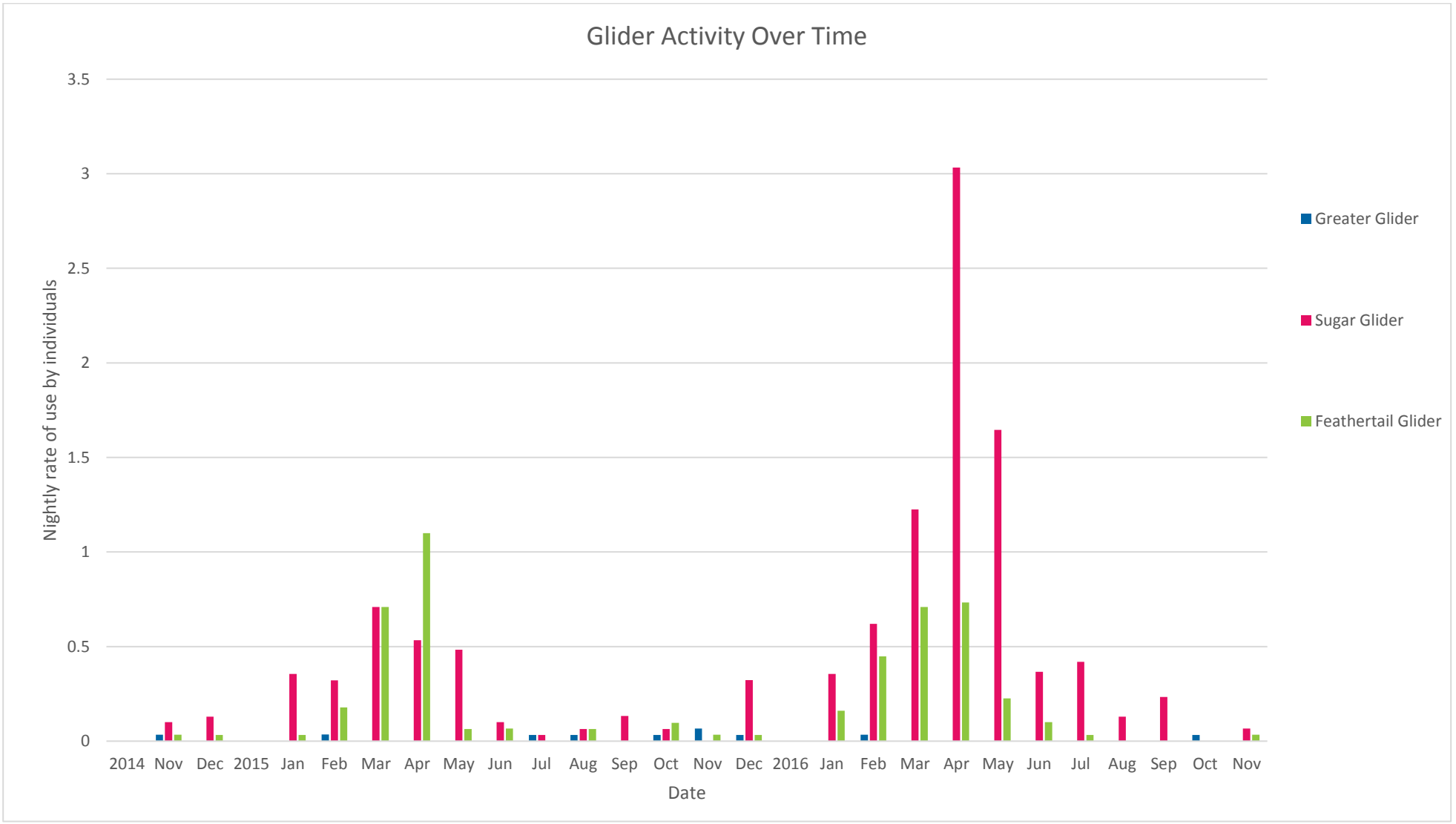


Figure 5 Glider Activity Over Time

Glider activity over time was measured as a nightly rate to control for variable month length. Data from cameras N1 and C6 were excluded from this figure, as those cameras did not last the full duration of the survey. A distinct seasonal period of glider activity is evident in both 2015 and 2016. Each year, nightly rate of use for individual Sugar Gliders and Feathertail Gliders is centred over autumn (March to May). Too few Greater Gliders were captured to observe any trends. Nightly rates of use of individual Sugar Gliders during the peaks increased significantly from 2015 to 2016 (Figure 5).

Excluding birds and bats, it is evident that pole use by fauna is dominated by volant mammal species (Table 8).

Whilst many more individuals were detected by the glider pole cameras, the spotlighting surveys resulted in detection of a different suite of species. No Yellow-bellied Gliders, Common Ringtail Possums or Common Brushtail Possums were detected by cameras. Contrastingly, small non-volant species such as Eastern Pygmy Possum and Agile Antechinus were not detected by spotlighting. Ultimately, the same number of arboreal mammal species were observed spotlighting compared to the use of cameras (Table 8).

Table 8 Number of Individuals of Volant Vs Non-Volant Mammals Detected

Species	No. of Individuals		
	Preliminary Spotlighting	Control Spotlighting	Glider Pole Cameras
Volant			
Feathertail Glider			161
Greater Glider	1	16	12
Sugar Glider	5		374
Yellow-bellied Glider	2	1	
No. of Volant Species	**3**	**2**	**3**
Non-Volant			
Agile Antechinus			14
Common Brushtail Possum	1	2	
Common Ringtail Possum	6	6	
Eastern Pygmy Possum			1
No. of Non-Volant species	**2**	**2**	**2**
Total Species	**5**	**4**	**5**

4. Discussion and conclusions

Aerial wildlife crossing structures (glider poles and rope bridges) are being increasingly used to mitigate barriers and or mortality impacts (references within Soanes and van der Ree 2009). For the Toolangi forest, there is little risk of mortality as a result of road traffic along the pipeline alignment; but the 30 – 60 m wide gap in the canopy along the ROW is likely to make it difficult for some species to cross between the forest patches.

On average substantially more animals (individuals) were detected per pole in the north section than in the central section. This likely reflects the more intact and connected nature of the forest patch in the northern section compared to the central section. In the northern section the forest extends to the east for many kilometres. Whilst, the central section is connected to this same large patch of forest there are several large cleared areas nearby, including a quarry. The possibility of edge effects operating in the central section is great with all cameras within approximately 1.5 kilometres of the southern extent of the forest compared to the north section which is approximately twice as long. There is no visible difference in forest age or time since logging in the aerial imagery when comparing the two sections, however if hollow density is different then this could also explain the disparity in numbers.

There is a peak in numbers of individuals of all animals, individual gliders, individual birds and individual Sugar Gliders at N11. North of that location, between N01 and N10, the forest to the west of the Melba Highway is narrow and fragmented. Just north of N11, the forest west of the Melba Highway becomes more intact and the increase in animal detections may be related to the more intact nature of the forest here. Similarly, it could be related to a high density of hollows at this location however, numbers of gliders at N10 the nearest pole are also expected to be higher if this is the case given its proximity (no data on hollow density throughout the forest is available). Linkage N11 is unique in that it is across the widest gap in the canopy (ROW approximately 60 m wide) and is the only monitored linkage with four poles across (most linkages contain only two poles bridging a gap of approximately 30 m). Sugar Gliders, which make up the bulk of the use of this pole (N11) have a maximum gliding distance of up to 50 m (OEH 2016, Van Dyck and Strahan 2008), so can bridge a 30 m gap, but not a 60 m gap. It is possible that the high usage rates here by Sugar Gliders reflect the greater span of the ROW at this location and therefore the species' need for a linkage here. There is no obvious pattern of use by the other faunal groups (birds, bats or small mammals).

Use of the poles by gliders is expected to increase over time. Previous studies indicate that habituation to crossing structures varies from a few weeks through to several years (references within Soanes and van der Ree 2009). In one Victorian study, possum and glider species were observed using canopy bridges within a few months of their construction (references within Soanes and van der Ree 2009). Another study at that same location however, indicated that it took four years from installation for rope bridges and glider poles to re-establish glider movement (Soanes 2013). Contrastingly, sites without crossing structures remained a barrier to movement (Soanes 2013). For this Toolangi project, glider activity level was not monitored prior to or since the establishment of the glider poles, however, glider use over the course of the camera study increased with time from 2015 to 2016.

Peak activity times were apparent for both Sugar Gliders and Feathertail Gliders over Autumn (March to May). Sugar Gliders' births occur in July to August in south eastern Australia (Menkhorst and Knight 2011, Van Dyck and Strahan 2008) and young become independent when they are seven to ten months old (Australian Wildlife Conservancy 2017). Feathertail Glider births occur in June to January in south eastern Victoria and young are weaned at approximately 100 days (Van Dyck and Strahan 2008). The peaks in activity seen may be reflective of the time that young of these species become independent and therefore both the young and the adults are active at this time (i.e., there are more animals getting around). The decrease at the beginning of winter is harder to explain, but may be a result of young leaving the area in search of their own home range.

Different suites of species were observed in the two different methods of survey for this project; spotlighting and cameras. Several of the larger glider or possum species were not observed using the pole cameras (Yellow-bellied Glider, Common Brushtail Possum and Common Ringtail Possum). This was unexpected but may reflect very low numbers of Yellow-bellied Gliders in the forest and the fact that both Common Brushtail and Common Ringtail Possums are non-volant and tend to cross at ground level or by jumping short distances from canopy to canopy.

Whilst there is a gap in the canopy of 30-60 m, by the beginning of the survey period much of the ground layer and mid layer vegetation had re-established within the ROW. Contrastingly, no small non-volant mammals or Feathertail Gliders were observed spotlighting. Animals of this size are very difficult to detect in tall forest and thermal imaging is likely a more successful method for surveying for these species. Interestingly, no Sugar Gliders were observed in 16 nights of control spotlighting (eight two-night surveys). However, of these eight surveys, only one was conducted in Autumn in what has been shown to be the peak activity season for this species at this site.

Numbers of individual Greater Gliders observed using the glider poles was low compared to other glider species. This may be because the Greater Glider is much larger and their density in the forest is lower (as a result of historical logging) due to the lack of suitably sized hollows for a species of this size. The abundance of Greater Gliders on survey sites has been documented as significantly greater on sites with a higher abundance of tree hollows (TSSC 2016). Smaller numbers of Greater Gliders (12) and Yellow-bellied Gliders (0) could also reflect the fact that these species can reportedly glide over 100 m (Menkhorst and Knight 2011) and 140 m respectively (OEH 2016). Therefore Greater Gliders and Yellow-bellied Gliders would not need to use the glider poles to bridge the ROW gap that is typically 30 m and never more than 60 m wide. However, it is noted that due to topography and tree height they may not always be able to glide their maximum distance. Contrastingly, Sugar Gliders and Feathertail Gliders are much smaller and therefore require smaller hollows which are likely more abundant. They also have shorter gliding distances making the glider poles more important (Sugar Glider – up to 50 m, Feathertail Glider – up to 15 m, Van Dyck and Strahan 2008).

A potential risk of erecting poles in cleared areas is that they create artificial perches for predatory birds, which could then pick off unsuspecting gliders. However, predator species (e.g. owl species), were near absent from the glider pole camera photos but are known to occur in the forest as a result of spotlighting (e.g. Powerful Owl). Currawongs and Kookaburras have been known to predate Feathertail Gliders but numbers of individuals using the poles of these species was very low (one and two individuals respectively) and these bird species are typically diurnal as opposed to Feathertail Gliders and Sugar Gliders which are typically nocturnal.

5. Conclusions and recommendations

Many studies have reported increases in animal movement across barriers through observation of use of crossing structures yet there is little information on the viability and survival of populations as a result of this mitigation measure (Soanes and van der Ree 2009). Soanes and van der Ree (2009) also note that long-term monitoring of populations prior to barrier mitigation occurring is notably absent and therefore the placement of many structures lacks an ecological basis; therefore conclusions regarding the effectiveness of these structures has been limited.

Gliding poles have been trialled in several countries including Australia although literature documenting the use and effectiveness of these structures is scarce.

Because there is no information on gliders crossing the ROW prior to the implementation of the glider pole cameras, it is difficult to establish the degree to which the mitigation measure is successful or effective.

The effective use of glider poles relies on species being able to traverse by air, and provides little assistance to arboreal species that are non-volant e.g. Eastern Pygmy Possums, Common Ringtail Possums. Rope bridges differ in this respect, and the addition of rope bridges at intervals along the ROW may benefit non-volant species in their attempts to cross the ROW.

For glider poles, some modifications to the method and information collected would be required to provide more measurable indices of effectiveness, such as:

- Undertake more substantial surveys/monitoring prior to establishment of wildlife crossing structure to gain a better understanding of glider species presence and abundance prior to monitoring to better inform crossing structure placement.
- Set up cameras on multiple poles within an individual linkage to confirm that gliders are moving between poles and across the ROW.
- Change the camera set up at each pole (e.g. use fish eye lens or short video) to determine if species are gliding to/from the poles, or just moving up and down the poles.
- Radio track individual gliders to determine if gliders are only crossing at the poles or if they are also crossing at locations without poles.

The aim of the establishment of glider poles for this project was to enable gliders to cross the canopy gap over the ROW. It is difficult to tell if gliders are actually gliding between poles and/or between poles and the forest due to the narrow field of view of the cameras, however, it would be safe to assume that gliding species are using the poles in this way and not climbing them. In that regard, the establishment of the poles would appear to have been successful. Additionally, other fauna groups have been found to also use the poles.

The other interesting point to note is the peak activity period of both Sugar Gliders and Feathertail Gliders at this site. This information will better enable spotlighting surveys to detect these species if this peak activity period is targeted.

6. References

Australian Wildlife Conservancy (2017) Species Profile – Sugar Glider. Accessed from http://www.australianwildlife.org/wildlife/sugar-glider.aspx Accessed on 6 April 2017

Menkhorst, P and Knight, F (2011) A Field Guide to the Mammals of Australia 3rd Ed. Oxford University Press. Melbourne, Australia

Office of Environment and Heritage (OEH) (2016) Gliding Possums What do they Look like? Available from: http://www.environment.nsw.gov.au/animals/GlidingPossums.htm

Soanes, K and van der Ree, R (2009) Arboreal Mammals use an Aerial Rope Bridge to Cross a Major Highway. Wildlife-Vehicle Collisions – Data Collection, Monitoring and Modelling Session 223. International Conference on Ecology and Transportation (ICOET) 2009 Proceedings

Soanes, K (2013) Mysterious poles make road crossing easier for high flying mammals. The Conversation. Available from http://theconversation.com/mysterious-poles-make-road-crossing-easier-for-high-flying-mammals-11323

Threatened Species Scientific Committee (TSSC) (2016) NON-CURRENT Approved Conservation Advice for Petauroides volans (greater glider). Canberra Department of the Environment. Available from : http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-05052016.pdf

Van Dyck, S and Strahan, R (2008) The Mammals of Australia, Third Ed. Reed New Holland. Australia

Appendices

Appendix A – Fauna detected during the monitoring

Species		No. of Individuals		
Common Name	Scientific Name	Preliminary Spotlighting	Control Spotlighting	Glider Pole Cameras
Mammals				
Agile Antechinus	*Antechinus agilis*			14
Common Brushtail Possum	*Trichosurus vulpecula*	1	2	
Eastern Grey Kangaroo	*Macropus giganteus*	2	2	
Eastern Pygmy Possum	*Cercartetus nanus*			1
Short-beaked Echidna	*Tachyglossus aculeatus*	1	1	
Feathertail Glider	*Acrobates pygmaeus*			161
Greater Glider	*Petauroides volans*	1	16	12
Long-nosed Bandicoot	*Perameles nasuta*	3	4	
Microbat spp.		>100	30	90
Common Ringtail Possum	*Pseudocheirus peregrinus*	6	6	
Sugar Glider	*Petaurus breviceps*	5		374
Swamp Wallaby	*Wallabia bicolor*	5	17	
Wombat	*Vombatus ursinus*	7	4	
Yellow-bellied Glider	*Petaurus australis*	2	1	
*Rodent spp.		2		
*European Rabbit	*Oryctolagus cuniculus*	2	1	
*European Red Fox	*Vulpes vulpes*	2		
*Samba Deer	*Rusa unicolor*	1		
Birds				
Australian Magpie	*Gymnorhina tibicen*			3
Australian Raven	*Corvus coronoides*			2
Barn Owl	*Tyto alba*	1		
Southern Boobook	*Ninox boobook*	6	2	
Crimson Rosella	*Platycercus elegans*			1
Grey Shrike-thrush	*Colluricincla harmonica*			2
Honeyeater spp.				2
Laughing Kookaburra	*Dacelo novaeguineae*		1	2
Pied Currawong	*Strepera graculina*			1
Powerful Owl	*Ninox strenua*	1	2	

Species		No. of Individuals		
Common Name	Scientific Name	Preliminary Spotlighting	Control Spotlighting	Glider Pole Cameras
Red-browed Treecreeper	*Climacteris erythrops*			14
Tawny Frogmouth	*Podargus strigoides*	1	1	1
Treecreeper spp.	*Cormobates spp.*			20
White-throated Treecreeper	*Cormobates leucophaeus*			35
Reptiles				
Tiger Snake	*Notechis scutatus*		1	
Frogs				
Common Froglet	*Crinia signifera*	✓	✓	
Eastern Sign-bearing Froglet	*Crinia parasignifera*		✓	
Plains Brown Tree Frog	*Litoria paraewingi*		✓	
Pobblebonk	*Limnodynastes dumerilii*	✓	✓	
Southern Brown Tree Frog	*Litoria ewingii*	✓	✓	
Spotted Marsh Frog	*Limnodynastes tasmaniensis*		✓	
Striped Marsh Frog	*Limnodynastes peronii*	✓		
Victorian Smooth Froglet	*Geocrinia victoriana*		✓	

Key to Table

✓ Species present but count not taken

*Non-native species

Appendix B – Preliminary Spotlighting Survey Parameters

Key Recorded Values	Round 1		Round 2		Round 3	
Dates of Survey	30/01/2013	31/01/2013	14/02/2013	18/02/2013	27/02/2013	28/02/2013
Start Time	9:33 PM	9:53 PM	9:20 PM	9:00 PM	8:58 PM	8:55 PM
End Time	12:53 AM	11:10 PM	1:28 AM	12:55 AM	11:15 PM	11:19 PM
Section/s Surveyed (North, Central, Southern)	C & S	N	C & S	N	N	C & S
Cloud Cover (% sky covered)	0	100	0 - 80	0	100	30 - 100
Air Temperature (°C)	13.1 -17.6	10.2 - 13.5	14.1 - 23.5	19.4 - 22	16.1	14.5 - 15.9
Humidity (%)	45- 60	100	72 - 93	61 - 62	91 - 92	62 - 79
Wind Velocity (km/hr) & direction	0-4, S	2 – 10, S	0-2.5, N	1.7 – 3, S&N	5.6 - 7 SE	9- 13 S
Precipitation	None	periodic drizzle / light rain	None	None	None	None

Appendix C – Control Spotlighting Survey Parameters

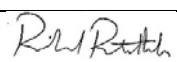
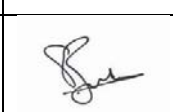
Key Recorded Values	Round 1		Round 2		Round 3		Round 4		Round 5		Round 6		Round 7		Round 8	
Dates of Survey	21 Jan 2015	22 Jan 2015	15 April 2015	16 April 2015	19 Aug 2015	20 Aug 2015	18 Nov 2015	19 Nov 2015	25 Feb 2016	29 Feb 2016	22 June 2016	6 July 2016	21 Sept 2016	22 Sept 2016	16 Nov 2016	17 Nov 2016
Start Time	9:37 PM	9:24 PM	6:37 PM	7:18 PM	6:30 PM	6:10 PM	8:50 PM	8:40 PM	8:31 PM	8:25 PM	5:35 PM	5:30 PM	7:00 PM	6:30 PM	8:35 PM	8:35 PM
End Time	1:46 AM	11:28 PM	10:21 PM	9:46 PM	10:15 PM	9:40 PM	11:07 PM	10:30 PM	10:35 PM	10:02 PM	7:40 PM	8:30 PM	9:15 PM	8:30 PM	11:00 PM	11:05 PM
Cloud Cover (% sky covered)	0-30	10	0	5-80	0	0	100	0	0	0	0	0	0-100	90-100	0	0
Air Temperature (°C)	17.2 – 26.4	18.7 – 21.9	18.2 - 23.9	12.6– 13.6	1.9 – 8.9	6.7 - 13.3	18.6-20.2	17.7	17.6-23.4	19.2-23.8	11.9-12.6	10.8	8.8-11.9	10-10.3	13-16	15.5-23.5
Humidity (%)	49 - 84	71 - 84	50-71	67-72	76-96	63-84	54-59	73	53-79	58-80	65-72	87-91	89-93	85-89	70-92	54-87
Wind Velocity (km/hr) & direction	2 -18, E, SE, N	2 – 7, W, N	7, N, S	6, SSE, S	0	0-7, E, NNE	1.8, SE	13-16.7	4-17, WSW, SSW	13, W, WSW	11-17, NNW, W	9-13, S	0-9, SE	0-7, S	0-5, NW	2-7, NNW, E

GHD

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

G:\31\29843\WP\256223.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft A						12/04/17
0	Kelly Dalton	Richard Retallick		Steven Brattle		31/05/17

www.ghd.com