Yaloak South Wind Farm: Wedge-tailed Eagle Monitoring (Year 3)

FINAL REPORT

Prepared for Pacific Hydro

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Summary

Biosis Pty Ltd was commissioned by Pacific Hydro to undertake Wedge-tailed Eagle *Aquila audax* monitoring as part of the implementation of the Bird and Avifauna Management Plan (BAMP) at the Yaloak South Wind Farm (YSWF). As per the approved BAMP (Biosis 2019a, 2019b), monitoring was undertaken of Wedge-tailed Eagle flights and breeding activity, with the primary objective of providing a comparison of flight and breeding activity prior to construction of the wind farm with that of activity recorded during the early years of its operation.

Biosis began implementation of the various monitoring requirements of the approved BAMP in July 2018 during YSWF's first year of operation (July 2018 – June 2019) (Year 1), continuing with monitoring activities into the second (July 2019 – June 2020) (Year 2) and third (July 2020 – June 2021) (Year 3) years of operation until the monitoring program's completion in June 2021.

This report summarises the results from the Year 3 monitoring period of July 2020 through to June 2021. It also provides a comparison of Wedge-tailed Eagle activity prior to construction of the wind farm with data accumulated over Years 1 – 3 of operation. Concurrent with the monitoring of Wedge-tailed Eagle flight and breeding activity addressed in this report, Elmoby Ecology has undertaken a carcass search program. The results of the carcass search program are not otherwise referenced in this report.

Wedge-tailed Eagle flight activity

The objective of point-count surveys at YSWF is to document Wedge-tailed Eagle flight activity and behaviour around turbines during the first three years after commissioning of the last turbine. Monthly flight activity surveys were conducted at ten locations within YSWF from July 2018 to June 2021 using the same methods as pre-construction surveys. Wedge-tailed Eagle monitoring completed to date is considered to meet Pacific Hydro's monitoring and reporting obligations, as outlined within the approved BAMP for the YSWF (Biosis 2019b).

Consistent with previous years of monitoring, no defined seasonal patterns of Wedge-tailed Eagle flight paths were observed during the Year 3 monitoring period. However, flight paths observed during the Year 3 monitoring period appear similar to behaviour and site use observed during Years 1 and 2; with the majority of flights recorded above escarpments both within and adjacent to the YSWF site.

Observations of Wedge-tailed Eagles during the Year 3 monitoring period within the YSWF site were typically less frequent when compared with surveys undertaken during the pre-construction monitoring period. Reasons for a decline in Wedge-tailed Eagle observations from within the site during the post-construction monitoring period remain difficult to discern in the absence of several years of monitoring prior to the construction of YSWF and without the benefit of suitably comparable control monitoring sites.

A reduction in the number of observations of Wedge-tailed Eagles from within the site during the post-construction monitoring period may be attributed to multiple variables; including avoidance of operating turbines within the YSWF, weather, climate and/or the availability of prey prompting the movement of juveniles and sub-adults at greater distances into the surrounding landscape (away from the Brisbane Ranges National Park, which adjoins the site to the south).

Movements of juveniles and sub-adults at greater distances into the surrounding landscape may be considered highly plausible given:

- Continued observation of resident pairs in flight from within the site throughout the duration of the monitoring program.

- Flight paths and breeding behaviours were found to remain similar in occurrence and behaviour to those reported during the pre-construction period.
- Wedge-tailed Eagle juveniles and sub-adults are well documented as being highly dispersive.
- Flight activity over post-construction years (Year 1 – Year 3) showed no statistical differences between any year.

Wedge-tailed Eagle nest activity

The objective of the Wedge-tailed Eagle nesting studies is to document breeding activity and nesting success within and adjacent to the YSWF site. Surveys to detect and monitor Wedge-tailed Eagle nests were undertaken within 5 kilometres of the YSWF during breeding seasons in each of the first three years following the commissioning of the last YSWF turbine. Monitoring of nests also included those previously identified in 2009 that could be detected.

Nesting density and success (measured by the number of juveniles fledged) of resident pairs occupying breeding territories within and adjacent to the YSWF site between Years 1 and 3 were analysed in order to determine if collected results differ in similar environs not in the vicinity of wind energy facilities. Wedge-tailed Eagle nest monitoring completed to date is considered to meet Pacific Hydro's monitoring and reporting obligations, as outlined within the approved BAMP for the YSWF (Biosis 2019b).

Post-construction monitoring detected no active nests in 2018, three active nests in 2019 and one active nest in 2020. Only one nest was found to be active during two consecutive years during the post-construction monitoring period (2019 and 2020). Whilst no active nests were detected in 2018 (Year 1), the detection of three active nests during the 2019 breeding season (Year 2) is consistent with the detection of three active nests during pre-construction surveys undertaken in 2006 and 2009.

Nest monitoring undertaken in 2020 (Year 3) detected a single chick to have successfully fledged as of October 28 2020. All active nests monitored in 2019 and 2020 were determined to have contained egg/s, with no other nests observed to have been lined with natural (fresh green foliage) materials. Although breeding activity was lower in 2020 compared with 2019, the number of young fledged remained consistent; averaging 1.0 for young fledged per attempt in which eggs were laid and outcomes were known.

Results of the Wedge-tailed Eagle post-construction nesting study (Years 1 – 3) indicate breeding densities within the YSWF site and greater Yaloak Estate remain consistent with those reported during the pre-construction monitoring period. Comparisons of datasets over Years 1 – 3 with studies undertaken in south-eastern Australia also found that breeding densities and fledgling success recorded within YSWF to be within range of results reported within similar environments not in the vicinity of wind energy facilities. Collected findings suggest that the operation of YSWF may have little influence over Wedge-tailed Eagle breeding behaviour or nesting success.

Recommendations

On the basis of the findings of the post-construction flight and nesting activity monitoring undertaken in the first three years since the commencement of operations of the YSWF, further studies of Wedge-tailed Eagle flight activity or nesting monitoring are not recommended. Impacts to Wedge-tailed Eagles will continue to be monitored throughout the operational life of the wind farm by site personnel in accordance with Pacific Hydro's Injured or Dead Bird and Bat Procedure. To ensure operations of YSWF do not result in a net significant or lasting impacts on the viability or conservation status of the Wedge-tailed Eagle mainland population trigger levels for responsive management response(s) outlined within the approved BAMP will continue to apply.[1]

Should triggers levels be met at any point through ongoing carcass detection monitoring undertaken by site personnel, the Procedures for Mitigation Measures (outlined in the BAMP for YSWF) should be initiated. This may involve the recommendation to undertake further monitoring of Wedge-tailed Eagle flight activity in conjunction with carcass detection surveys to determine the significance of impacts.

We also recommend the continuation of the following practices:

- All new site personnel continue to be trained on procedures for the event in which they encounter dead or injured birds and bats, as per methods previously outlined in the BAMP (Biosis 2019b, Biosis 2019a).
- Carcasses of livestock and other larger animals such as destroyed pest animals or legally destroyed kangaroos (referred to below collectively as 'mammal carcasses') continue to be removed in a timely manner. This will reduce the incidence of collision with turbines by birds that routinely feed on carrion, such as the Wedge-tailed Eagle.
- Sheep of the Yaloak Estate continue to be managed so as to reduce the incidence of lambing “under” turbines, as per arrangements previously agreed within the BAMP. Routine checks (daily) between mid-July to the end of August should remain in place to ensure any fallen ewes or sheep carcasses are removed in a timely manner.

[1] BAMP trigger levels correspond with the detection of:

- Ten Wedge-tailed Eagle individuals during routine management over any 12-month period.
- More than an average of seven individuals per annum over any two consecutive years.

1. Introduction

1.1 Project background

Yaloak South Wind Farm (YSWF) covers approximately 1,720 hectares and is located 16 kilometres south of Ballan in western Victoria (Figure 1). The facility was completed in May 2018 with a total of 14 turbines.

Biosis was commissioned by Pacific Hydro to prepare the Bird and Bat Adaptive Management Plan (BAMP) for YSWF in response to Condition 19c of the Planning Permit issued for YSWF issued under the Moorabool Planning Scheme (Permit No: P2010002). The approved BAMP (Biosis 2019b, Biosis 2019a) specifies relevant monitoring and reporting requirements, which include documentation of the distribution, abundance and activity (collectively termed 'utilisation') of Wedge-tailed Eagles *Aquila audax* at the property and associated breeding pairs in the vicinity of the wind energy facility.

Biosis began implementation of the various monitoring requirements of the approved BAMP in July 2018 during YSWF's first year of operation (July 2018 – June 2019), continuing with monitoring activities into the second and third years of operation until the monitoring program's completion in June 2021. Relevant monitoring and reporting requirements outlined in the BAMP for YSWF related to Wedge-tailed Eagle monitoring undertaken by Biosis are provided in Appendix 1.

In accordance with the BAMP, this report has been prepared following the third year of operation (Year 3) of the wind farm and summarises raptor nesting and Wedge-tailed Eagle utilisation data collected between July 2020 and June 2021. Raptor nesting and Wedge-tailed Eagle utilisation data collected during this period also adds to monthly data previously collected by BL&A (BL&A 2007) and Biosis (Biosis 2019c, Biosis 2020) over the duration of the BAMP monitoring program.

1.2 Monitoring program objectives

Wedge-tailed Eagle utilisation

The objective of the Wedge-tailed Eagle flight monitoring surveys is to document Wedge-tailed Eagles utilising the YSWF in at least three of the first five years after commissioning of the last turbine to discern whether changes in activity can be detected as a result of the wind farm's operation.

Wedge-tailed Eagle nesting activity

The objective of the Wedge-tailed Eagle nesting activity study is to document the activity and nesting success of resident pairs occupying breeding territories within the YSWF in at least three of the first five years after commissioning of the last turbine to:

- Estimate the local population's likely reproductive and dispersal capacity.
- Assess whether Wedge-tailed Eagle nesting activity and success in the vicinity of YSWF differs substantially from nesting activity and success at locations not in the vicinity of wind energy facilities.

Reporting

Matters addressed in the Year 3 report include:

- Summary and comparison of observations of Wedge-tailed Eagles collected between July 2020 and June 2021 against previous iterations of data collected over the duration of the monitoring program.

- Locations of Wedge-tailed Eagle nests identified/monitored during the 2020 breeding seasons against those previously identified during previous iterations of monitoring.
- Assessment of whether data indicates that eagles avoid the wind turbines.
- An assessment of Wedge-tailed Eagle nesting activity and success, particularly as it compares with rates documented for the species elsewhere at locations not in the vicinity of wind energy facilities.

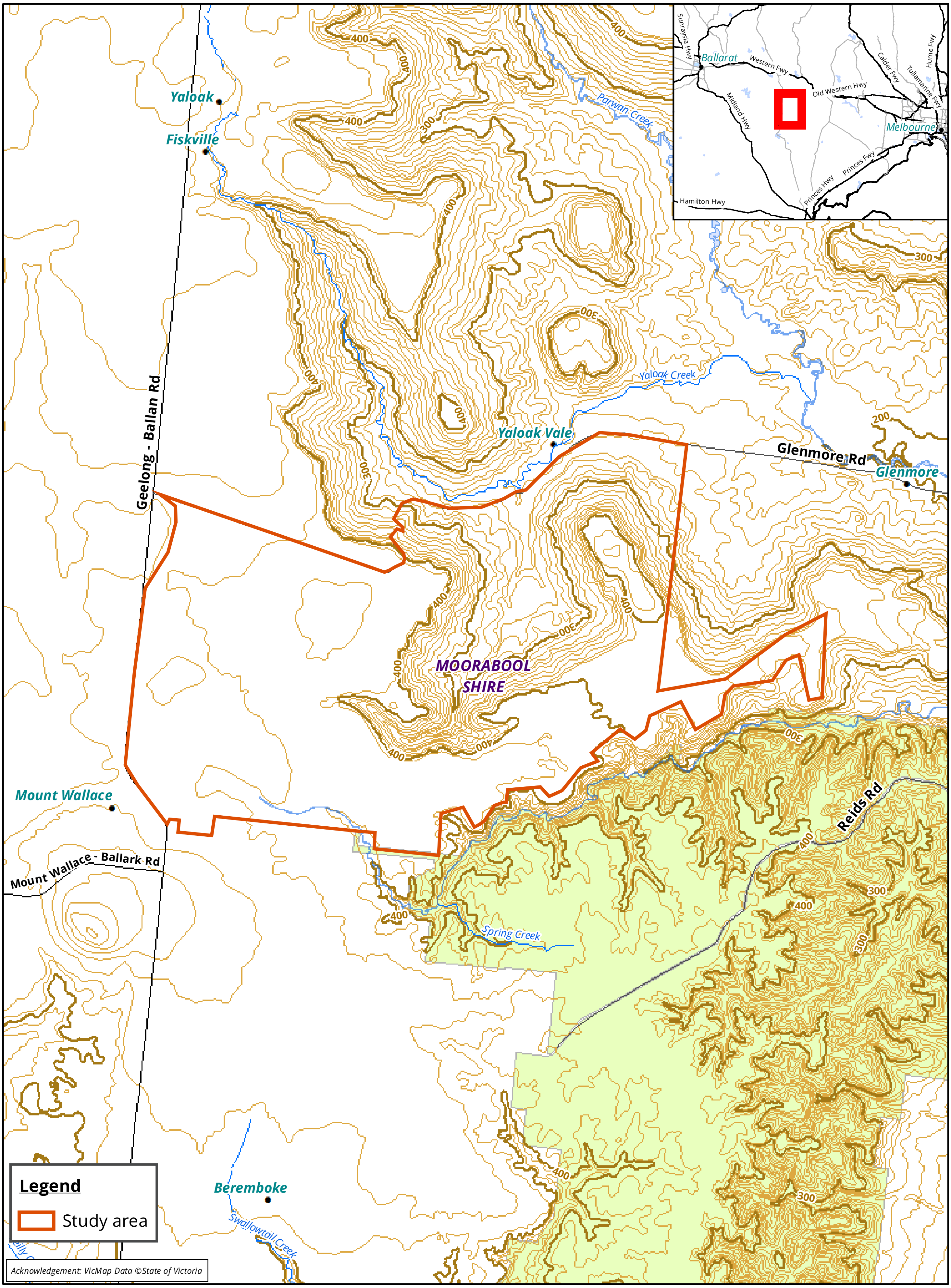

Figure 1 Location of the Study Area - Yaloak South Windfarm, Victoria

Matter: 30298,
Date: 22 October 2020,
Checked by: ERB, Drawn by: SKM, Last edited by: smitchell
Location: P:\30200s\30298\Mapping\30298_F1_Locality.mxd

0 0.5 1 1.5 2
Kilometers
Scale 1:50,000 @ A4, GDA 1994 MGA Zone 55

N

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2. Methods

Surveys undertaken during Year 3 of the monitoring program have applied methodologies that are consistent with those outlined in the BAMP for the operation of YSWF (Biosis 2019b). Detailed methodologies for Year 3 of monitoring are described in the below sections.

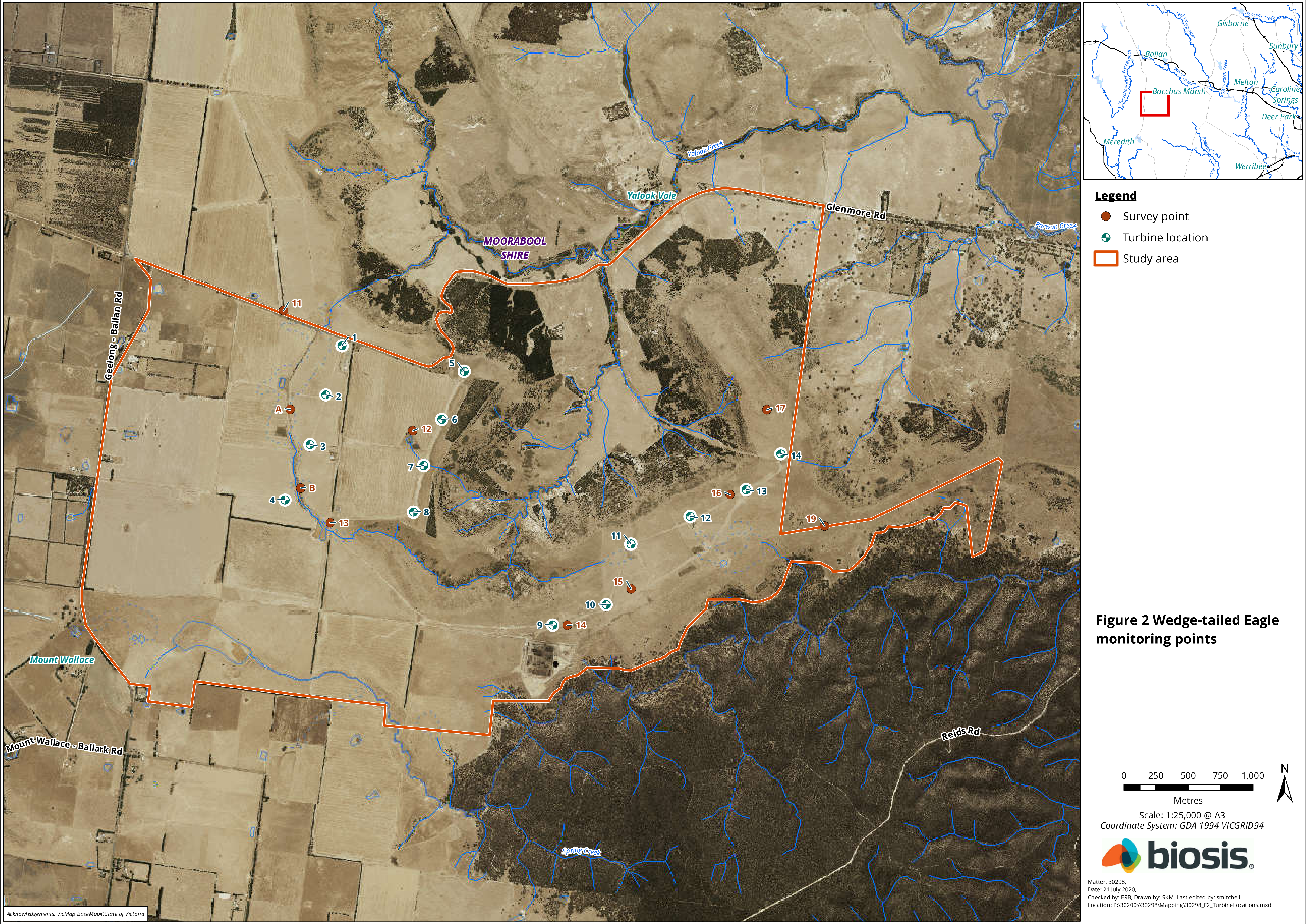
2.1 Point-count surveys

Monitoring of Wedge-tailed Eagles during the Year 3 monitoring period was undertaken at point locations surveyed during baseline surveys. The monitoring points are positioned at different vantage points across the YSWF site to best enable the greatest number of WTE occurrences to be documented.

The locations of the 10 monitoring points are provided in Table 1 (below) and Figure 2.

Table 1 Location of monitoring points

Point No.	Location description	Easting (GDA94) Zone 55	Northing (GDA94) Zone 55
11	Near turbine YS01	256374	5822287
12	Between turbines YS06 and YS07	257394	5821375
13	Between turbines YS04 and YS08	256769	5820647
14	Between turbines YS09 and YS10	258625	5819893
15	Between turbines YS10 and YS11	259115	5820185
16	Between turbines YS12 and YS13	259866	5820934
17	North of turbine YS14	260137	5821596
19	East of the wind farm	260603	5820706
A	Between turbines YS02 and YS03	256440	5821522
B	Between turbines YS03 and YS04	256534	5820914



Legend

- Survey point
- Turbine location
- Study area

Figure 2 Wedge-tailed Eagle monitoring points

0 250 500 750 1,000

Metres

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 VICGRID94

N

biosis.

Matter: 30298,
Date: 21 July 2020,
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Location: P:\30200s\30298\Mapping\30298_F2_TurbineLocations.mxd

2.1.1 Methods

Surveys for Wedge-tailed Eagles were undertaken at monitoring points by one stationary observer (qualified Zoologist) for a period of 20 minutes. Within this period the following information was recorded:

- Start time and date.
- Weather conditions.
- Observations of Wedge-tailed Eagles, with descriptions of their behaviour, distance from observer and height of observation.

During these surveys, each new sighting of a Wedge-tailed Eagle was recorded as one activity. If a Wedge-tailed Eagle disappeared from view of the observer and then came back into view it was recorded as a separate activity. The number of records therefore relates to flight activity and does not reflect a count of the number of individuals.

Flight paths of Wedge-tailed Eagles were also recorded, as this approach may improve understanding of trends in eagle activity over the landscape. Flight paths were mapped from the first sighting of an individual Wedge-tailed Eagle until it was no longer within sight. If multiple eagles were observed flying at the same time, whichever was sighted first was mapped.

2.1.2 Frequency and survey timing

Surveys during the Year 3 monitoring period were undertaken once per month between July 2020 and June 2021, inclusive. During monthly surveys, each monitoring point was surveyed twice, to enable one survey to be conducted in the morning (before 12:00pm) and one to be conducted in the afternoon (after 12:00pm).

Surveys for Wedge-tailed Eagles were carried out across variable daylight hours and a variety of weather conditions, with the exception of conditions that would impede the ability of observers to undertake the surveys.

2.1.3 Data analysis

Flight activity datasets were analysed and compared using IBM SPSS Statistics to determine whether or not there is a statistically significant difference in Wedge-tailed Eagle flight activity recorded in any year monitored during the post-construction period.

The statistical significance was determined by a repeated measures ANOVA and analysis of Estimated Marginal Means (EMMs) through a post-hoc Bonferroni test. A Mauchly's Test of Sphericity was also undertaken at the time of the repeated-measures ANOVA to ensure sphericity had not been violated, and that the Greenhouse-Geisser correction method did not need to be applied.

2.1.4 Limitations

Assumptions and limitations relating to the above mentioned investigations include:

- Mapping was conducted using hand-held GPS units. The accuracy of this mapping is therefore subject to the accuracy of the GPS units (generally +/- 5 metres) and dependent on the limitations of aerial photo rectification.
- There is a nine year interval between the pre-construction and Year One post-construction monitoring period. Biosis acknowledge it is difficult to determine the significance of results in the absence of several years of monitoring prior to construction of YSWF.

- In the pre-construction phase, no flight activity surveys were conducted during the months of February, April, May and June. As a consequence, these months have been excluded when comparing flight activity between pre-construction and post-construction monitoring periods (see Figure 3).
- There is considerable variability in the number of surveys that were undertaken during each month of the pre-construction period. Pre and post-construction data for the months of January, March and July – December has therefore been compared by the mean number of flights recorded per year for each monitoring site. For example, during the pre-construction monitoring period, there were 34 surveys undertaken at point 14 with a total of 172 flights recorded. The mean number of flights observed at site 14 for this monitoring period is therefore equal to 5.1.
- Due to the asymmetrical monitoring effort and nine year interval between pre-construction and the Year 1 post-construction monitoring, pre-construction flight activity data was not included in statistical data comparisons.
- It is important to note that the approved BAMP Wedge-tailed Eagle monitoring program does not follow a typical 'BACI' (Before-After-Control-Impact) design. No control sites were established as part of the monitoring program, which significantly limits the robustness of our statistical analysis. To aid in the interpretation of our results, a number of parameters including both qualitative and quantitative metrics have been recorded over the duration of the monitoring period, including onsite prey availability and survey weather details.
- No flight path data was recorded during the pre-construction period. As a result, comparisons of flight activity have remained limited to data collected during the post-construction period.
- Ecological monitoring programs may be confounded by varying responses of populations to impacts or environmental conditions in differing ways. Therefore, a number of parameters including both qualitative and quantitative metrics are recorded to establish multiple lines of evidence to inform the interpretation of results.

2.2 Wedge-tailed Eagle nest monitoring

2.2.1 Locations

Monitoring of Wedge-tailed Eagle nests was undertaken within the YSWF site and in suitable, accessible environments from within a surrounding 5 kilometre search area.

2.2.2 Methods

Surveying raptor breeding activity based on nest characteristics during the later stages of breeding and after the fledgling season increases sampling capacity and minimising disturbances to nesting birds (Wiersma, J & Koch, A 2012).

Roaming surveys to locate and map Wedge-tailed Eagle nests were conducted by two Zoologists using all accessible roads within and surrounding YSWF in suitable environs. Field methodologies to locate nests included:

- One Zoologist driving whilst the other scanned for nests using binoculars from the passenger seat.
- Walking along the ridge of one side of a valley and searching in trees on the opposite side with binoculars and a spotting scope.

Once a nest was detected, observations from a prominent vantage point were made using a spotting scope from approximately 100 metres away in order to minimise disturbance. An observer watched the nest for approximately an hour and recorded observations of any activity of the nest and from adult eagles observed nearby to gain information on habitat use and possible locations of other nests. Nest activity was characterised as:

- Active, if it was lined with fresh leaves, contained eggs, a chick, or was observed to be occupied by an adult incubating (Cherriman 2013).
- Abandoned, if it presented partial or total collapse (Cherriman 2013).
- Occupied, if it presented a flat top (Wiersma, J & Koch, A 2012), the best characteristic for predicting nest use outside of additional observations fresh chick, leaves, whitewash and prey remains.

2.2.3 Frequency and survey timing

Roaming surveys to locate and map the locations of Wedge-tailed Eagle nests were undertaken early in the breeding season on the 25, 26 and 27 August 2021.

Observations of nests during the monitoring period were made once a fortnight, as per the requirements of the BAMP. Each nest located during searches, including those previously identified by BL&A (2007) and Biosis (2020), were observed a further four times through the rest of September until the end of October 2019.

2.2.4 Data analysis

The objective of monitoring is to assess whether Wedge-tailed Eagle nesting activity and success in the vicinity of YSWF differs substantially from nesting activity and success at locations not in the vicinity of wind energy facilities.

Established pairs of adult Wedge-tailed Eagles occupy large home-ranges that may overlap with adjacent pairs. Within the home range they defend a smaller breeding territory during the breeding season. As breeders are the individuals that contribute to future generations (Olsen 2005), we have attempted to estimate the mean area associated with each breeding territory (for a given breeding pair) by calculating the density of active nests detected within Yaloak South Wind Farm site using nearest-neighbour methods (Krebs 1989 as cited in Sharp, A, Norton, M, & Marks, A 2016; Cherriman 2013). This method assumes the territory shape to be circular, and calculates the area of a circle with a radius equal to half the average distance between active nests.

To calculate the distance of active nests to other active nests over the duration of the monitoring program, the ArcGIS Average Nearest Neighbour tool was used. This tool works by measuring the distance between each feature centroid and its nearest neighbour's centroid location.

The reproductive success of Wedge-tailed Eagles is variable and can be measured in different ways (Olsen 2005). Failure can occur at any stage, but is generally considered where pairs fail to lay or chicks are lost soon as after hatching (Olsen 2005). For the purposes of estimating reproductive success and dispersal capacity for the 2020 breeding season, consideration was given to the number of nests that were found to be lined with fresh leaves and those in which eggs were laid, as a relative measure of successful breeding. Ultimate success of a breeding attempt is generally measured by the successful fledging of young from a nest (Cherriman 2013).

2.2.5 Limitations

Assumptions and limitations relating to the above mentioned investigations include:

- Mapping was conducted using hand-held GPS units. The accuracy of this mapping is therefore subject to the accuracy of the GPS units (generally +/- 5 metres) and dependent on the limitations of aerial photo rectification.

- Large tracts of land adjacent to the YSWF site within the 5 kilometre search area occur on private land. Access within these areas was significantly restricted. As a result, the mean distance to nearest neighbour (Krebs 1989) was utilised as a proxy measure of nest density.
- An important assumption underlying the nearest neighbour method is that all individuals (in this case, active nests) are known. It is unlikely that this assumption was strictly met due to the potential for some nests to be overlooked during ground-based searches (attributed to the undulating terrain and the species preference for selecting nesting trees within these environments). Nevertheless, it is strongly considered that the search effort, open nature of the vegetation and the significant size of Wedge-tailed Eagles' nests resulted in relatively few nests escaping detection.
- Nests identified are not necessarily in the centre of circular territories, thus Average Nearest Neighbour analysis is not intended to represent a precise reflection of breeding territory shape and size (Olsen 2005).

3. Results

3.1 Wedge-tailed Eagle utilisation

3.1.1 Flight activity

A total of 330 observations of Wedge-tailed Eagle individuals or convocations were recorded during point-count surveys undertaken in the Year 3 monitoring period. Of those observed, 325 were observed in flight and five were recorded as perched.

Mean observations of Wedge-tailed Eagle groups or individuals recorded in flight during monthly point-count surveys in the Year 3 monitoring period are presented in Figure 3, below, against previous iterations monitoring. Survey details of flight height (when flying), height above ground (when perched) and distance from observer are provided in Appendix 2.

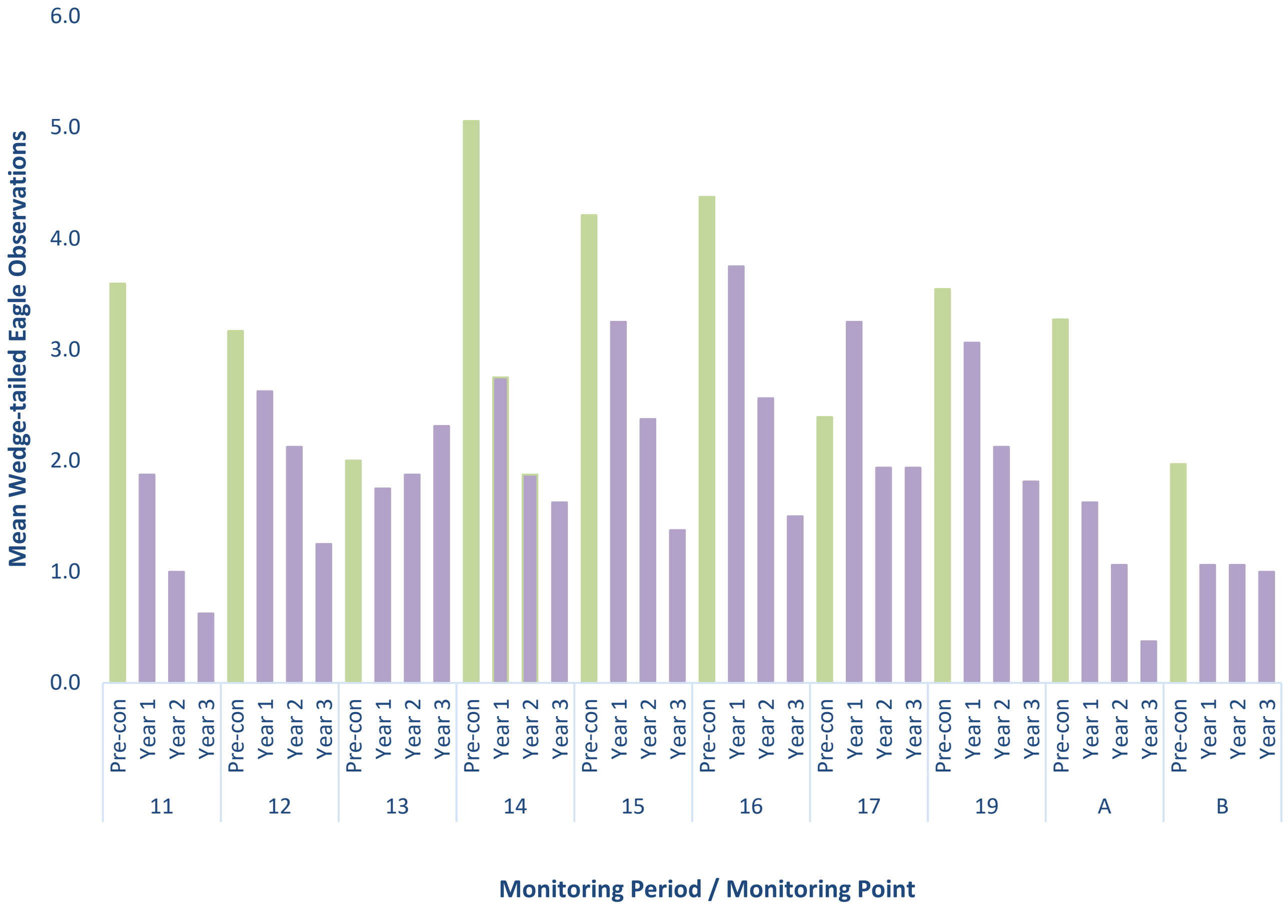


Figure 3 **Comparison of pre-construction (2009-2010) and post-construction (Year 1: 2018-2019; Year 2: 2019-2020 and Year 3: 2020-2021) mean Wedge-tailed Eagle flight observations. Flight observations are averaged by the total number of surveys undertaken at each monitoring point over each monitoring year and have excluded data recorded in the months of February, April, May and June, as per reasons outlined in section 2.1.4 of this report.**

Consistent with previous iterations of monitoring, mean observations of Wedge-tailed Eagles were recorded across all months during the Year 3 monitoring period but were typically less frequent when compared with the pre-construction monitoring period and Year 1 and 2 (Figure 3).

Despite the mean number of observations of Wedge-tailed Eagles at point-count monitoring points having declined between 2018 to 2021 (2018/19 40.90±17.96; 2019/20 41.60±12.56.96 and 2020/21 33.00±16.44), results of a one-way repeated-measures ANOVA indicated that there were no significant differences in flight activity between any year during the post-construction monitoring period ($F (2, 58) = 2.641$ $p=0.99$). The results of a Bonferroni post-hoc test comparing estimated marginal means between years are presented below in Table 2.

Table 2 Bonferroni post-hoc comparisons of yearly flight activity recorded during the post-construction monitoring period (Year 1 – 3)

Year	Compared with	Mean difference	Std. Error	Sig. [a]	Lower Bound	Upper Bound
Year 1	Year 2	-0.700	2.574	1.000	-8.249	6.849
	Year 3	7.900	5.313	0.514	-7.686	23.486
Year 2	Year 1	0.700	2.574	1.000	-6.849	8.249
	Year 3	8.600	4.118	0.199	-3.480	20.68
Year 3	Year 1	-7.900	5.313	0.514	-23.486	7.686
	Year 2	-8.600	4.118	0.199	-20.680	3.480

Note to table: Based on estimated marginal means

a. Adjustment for multiple comparisons

Seasonal comparisons of Wedge-tailed Eagle flight observations recorded over the post-construction monitoring period are presented in Figure 4. Flight paths of Wedge-tailed Eagles individuals or convocations mapped in the Year 3 monitoring period are presented in Figure 5 through Figure 8; with the flight path of convocations recorded as the first individual sighted.

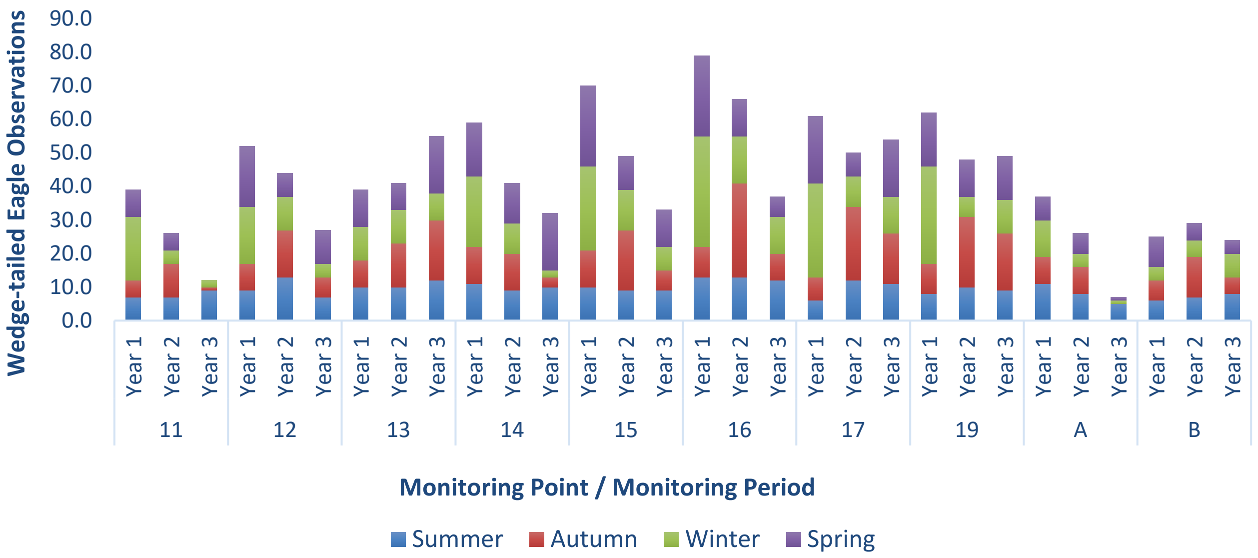


Figure 4 Seasonal comparison of Wedge-tailed Eagle flight observations recorded during the post-construction period.

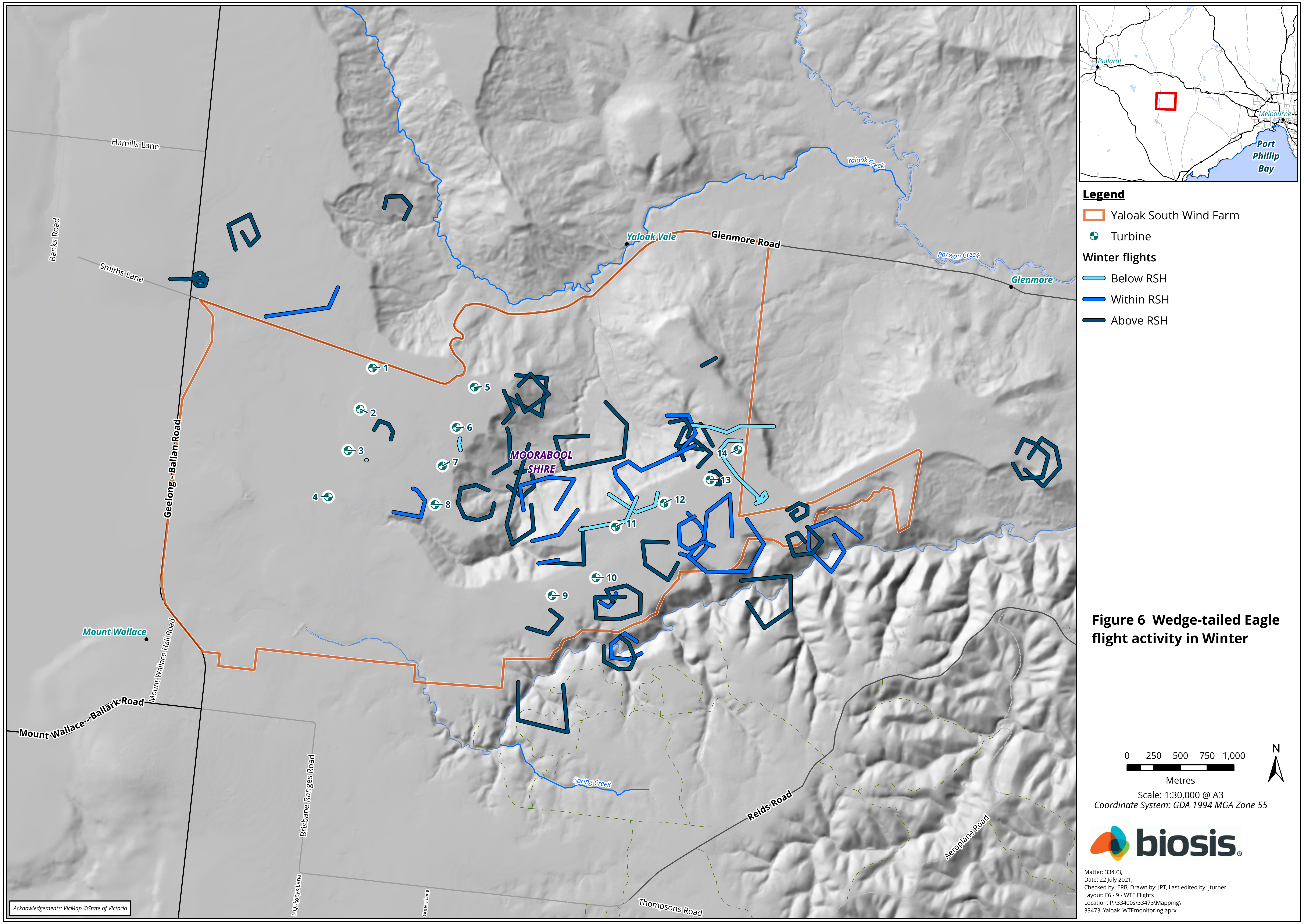


Figure 6 Wedge-tailed Eagle flight activity in Winter

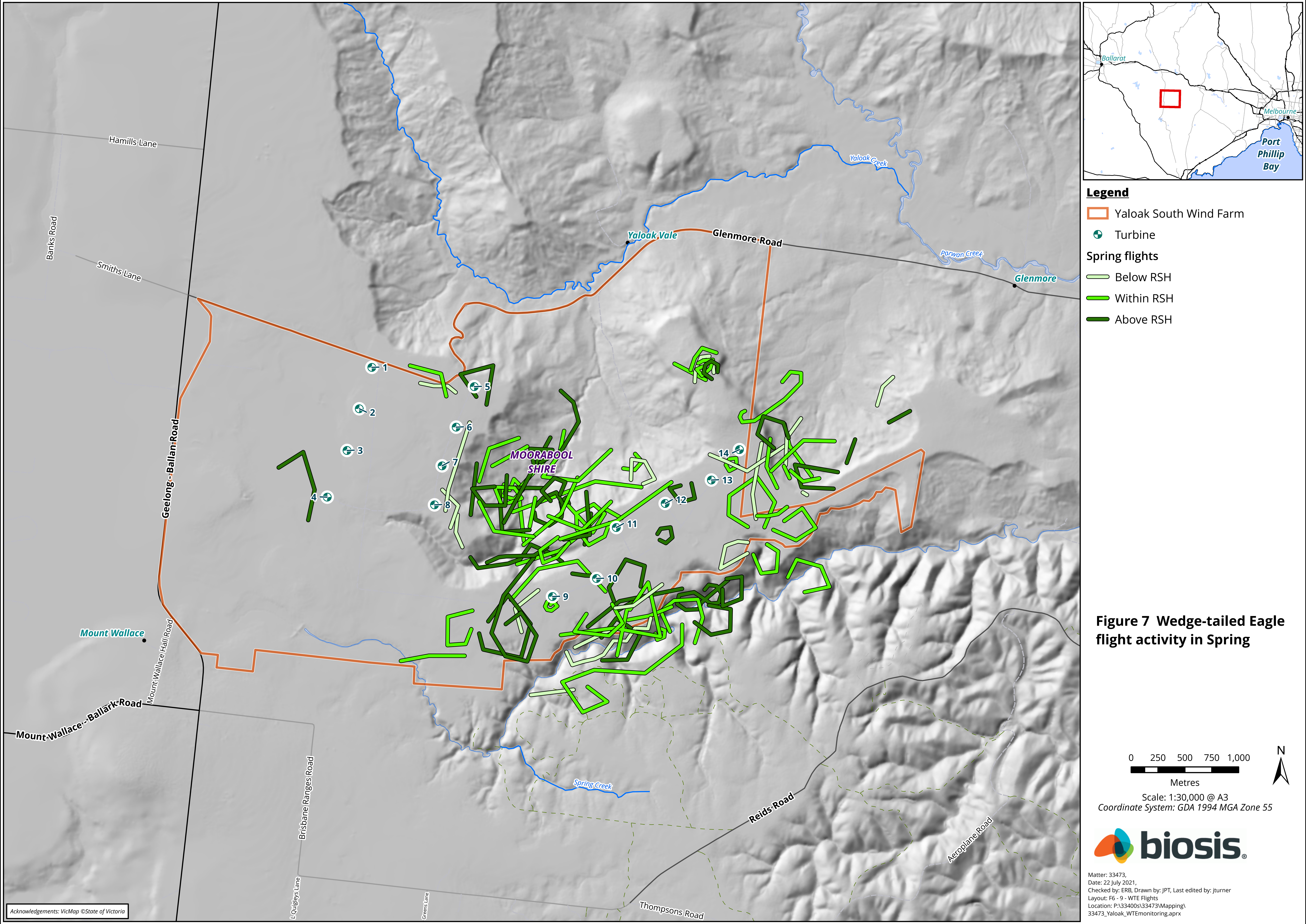
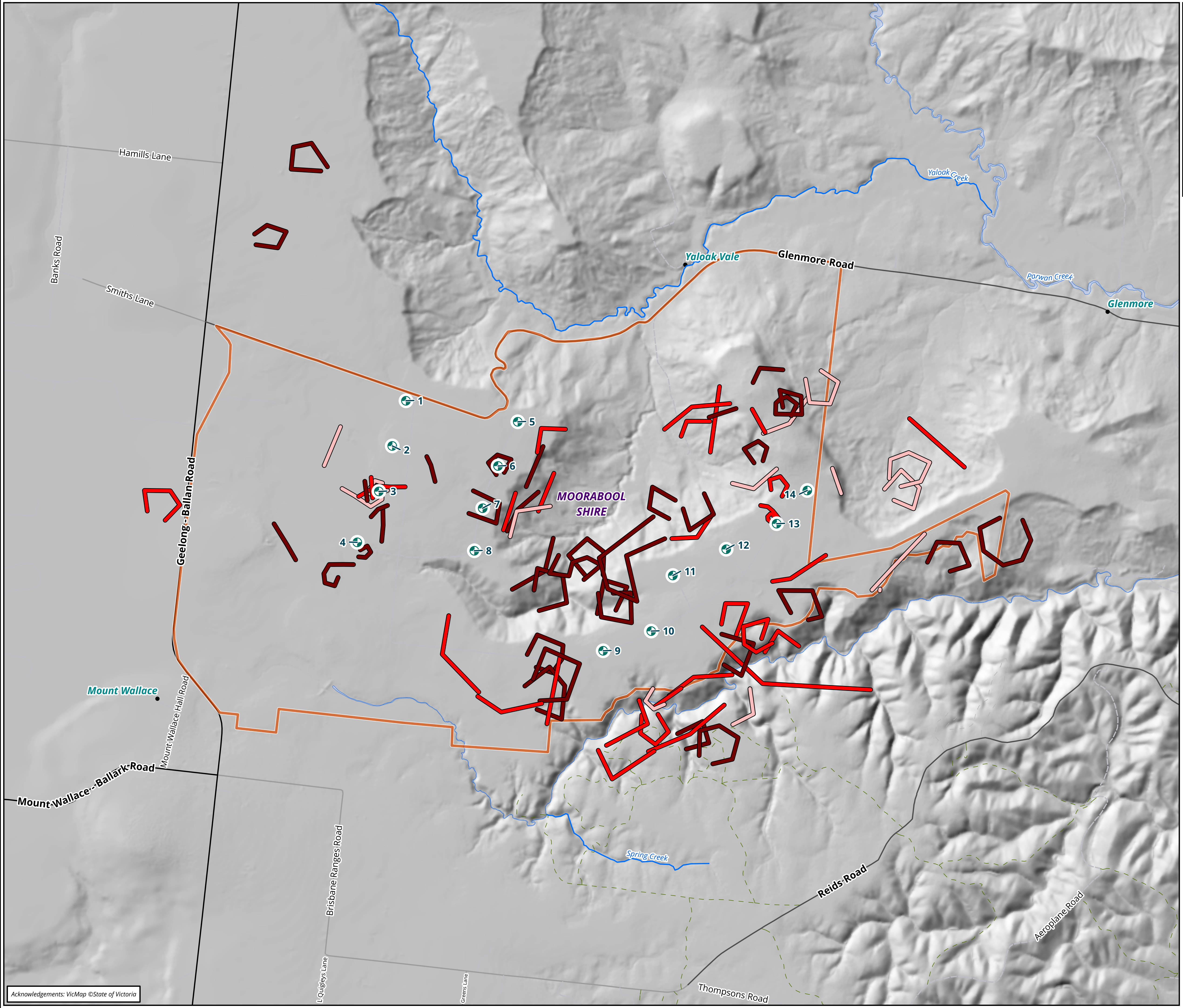
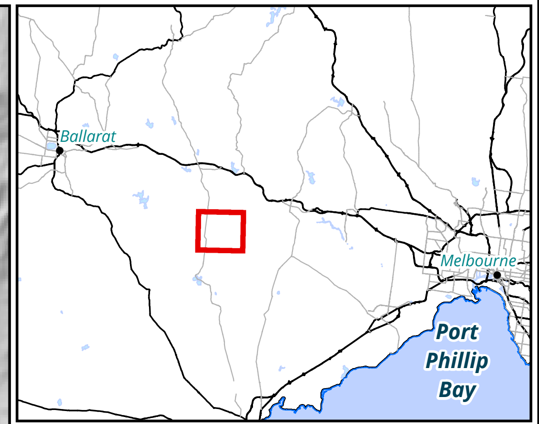


Figure 7 Wedge-tailed Eagle flight activity in Spring





Legend

Yaloak South Wind Farm

Turbine

Summer flights

Below RSH

Within RSH

Above RSH

Figure 8 Wedge-tailed Eagle flight activity in Summer

0 250 500 750 1,000

Metres

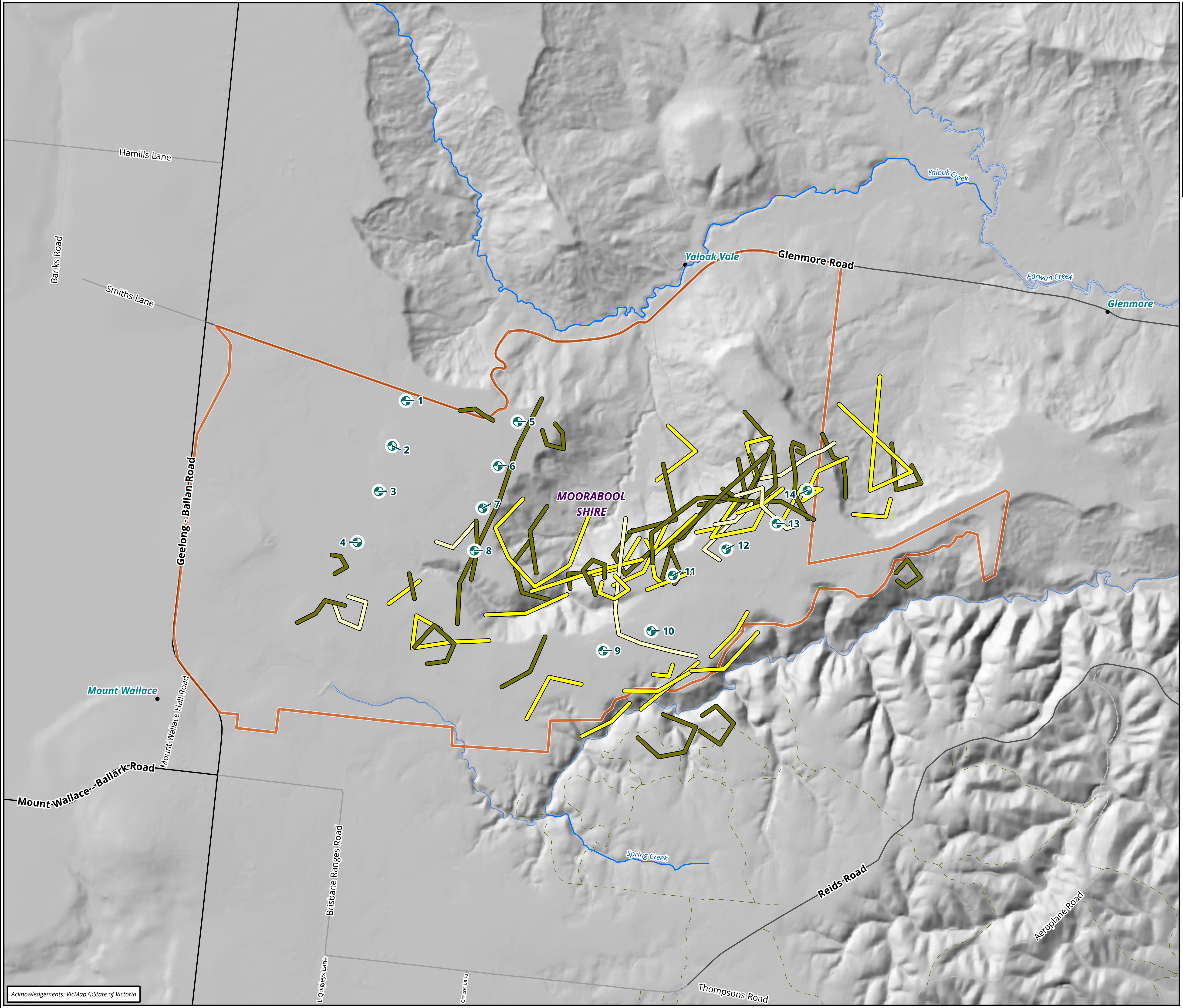
Scale: 1:30,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

N

biosis.

Matter: 33473,
Date: 22 July 2021,
Checked by: ERB, Drawn by: JPT, Last edited by: jturner
Layout: F6 - 9 - WTE Flights
Location: P:\33400s\33473\Mapping\
33473_Yaloak_WTEmonitoring.aprx



Legend

Yaloak South Wind Farm

Turbine

Autumn flights

Below RSH

Within RSH

Above RSH

Figure 9 Wedge-tailed Eagle flight activity in Autumn

0 250 500 750 1,000

Metres

Scale: 1:30,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis.

Matter: 33473,
Date: 22 July 2021,
Checked by: ERB, Drawn by: JPT, Last edited by: jturner
Layout: F6 - 9 - WTE Flights
Location: P:\33400s\33473\Mapping\33473_Yaloak_WTEmonitoring.aprx

No defined seasonal or directional flight paths were recorded over the duration of the post-construction monitoring program (Appendix 3; Figure 5 – Figure 8). Although, consistent with previous years of monitoring, observations were typically lower at monitoring sites located at greater distances and/or elevations which impede view of escarpments within and adjacent to the site (Figure 4 – Figure 8).

3.1.2 Rotor Swept Height (RSH)

The proportion of Wedge-tailed Eagle flights recorded below, within and above RSH (as measured above ground level; AGL) during point-point surveys during the Year 3 monitoring period is presented in Figure 9 below against previous iterations of monitoring.

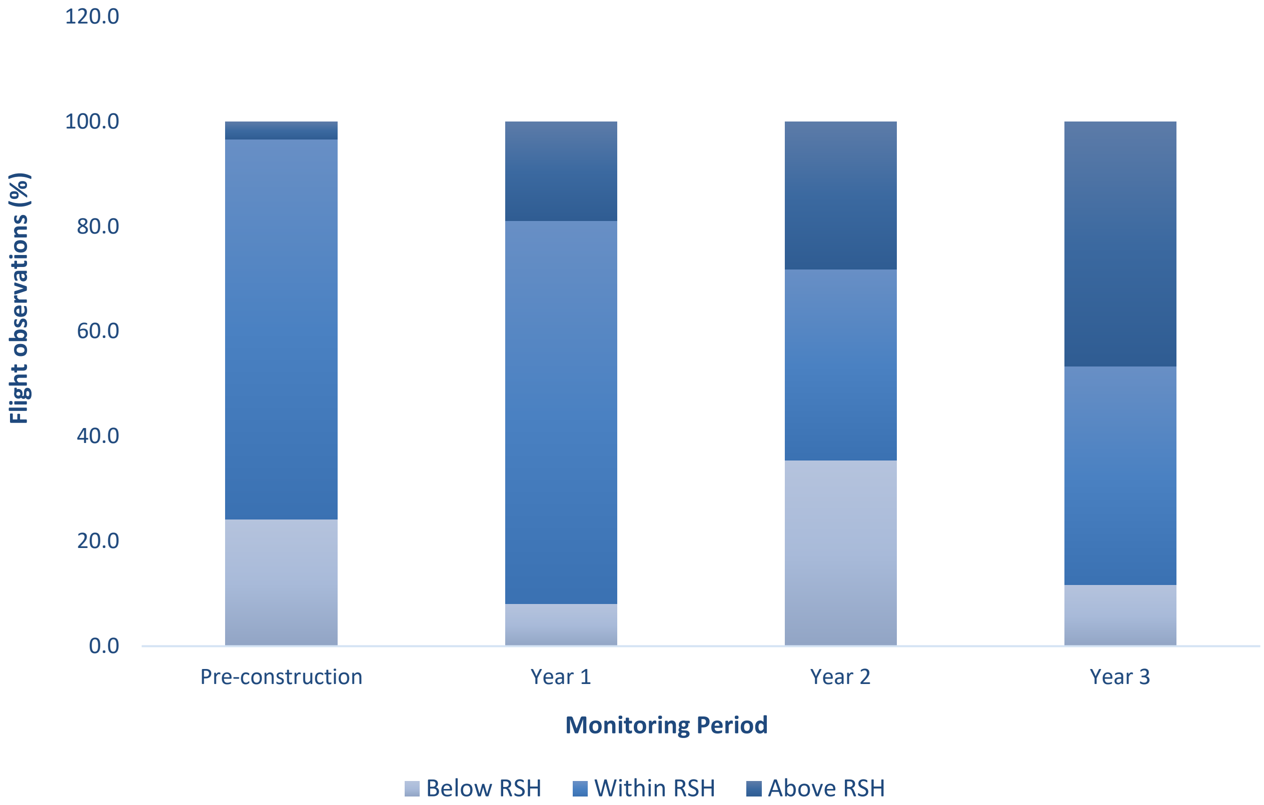


Figure 9 Proportion of flights recorded below, within and above RSH during fixed-point surveys over the duration of the monitoring program.

Of the Wedge-tailed Eagle flights recorded during point-count surveys within the third year of the wind facility's operations (Figure 9), approximately:

- 46.6.5% were recorded above rotor-swept height (RSH) (above 126.25 metres).
- 41.6% were recorded within RSH (33.75-126.25 metres).
- 11.8% were recorded below RSH (below 33.75 metres).

Flight heights recorded above RSH (AGL) show a trend of increase since the commencement of turbine operations (Figure 9).

3.2 Wedge-tailed Eagle nesting activity

3.2.1 Roaming surveys

No additional Wedge-tailed Eagle nests were detected during roaming surveys within the defined search area in winter (August) 2020), despite access being granted by a neighbouring landowner to investigate remnant vegetation in White Elephant Reserve (north-east of YSWF) within his property. Three nests (Nest #7, Nest #8 and Nest #11) detected during pre-construction surveys were not found in any year during post-construction monitoring (Years 1 – 3) and thus considered to have completely degraded since initial identification.

Of the 8 nests re-visited (Nest #1 – Nest #6, Nest #9 and Nest #10) during roaming surveys undertaken in the Year 3 monitoring period:

- One was determined to be active based on the observation of a single Wedge-tailed Eagle chick (Table 3). A photo of this chick is presented in Photo 1 below.
- Four were determined to be occupied, based on the presence of a flat top (Wiersma, J & Koch, A 2012) (Table 3).
- Three were determined to be abandoned, based on the nest's partial or total collapse (Table 3). This includes one nest (Nest #4) that was previously active in 2019 that was observed to have collapsed below the tree during the 2020 breeding season. However, it is noted that aerial courtship by the breeding pair occupying this territory was observed in late May and June 2021 near to the location of this nest during monthly flight monitoring surveys. We therefore consider there is potential for this nest to have been re-built during the 2021 breeding season.

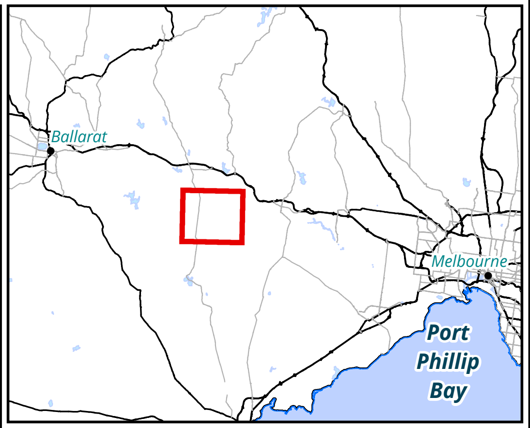
Photo 1 Wedge-tailed Eagle Chick detected in Nest #3 on 27 August 2020 during roaming surveys. Parent observed with chick on arrival, but departed shortly after monitoring commenced before photo could be taken. Judged on feather development, chick presumed to be <10 days in age based on no primary underpins (Marchant & Higgins 1993).

Table 3 2020 Wedge-tailed Eagle nest characteristics and activity

Nest No.	Year Detected	Tree species	2020 Activity	Year(s) Active	Distance to nearest active nest	Distance to nearest turbine	2019 Young Hatched	2019 Young Fledged	2020 Young Hatched	2020 Young Fledged
Nest #1	2006	*Eucalyptus* sp.	Occupied	-	73 m	525 m	-	-	-	-
Nest #2	2006	*Eucalyptus* sp.	Occupied	-	64 m	497 m	-	-	-	-
Nest #3	2006	*Eucalyptus* sp.	Active	2019	2380 m	434 m	1	1	1	1
Nest #4	2006	Pine sp.	Abandoned*	2006, 2009, 2019	2380 m	530 m	1	1	-	-
Nest #5	2018	*Eucalyptus* sp.	Abandoned	-	3675 m	3860 m	-	-	-	-
Nest #6	2006	*Eucalyptus* sp.	Abandoned	2006, 2009	3154 m	4359 m	-	-	-	-
Nest #7	2006	NA	NA	-	NA	NA	-	-	-	-
Nest #8	2006	NA	NA	-	NA	NA	-	-	-	-
Nest #9	2019	*Eucalyptus* sp.	Occupied	2019	8437 m	7553 m	1	Unknown	-	-
Nest #10	2006	*Eucalyptus* sp.	Occupied	-	3503 m	6504 m	-	-	-	-
Nest #11	2006	NA	NA	2006, 2009	NA	NA	-	-	-	-

* Potential to have been re-built (occupied) during the 2021 breeding season.

NA Nest unable to be detected.



Legend

- Yaloak South Wind Farm
- Yaloak Estate
- Turbine

Wedge-tailed Eagle nests

- Abandoned
- Active
- Occupied
- Could not locate

Figure 10 Locations and activity of Wedge-tailed Eagle nests monitored during the 2020 breeding season

0 500 1,000 1,500

Metres

Scale: 1:40,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis.

Matter: 33473,
Date: 22 July 2021,
Checked by: ERB, Drawn by: JPT, Last edited by: jturner
Layout: F10 WTE Nests
Location: P:\33400s\33473\Mapping\
33473_Yaloak_WTEmonitoring.aprx

3.2.2 September – October nest checks

Since Wedge-tailed Eagle chicks generally hatch in Victoria during September and October, fortnightly monitoring of both the active nest and those determined to have the most potential for occupation were monitored on five additional occasions through September until the end of October 2020. During these surveys, no other nests were determined to be active (based on the absence of lining, egg/s or chick/s).

During fortnightly monitoring of the active nest, the chick in Nest #3 was often observed with a parent, preening or eating fresh carrion (presumably European Rabbit *Oryctolagus cuniculus* or Red Fox *Vulpes vulpes*). Details and development of this chick and its parents are described in Photo 2 through Photo 7 below. The locations and activity of the active nest and those previously re-visited during the 2020 breeding season are provided in Table 3 and Figure 10.

Photo 2 Photo taken during nest monitoring undertaken on 11 September 2020. Chick observed alone in nest for duration of survey. Fresh carrion noted in corner of nest. Judged on feather development, chick presumed to be ≥28 days in age based on the appearance of upper wing coverts (Marchant & Higgins 1993).

Photo 3 **Photo taken during nest monitoring undertaken on 25 September 2020. Adult parents observed flying in valley adjacent to nest. Chick was observed eating fresh carrion, stretching and preening for duration of survey. Judged on feather development, chick presumed to be ≥42 days in age based on feather development on breast, belly, back, mantle, forehead & ear coverts (Marchant & Higgins 1993).**

Photo 4 **Photo taken during nest monitoring undertaken on 8 October 2020. Chick was observed laying on stomach within nest during the duration of the survey, thus feather development difficult to discern.**

Photo 5 **Photo taken during nest monitoring undertaken on 8 October 2020. Parents perched in nearby tree, 200 metres north of nest for duration of survey.**

Photo 6 Photo taken during nest monitoring undertaken on 22 October 2020. Fledgling was observed alone, perched in branch adjacent to nest preening for one hour survey. Judged on feather development, chick is estimate to be ≥49 days based on primary and secondary feathers being almost full length.

Photo 7 Photo taken during nest monitoring undertaken on 28 October 2020. Fledgling was observed flying alone in the valley for most of the monitoring visit, returning to perch in nearby tree for the last 15 minutes of survey.

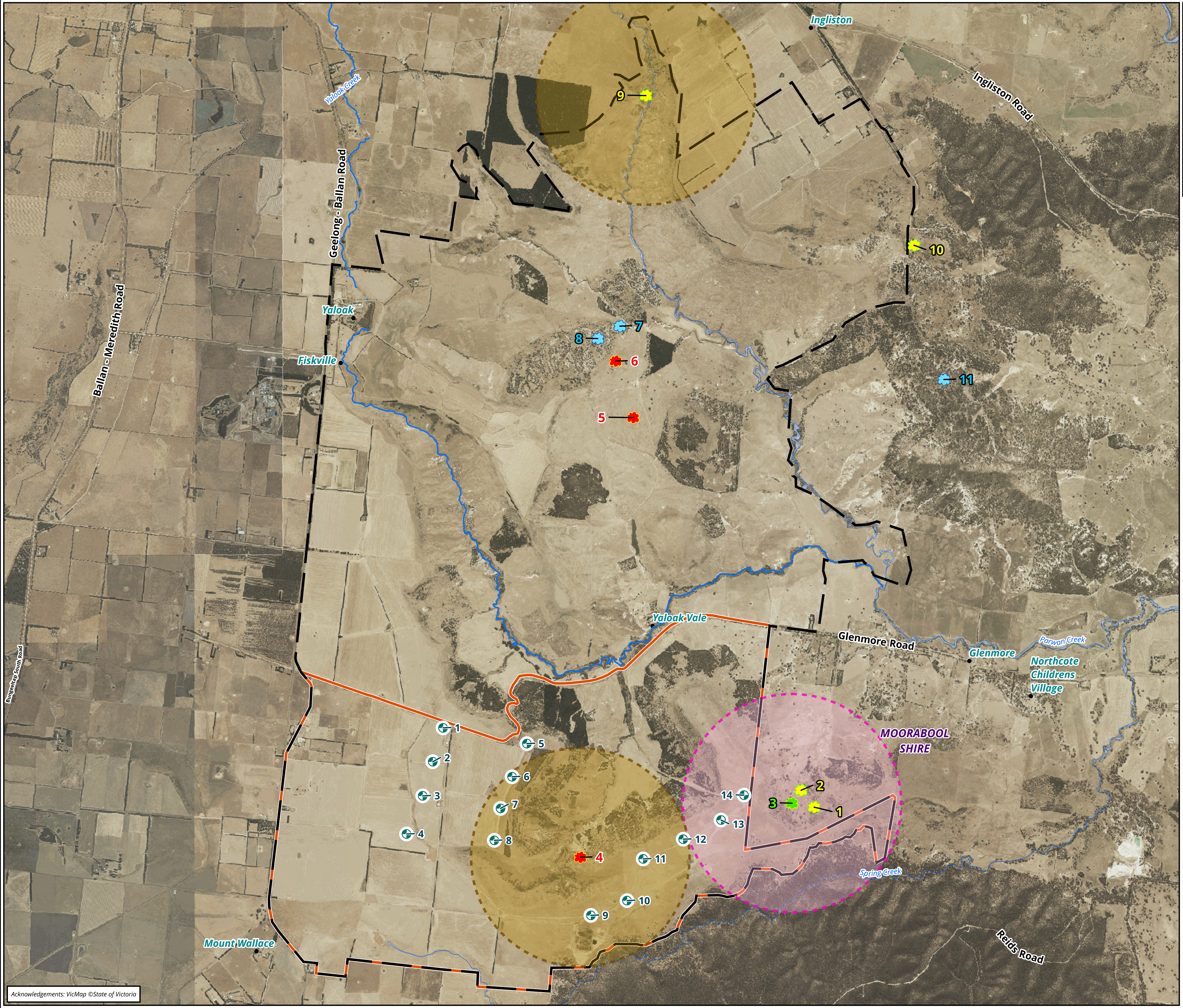
Nest monitoring undertaken in 2020 determined the single chick present within Nest #3 to have successfully fledged as of October 28 2020, based on observations of it flying alone within the valley adjacent to the nest. This individual was also recorded flying within the valley during monthly flight monitoring undertaken in the months of November 2020 through February 2021.

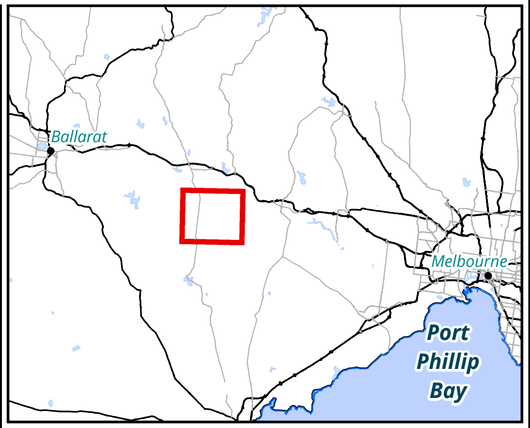
3.2.3 Breeding density and nesting success

All active nests monitored in 2020 were determined to have contained egg/s, with no other nests observed to have been lined with natural (fresh green foliage) materials during the breeding season. Breeding success, for active nests in 2020 in which breeding was attempted (i.e. egg/s laid) and where the outcome was known (n=1), averaged 1.0 for young fledged. This estimate for breeding productivity takes into account that no other nests were found to have been lined (occupied) during monitoring undertaken 2020 and thus assumes that the number of nonbreeding pairs was not underestimated (Cherriman 2013).

Established pairs of adult Wedge-tailed Eagles occupy large home-ranges that may overlap with adjacent pairs. Within the home range they defend a smaller breeding territory during the breeding season. Judged on the average distance between active nests detected during this study (4.4 kilometres; 2.4-8.4 km, n=3), it is considered that at least three Wedge-tailed Eagle breeding pairs occupy a probable core breeding territory of one pair per 15.21 square kilometres (4.52-55.41km^2) within the YSWF site and greater Yaloak Estate. Of these three territories, only one territory was found to be active in both years (2019 and 2020).

The estimated locations of these breeding territories are provided in Figure 11 below.





Legend

- Yaloak South Wind Farm
- Yaloak Estate
- Turbine

Wedge-tailed Eagle nests

- Abandoned
- Active
- Occupied
- Could not locate

Estimated breeding territory

- Territory/ies active in 2019
- Territories active in 2019 and 2020

Figure 11 Estimated size of three Wedge-tailed Eagle breeding territories identified during the post-construction monitoring period within the Yaloak South Wind Farm and in suitable environs immediately adjacent

0 500 1,000 1,500

Metres

N

Scale: 1:40,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

Matter: 33473,
Date: 22 July 2021,
Checked by: ERB, Drawn by: JPT, Last edited by: jturner
Layout: F11 WTE Territory
Location: P:\33400s\33473\Mapping\
33473_Yaloak_WTEmonitoring.aprx

4. Discussion

This section of the report provides an overview of the presence, behaviour, movements and habitat use of the Wedge-tailed Eagle during the post-construction monitoring period (Year 1 – Year 3) and discusses potential factors that may account for observed results.

Flight activity

A total of 330 observations of Wedge-tailed Eagle individuals or convocations were recorded during point-count surveys undertaken in the Year 3 monitoring period. Of those observed, 325 were observed in flight and five were recorded as perched.

Consistent with previous years of monitoring, no defined seasonal patterns of Wedge-tailed Eagle flight paths were observed during the Year 3 monitoring period (Figure 5 – Figure 8). However, flight paths observed during the Year 3 monitoring period appear similar to behaviour and site use observed during Years 1 and 2 (Appendix 3) and described prior to construction (Biosis 2010). The majority of flight paths recorded were above escarpments both within and adjacent to the YSWF site. It is considered this behaviour is likely attributable to ridges providing orographic uplift and energy for movement.

Observations of Wedge-tailed Eagles were recorded across all months during the Year 3 monitoring period within the YSWF site but were typically less frequent when compared with surveys undertaken during the pre-construction monitoring period (Figure 3). Reasons for a decline in Wedge-tailed Eagle observations from within the site during the post-construction monitoring period remain difficult to discern in the absence of several years of monitoring prior to the wind farm's construction and without the benefit of suitably comparable control monitoring sites.

A reduction in the number of observations of Wedge-tailed Eagles from within the site during the post-construction monitoring period may be attributed to multiple variables; including operating turbines of the YSWF, weather, climate and/or the availability of prey prompting the movement of juveniles and sub-adults at greater distances into the surrounding landscape (away from the Brisbane Ranges National Park, which adjoins the site to the south).

Adult Wedge-tailed Eagles in temperate south-eastern Australia generally reside permanently within a stable home range, whilst older juveniles and sub-adults are dispersive and more mobile. Reductions in site observations from within the site during the post-construction period attributed to the movement of juveniles and sub-adults away from the YSWF site may be considered highly plausible given:

- A significant decline in the observed presence of prey species onsite (i.e. Eastern Grey Kangaroos), which may be attributed to the construction of the 1.8 metre fence along the YSWFs southern boundary with the Brisbane Ranges National Park.
- Continued observation of resident Wedge-tailed Eagle pairs in flight from within the site throughout the duration of the monitoring program; particularly during the breeding months when undertaking aerial courtship.
- Flight paths and breeding activities remain similar in occurrence and behaviour to those reported during the pre-construction report (i.e. concentrated close to escarpments within the site and the Brisbane Ranges National Park, which borders the site to the south).
- Recent Wedge-tailed Eagle radio-tracking studies undertaken in Western Australia which found juveniles and sub-adults to be able to disperse at distances up to 2000 kilometres (Cherriman 2018).

- Comparisons of flight activity during the post-construction monitoring period, which found no statistical differences in flight activity between any year of flight monitoring.

The height at which Wedge-tailed Eagles fly within the YSWF site is relevant to the likelihood of collision with wind turbines. Birds flying at heights occupied by the moving rotors of a turbine (RSH) at YSWF are considered to be those at greatest risk of collisions with turbines.

Whilst on several occasions Wedge-tailed Eagles were recorded soaring or hovering very close to operating turbines within the site, the greatest proportion of flights recorded during the Year 3 monitoring period (46.6%) were observed at heights (AGL) above RSH. Increases in the flight height of Wedge-tailed Eagles flying within the YSWF site during the second and third years of monitoring in comparison to flights recorded during the pre-construction and Year 1 monitoring period may be attributed to Wedge-tailed Eagles demonstrating distinct avoidance of operating turbines within the site. Observers documenting the flight tracks and behaviours of Tasmanian Wedge-tailed Eagles *Aquila audax fleayi* and White-bellied Sea Eagles *Haliaeetus leucogaster* within the Bluff Point Wind Farm site noted similar results during studies undertaken in 2006 – 2009, with both species found to demonstrate a distinct avoidance of the turbines, which altered in response to different stages in the wind-farm development (Hull & Muir 2013).

Breeding activity

No additional Wedge-tailed Eagle nests were detected within 5 kilometres of YSWF during roaming surveys in winter 2020 (Year 3), despite intensive searches being extended into remnant vegetation within White Elephant Reserve (north-east of YSWF).

Wedge-tailed Eagle nests detected within the defined search area over the duration of the post-construction monitoring period were located in emergent, living eucalypts *Eucalyptus* spp. and were predominantly found on slope habitat concentrated to valleys, or in flat areas (creek lines) that are immediately adjacent. Whilst nests were detected in both living and dead trees, active nests were only found in the canopies of live trees.

Territoriality in Wedge-tailed Eagles has been hypothesized to set an upper limit to the number of breeding pairs and is influenced by the long-term availability of prey species, competition for food resources and the availability of nesting sites. Whilst various nest sites may be used in different years, a given nest may be reused for many years and even by subsequent generations of birds. Post-construction monitoring detected no active nests in 2018, three active nests in 2019 and one active nest in 2020. Only one nest was found to be active during two consecutive years during the post-construction monitoring period.

Whilst there is an annual breeding season, it is not uncommon for reproductive rates to vary considerably between years, largely influenced by rainfall effecting the abundance and availability of prey species and/or age distribution of the population (Sharp, A, Norton, M, & Marks, A 2016). Total monthly rainfall (mm) was significantly higher during the months of May and June in 2019 (148.6mm and 157.4mm, respectively) (Bureau of Meteorology 2020) compared with the same months in 2020; despite annual rainfall being higher in 2020 (791mm) compared to 2019 (664mm). These months coincide with the beginning of the Wedge-tailed Eagle breeding season and may have resulted in a better nesting season in 2019 compared with 2020.

Whilst no active nests were detected during Year 1 of post-construction monitoring, the detection of three active nests during the 2019 breeding season is consistent with the detection of three active nests during pre-construction surveys undertaken in 2006 and 2009. The solid structure of some nests also suggests the presence of occupied territories of additional pair/s that may have not attempted to breed during this study (2018 – 2020) (Rowe, Brinsley, & Dennis 2017).

Although most paired adults are resident year round, the locations of their territories are more easily determined in the breeding season. Judged on the average distance between active nests monitored during this study (4.4 kilometres; 2.4-8.4 km, *n*=3), it is considered that three Wedge-tailed Eagle pairs occupy a probable core breeding territories of one pair per 15.21 square kilometres (4.52-55.41km^2). These nearest-neighbour distances are within the range of results previously reported for Wedge-tailed Eagles near to Bacchus Marsh, where the average distance between active nests was found to be 4.7 kilometres (4-5.5 km, n = 5) and the core breeding territory size averaged 17.6 square kilometres (12.6-23.8 km^2).

Nest monitoring undertaken in 2020 detected a single chick to have successfully fledged as of October 28 2020. All active nests monitored in 2019 and 2020 were determined to have contained egg/s, with no other nests observed to have been lined with natural (fresh green foliage) materials. Although breeding activity was lower in 2020 compared with 2019, the number of young fledged remained consistent; averaging 1.0 for young fledged per attempt in which eggs were laid. These results are higher than those recorded for pairs in recent studies in Perth, Western Australia (Cherriman 2013) and in Fleurieu Peninsula, South Australia (Rowe, Brinsley, & Dennis 2017), but consistent with that of the south-eastern mainland population breeding average (Olsen 2005, Debus et al 2007).

5. Conclusion

Post-construction monitoring of Wedge-tailed Eagle utilisation and nesting activities has been important as a means to assess whether significant changes in utilisation and / or breeding activities can be discerned as a result of the operation of the Yaloak South Wind Farm.

Wedge-tailed Eagle flight activity

The objective of point-count surveys at YSWF is to document Wedge-tailed Eagle flight activity and behaviour around turbines during the first three years after commissioning of the last turbine. Monthly flight activity surveys were conducted at ten locations within YSWF from July 2018 to June 2021 using the same methods as pre-construction surveys. Wedge-tailed Eagle monitoring completed to date is considered to meet Pacific Hydro's monitoring and reporting obligations, as outlined within the approved BAMP for the YSWF (Biosis 2019b).

Consistent with previous years of monitoring, no defined seasonal patterns of Wedge-tailed Eagle flight paths were observed during the Year 3 monitoring period. However, flight paths observed during the Year 3 monitoring period appear similar to behaviour and site use observed during Years 1 and 2 and described prior to construction; with the majority of flights recorded above escarpments both within and adjacent to the YSWF site.

Observations of Wedge-tailed Eagles during the Year 3 monitoring period within the YSWF site were typically less frequent when compared with surveys undertaken during the pre-construction monitoring period. Reasons for a decline in Wedge-tailed Eagle observations from within the site during the post-construction monitoring period remain difficult to discern in the absence of several years of monitoring prior to the construction of YSWF and without the benefit of suitably comparable control monitoring sites.

A reduction in the number of observations of Wedge-tailed Eagles from within the site during the post-construction monitoring period may be attributed to multiple variables; including avoidance of turbines within the YSWF, weather, climate and/or the availability of prey prompting the movement of juveniles and sub-adults at greater distances into the surrounding landscape (away from the Brisbane Ranges National Park, which adjoins the site to the south).

Movements of juveniles and sub-adults at greater distances into the surrounding landscape may be considered highly plausible given:

- Continued observation of resident pairs in flight from within the site throughout the duration of the monitoring program.
- Flight paths and breeding behaviours were found to remain similar in occurrence and behaviour to those reported during the pre-construction period.
- Wedge-tailed Eagle juveniles and sub-adults are well documented as being highly dispersive.
- Flight activity over post-construction years (Year 1 – Year 3) showed no statistical differences between any year.

Wedge-tailed Eagle nest activity

The objective of the Wedge-tailed Eagle nesting studies is to document breeding activity and nesting success within and adjacent to the YSWF site. Surveys to detect and monitor Wedge-tailed Eagle nests were undertaken within 5 kilometres of the YSWF during breeding seasons in each of the first three years following the commissioning of the last YSWF turbine. Monitoring of nests also included those previously identified in 2009 that could be detected.

Nesting density and success (measured by the number of juveniles fledged) of resident pairs occupying breeding territories within and adjacent to the YSWF site between Years 1 and 3 were analysed in order to determine if collected results differ in similar environs not in the vicinity of wind energy facilities. Wedge-tailed Eagle nest monitoring completed to date is therefore considered to meet Pacific Hydro's monitoring and reporting obligations, as outlined within the approved BAMP for the YSWF (Biosis 2019b).

Post-construction monitoring detected no active nests in 2018, three active nests in 2019 and one active nest in 2020. Only one nest was found to be active during two consecutive years during the post-construction monitoring period (2019 and 2020). Whilst no active nests were detected in 2018 (Year 1), the detection of three active nests during the 2019 breeding season (Year 2) is consistent with the detection of three active nests during pre-construction surveys undertaken in 2006 and 2009.

Nest monitoring undertaken in 2020 (Year 3) detected a single chick to have successfully fledged as of October 28 2020. All active nests monitored in 2019 and 2020 were determined to have contained egg/s, with no other nests observed to have been lined with natural (fresh green foliage) materials. Although breeding activity was lower in 2020 compared with 2019, the number of young fledged remained consistent; averaging 1.0 for young fledged per attempt in which eggs were laid.

Results of the Wedge-tailed Eagle post-construction nesting study (Years 1 – 3) therefore considers breeding densities within the YSWF site and greater Yaloak Estate to remain consistent with those reported during the pre-construction monitoring period. Comparisons of datasets over Years 1 – 3 with studies undertaken in south-eastern Australia also found that breeding densities and fledgling success recorded within YSWF to be within range of results reported within similar environments not in the vicinity of wind energy facilities. Collected findings suggest that the operation of YSWF may have little influence over Wedge-tailed Eagle breeding behaviour or nesting success.

Recommendations

On the basis of the findings of the post-construction flight and nesting activity monitoring undertaken in the first three years since the commencement of operations of the YSWF, further studies of Wedge-tailed Eagle flight activity or nesting monitoring are not recommended. Impacts to Wedge-tailed Eagles will continue to be monitored throughout the operational life of the wind farm by site personnel in accordance with Pacific Hydro's Injured or Dead Bird and Bat Procedure. To ensure operations of YSWF do not result in a net significant or lasting impacts on the viability or conservation status of the Wedge-tailed Eagle mainland population trigger levels for responsive management response(s) will continue to apply.[2]

[2] BAMP trigger levels correspond with the detection of:

- Ten Wedge-tailed Eagle individuals during routine management over any 12-month period.
- More than an average of seven individuals per annum over any two consecutive years.

Should triggers levels be met at any point through ongoing carcass detection monitoring undertaken by site personnel, the Procedures for Mitigation Measures (outlined in the BAMP for YSWF) should be initiated. This may involve the recommendation to undertake further monitoring of Wedge-tailed Eagle flight activity in conjunction with carcass detection surveys to determine the significance of impacts.

We also recommend the continuation of the following practices:

- All new site personnel continue to be trained on procedures for the event in which they encounter dead or injured birds and bats, as per methods previously outlined in the BAMP (Biosis 2019b, Biosis 2019a).
- Carcasses of livestock and other larger animals such as destroyed pest animals or legally destroyed kangaroos (referred to below collectively as 'mammal carcasses') continue to be removed in a timely manner. This will reduce the incidence of collision with turbines by birds that routinely feed on carrion, such as the Wedge-tailed Eagle.
- Sheep of the Yaloak Estate continue to be managed so as to reduce the incidence of lambing “under” turbines, as per arrangements previously agreed within the BAMP. Routine checks (daily) between mid-July to the end of August should remain in place to ensure any fallen ewes or sheep carcasses are removed in a timely manner.

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Appendices

Appendix 1 Relevant BAMP reporting requirements

A1.1 Approximate timeline for surveys and reporting

Action	Authority report to be submitted to	Report type & frequency / timing
Results of Wedge-tailed Eagle flight activity investigations	DELWP (Victoria)	All raw data and in Annual Bird & Bat Management Report for relevant three years. Both to be submitted within three months of conclusion of annual monitoring period
Results of Wedge-tailed Eagle nest success investigations	DELWP (Victoria)	All raw data and in Annual Bird & Bat Management Report for relevant three years. Both to be submitted within three months of conclusion of annual monitoring period
Results of all bird and bat monitoring and investigations	Community, after verification by DELWP (Victoria)	In Bird & Bat Management Report for each year in which carcass monitoring is undertaken

Appendix 2 Wedge-tailed Eagle Observations

A2.2 Wedge-tailed Eagle observations recorded during point count surveys during the Year 3 monitoring period

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
30/07/2020	16	1	1	400	400	Flying	Imogen Merlo
30/07/2020	13	1	1	300	1500	Flying	Imogen Merlo
30/07/2020	16	1	1	300	400	Flying	Imogen Merlo
30/07/2020	17	1	1	500	2800	Flying	Imogen Merlo
30/07/2020	13	1	1	350	1500	Flying	Imogen Merlo
30/07/2020	A	1	1	1000	1500	Flying	Imogen Merlo
30/07/2020	B	1	1	1000	1000	Flying	Imogen Merlo
30/07/2020	11	2	2	250	1500	Flying	Imogen Merlo
30/07/2020	B	1	1	10	200	Perched	Imogen Merlo
30/07/2020	17	2	2	700	1000	Flying	Imogen Merlo
30/07/2020	12	1	1	500	1200	Flying	Imogen Merlo
30/07/2020	19	1	1	30	100	Perched/Flying	Imogen Merlo
30/07/2020	19	1	1	1500	200	Flying	Imogen Merlo
30/07/2020	16	1	1	100	1600	Flying	Imogen Merlo
30/07/2020	17	1	1	1000	2800	Flying	Imogen Merlo
30/07/2020	15	1	1	50	700	Perched/Flying	Imogen Merlo
30/07/2020	17	1	1	100	700	Flying	Matt Jones
30/07/2020	16	1	1	100	1200	Flying	Matt Jones
30/07/2020	B	1	1	200	2000	Flying	Matt Jones
30/07/2020	12	1	1	200	1000	Flying	Matt Jones

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
30/07/2020	13	1	1	150	1000	Flying	Matt Jones
30/07/2020	16	1	1	300	1500	Flying	Matt Jones
30/07/2020	13	1	1	250	2000	Flying	Matt Jones
30/07/2020	13	1	1	150	2000	Flying	Matt Jones
24/08/2020	16	1	1	50	1500	Flying	Erin Baldwin
24/08/2020	17	1	1	150	2500	Flying	Erin Baldwin
24/08/2020	17	1	1	2	150	Flying	Erin Baldwin
23/08/2020	15	1	1	40	2000	Flying	Erin Baldwin
24/08/2020	17	1	1	125	500	Flying	Erin Baldwin
23/08/2020	15	1	1	40	2000	Flying	Erin Baldwin
23/08/2020	15	1	1	80	200	Flying	Erin Baldwin
24/08/2020	19	1	1	30	250	Perched	Erin Baldwin
24/08/2020	19	1	1	150	850	Flying	Erin Baldwin
24/08/2020	19	1	1	125	650	Flying	Erin Baldwin
24/08/2020	19	1	1	50	500	Flying	Erin Baldwin
24/08/2020	19	1	1	30	850	Flying	Erin Baldwin
24/08/2020	B	1	1	500	2000	Flying	Imogen Merlo
24/08/2020	B	1	1	500	2000	Flying	Imogen Merlo
24/08/2020	B	1	1	400	3000	Flying	Imogen Merlo
24/08/2020	14	1	1	50	1000	Flying	Imogen Merlo
24/08/2020	16	1	1	500	100	Flying	Imogen Merlo
24/08/2020	14	1	1	400	1000	Flying	Imogen Merlo
24/08/2020	13	1	1	300	1500	Flying	Imogen Merlo
24/08/2020	15	1	1	200	2000	Flying	Imogen Merlo
24/08/2020	13	1	1	200	1500	Flying	Imogen Merlo

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
24/08/2020	17	1	1	200	600	Flying	Imogen Merlo
24/08/2020	16	1	1	500	1000	Flying	Imogen Merlo
18/09/2020	15	1	1	200	500	soaring	Imogen Merlo
18/09/2020	15	1	1	300	700	soaring	Imogen Merlo
18/09/2020	15	1	1	50	500	soaring	Imogen Merlo
18/09/2020	15	1	1	100	600	soaring	Imogen Merlo
18/09/2020	15	1	1	20	400	landing	Imogen Merlo
18/09/2020	16	1	1	20	600	soaring	Imogen Merlo
18/09/2020	17	1	1	20	700	soaring	Imogen Merlo
18/09/2020	17	1	1	30	700	soarinb	Imogen Merlo
18/09/2020	17	1	1	100	700	soaring	Imogen Merlo
18/09/2020	19	2	2	300	600	soaring	Imogen Merlo
18/09/2020	12	1	1	100	400	soaring	Imogen Merlo
18/09/2020	12	1	1	60	400	soaring	Imogen Merlo
18/09/2020	17	1	1	70	50	soaring	Imogen Merlo
18/09/2020	17	2	2	100	1000	soaring	Imogen Merlo
18/09/2020	19	1	1	130	600	soating	Imogen Merlo
18/09/2020	19	1	1	150	800	Flying	Erin Baldwin
18/09/2020	14	2	2	160	150	Flying	Erin Baldwin
18/09/2020	14	1	1	115	400	Flying	Erin Baldwin
18/09/2020	16	1	1	15	350	Flying	Erin Baldwin
18/09/2020	16	1	1	20	350	Flying	Erin Baldwin
18/09/2020	14	1	1	125	150	Flying	Erin Baldwin
18/09/2020	17	1	1	45	100	Flying	Erin Baldwin
18/09/2020	14	1	1	150	150	Flying	Erin Baldwin

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
18/09/2020	13	1	1	150	500	Flying	Erin Baldwin
18/09/2020	13	1	1	125	500	Flying	Erin Baldwin
18/09/2020	13	2	2	140	500	Flying	Erin Baldwin
18/09/2020	13	2	2	125	500	Flying	Erin Baldwin
28/10/2020	B	2	2	250	2000	Flying	Imogen Merlo
29/10/2020	15	1	1	500	700	Flying	Imogen Merlo
29/10/2020	19	1	1	400	1500	Flying	Imogen Merlo
29/10/2020	17	1	1	300	1700	Flying	Imogen Merlo
29/10/2020	15	1	1	50	1000	Flying	Imogen Merlo
28/10/2020	13	2	2	400	2500	Flying	Imogen Merlo
29/10/2020	19	2	2	30	1600	Flying	Imogen Merlo
29/10/2020	14	1	1	100	1500	Flying	Imogen Merlo
28/10/2020	13	1	1	500	2000	Flying	Imogen Merlo
28/10/2020	B	1	1	300	2000	Flying	Imogen Merlo
29/10/2020	17	1	1	270	2000	Flying	Imogen Merlo
28/10/2020	13	2	2	1500	2000	Flying	Imogen Merlo
28/10/2020	B	1	1	1000	2000	Flying	Imogen Merlo
29/10/2020	17	2	2	200	600	Flying	Imogen Merlo
29/10/2020	17	2	2	500	1500	Flying	Imogen Merlo
29/10/2020	17	1	1	500	1600	Flying	Imogen Merlo
29/10/2020	17	2	2	50	450	Flying	Imogen Merlo
28/10/2020	A	1	1	500	2000	Flying	Imogen Merlo
28/10/2020	12	1	1	120	650	Flying	Erin Baldwin
28/10/2020	12	1	1	125	650	Flying	Erin Baldwin
29/10/2020	13	1	1	150	400	Flying	Erin Baldwin

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
28/10/2020	14	3	3	45	210	Flying	Erin Baldwin
28/10/2020	14	1	1	118	550	Flying	Erin Baldwin
29/10/2020	13	1	1	35	450	Flying	Erin Baldwin
29/10/2020	13	1	1	35	500	Flying	Erin Baldwin
29/10/2020	13	2	2	115	600	Flying	Erin Baldwin
28/10/2020	14	1	1	35	550	Flying	Erin Baldwin
28/10/2020	12	1	1	145	650	Flying	Erin Baldwin
28/10/2020	14	1	1	25	450	Flying	Erin Baldwin
29/10/2020	19	2	2	55	350	Flying	Erin Baldwin
28/10/2020	12	1	1	120	650	Flying	Erin Baldwin
28/10/2020	16	1	1	45	600	Flying	Erin Baldwin
28/10/2020	14	1	1	25	380	Flying	Erin Baldwin
28/10/2020	14	1	1	132	100	Flying	Erin Baldwin
28/10/2020	12	1	1	145	1400	Flying	Erin Baldwin
29/10/2020	19	2	2	55	300	Flying	Erin Baldwin
28/10/2020	16	1	1	100	650	Flying	Erin Baldwin
29/10/2020	13	1	1	29	400	Flying	Erin Baldwin
29/10/2020	19	1	1	45	500	Flying	Erin Baldwin
28/10/2020	14	1	1	132	380	Flying	Erin Baldwin
28/10/2020	14	1	1	40	900	Flying	Erin Baldwin
29/10/2020	12	1	1	100	500	Flying	Erin Baldwin
29/10/2020	12	2	2	125	350	Flying	Erin Baldwin
19/11/2020	15	2	2	20	950	Flying	Matt Jones
18/11/2020	19	1	1	30	300	Flying	Matt Jones
19/11/2020	15	1	1	50	1200	Flying	Matt Jones

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
19/11/2020	15	1	1	100	1000	Flying	Matt Jones
19/11/2020	14	1	1	50	800	Flying	Matt Jones
18/11/2020	17	1	1	200	1500	Flying	Matt Jones
18/11/2020	16	1	1	50	1200	Flying	Matt Jones
16/12/2020	13	1	1	50	1000	Flying	Imogen Merlo
15/12/2020	16	1	1	200	2000	Flying	Imogen Merlo
15/12/2020	17	1	1	400	200	Flying	Imogen Merlo
15/12/2020	16	1	1	1200	1000	Flying	Imogen Merlo
15/12/2020	17	1	1	200	200	Flying	Imogen Merlo
15/12/2020	16	1	1	50	500	Flying	Imogen Merlo
16/12/2020	11	6	6	300	1000	Flying	Imogen Merlo
15/12/2020	16	1	1	1000	1000	Flying	Imogen Merlo
16/12/2020	19	1	1	15	700	Perched	Imogen Merlo
16/12/2020	12	1	1	400	2000	Flying	Imogen Merlo
15/12/2020	14	1	1	400	500	Flying	Imogen Merlo
16/12/2020	12	2	2	250	2000	Flying	Imogen Merlo
16/12/2020	A	1	1	600	1000	Flying	Imogen Merlo
15/12/2020	16	1	1	500	1000	Flying	Imogen Merlo
15/12/2020	14	1	1	450	500	Flying	Imogen Merlo
15/12/2020	15	1	1	300	2000	Flying	Imogen Merlo
15/12/2020	15	1	1	500	500	Flying	Imogen Merlo
16/12/2020	A	1	1	20	200	Flying	Imogen Merlo
15/12/2020	16	1	1	500	50	Flying	Imogen Merlo
16/12/2020	13	1	1	35	850	Flying	Erin Baldwin
16/12/2020	15	1	1	128	600	Flying	Erin Baldwin

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
16/12/2020	17	1	1	42	650	Flying	Erin Baldwin
15/12/2020	B	1	1	120	550	Flying	Erin Baldwin
15/12/2020	A	1	1	110	180	Flying	Erin Baldwin
15/12/2020	12	1	1	150	450	Flying	Erin Baldwin
16/12/2020	13	1	1	35	1000	Flying	Erin Baldwin
16/12/2020	15	1	1	25	600	Flying	Erin Baldwin
16/12/2020	15	2	2	45	1200	Flying	Erin Baldwin
16/12/2020	13	1	1	50	550	Flying	Erin Baldwin
15/12/2020	B	1	1	150	550	Flying	Erin Baldwin
16/12/2020	14	2	2	45	650	Flying	Erin Baldwin
16/12/2020	13	1	1	35	900	Flying	Erin Baldwin
15/12/2020	12	1	1	115	400	Flying	Erin Baldwin
16/12/2020	13	3	3	45	1000	Flying	Erin Baldwin
16/12/2020	17	1	1	45	500	Flying	Erin Baldwin
18/01/2021	13	1	1	250	1500	Flying	Erin Baldwin
18/01/2021	11	1	1	150	1700	Flying	Erin Baldwin
18/01/2021	A	1	1	200	1000	Flying	Erin Baldwin
18/01/2021	11	1	1	250	2000	Flying	Erin Baldwin
18/01/2021	17	1	1	32	600	Flying	Erin Baldwin
18/01/2021	14	1	1	25	550	Flying	Erin Baldwin
18/01/2021	14	1	1	40	500	Flying	Erin Baldwin
18/01/2021	16	1	1	122	30	Flying	Erin Baldwin
22/02/2021	19	2	2	100	1200	Flying	Imogen Merlo
22/02/2021	17	2	2	500	700	Flying	Imogen Merlo
21/02/2021	B	1	1	1000	2000	Flying	Imogen Merlo

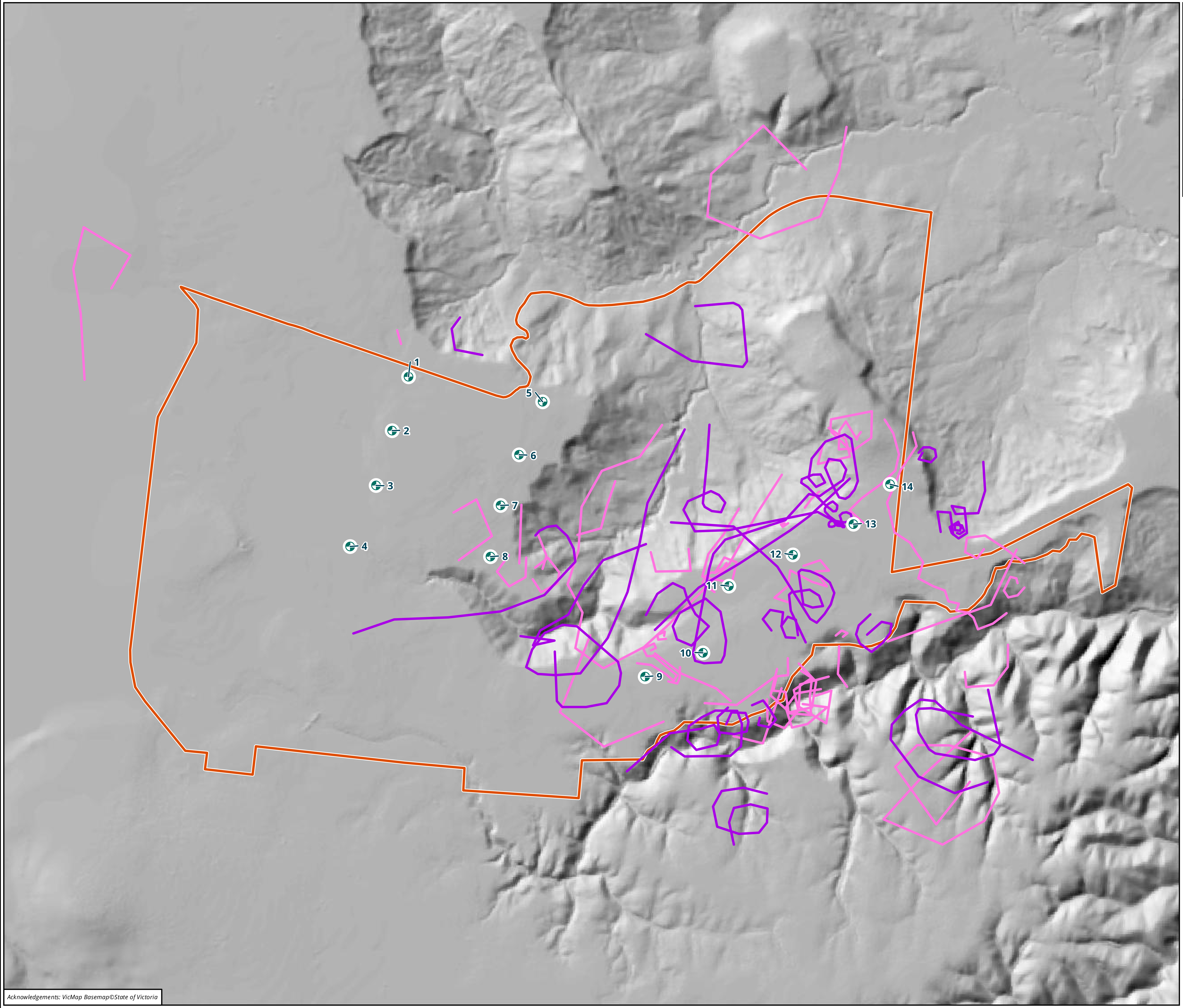
Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
22/02/2021	19	1	1	20	500	Flying	Imogen Merlo
22/02/2021	14	1	1	50	1000	Flying	Imogen Merlo
22/02/2021	13	1	1	250	200	Flying	Imogen Merlo
21/02/2021	B	2	2	500	2000	Flying	Imogen Merlo
22/02/2021	16	1	1	500	1200	Flying	Imogen Merlo
21/02/2021	12	1	1	500	1500	Flying	Imogen Merlo
22/02/2021	14	1	1	30	500	Flying	Imogen Merlo
22/02/2021	13	2	2	1000	2000	Flying	Imogen Merlo
22/02/2021	17	1	1	1200	2000	Flying	Imogen Merlo
22/02/2021	16	2	2	30	1200	Flying	Imogen Merlo
22/02/2021	19	3	3	100	700	Flying	Imogen Merlo
22/02/2021	15	1	1	50	100	Flying	Imogen Merlo
22/02/2021	19	2	2	20	1000	Flying	Imogen Merlo
22/02/2021	16	2	2	500	1000	Flying	Imogen Merlo
22/02/2021	15	1	1	500	1200	Flying	Imogen Merlo
22/02/2021	17	2	2	1000	2000	Flying	Imogen Merlo
22/02/2021	17	1	1	600	1000	Flying	Imogen Merlo
21/02/2021	14	1	1	30	500	Flying	Erin Baldwin
21/02/2021	14	1	1	25	500	Flying	Erin Baldwin
22/02/2021	11	1	1	50	650	Flying	Erin Baldwin
22/02/2021	B	2	2	125	350	Flying	Erin Baldwin
22/02/2021	A	1	1	150	450	Flying	Erin Baldwin
22/02/2021	B	1	1	30	250	Flying	Erin Baldwin
21/02/2021	15	1	1	120	500	Flying	Erin Baldwin
22/02/2021	12	1	1	115	100	Flying	Erin Baldwin

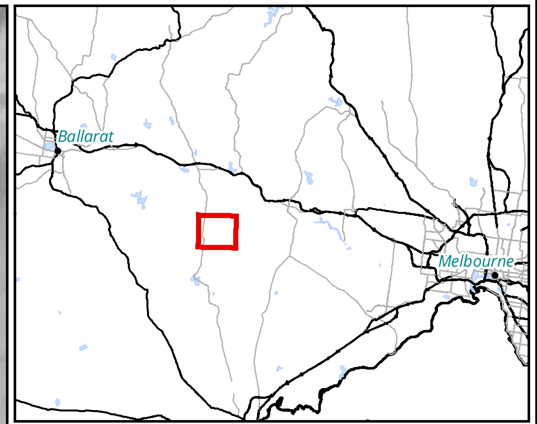
Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
12/03/2021	13	1	1	200	1700	Flying	Rose Baulch
11/03/2021	12	2	2	150	720	Flying	Rose Baulch
11/03/2021	12	1	1	130	640	Flying	Rose Baulch
12/03/2021	13	2	2	150	2500	Flying	Rose Baulch
12/03/2021	13	1	1	100	2300	Flying	Rose Baulch
11/03/2021	19	1	1	25	500	Flying	Rose Baulch
11/03/2021	16	1	1	3	300	Flying	Erin Baldwin
12/03/2021	B	2	2	115	400	Flying	Erin Baldwin
11/03/2021	19	1	1	150	500	Flying	Erin Baldwin
12/03/2021	B	1	1	135	400	Flying	Erin Baldwin
11/03/2021	19	1	1	100	150	Flying	Erin Baldwin
11/03/2021	19	4	5	60	500	Flying	Erin Baldwin
11/03/2021	19	1	1	140	200	Flying	Erin Baldwin
11/03/2021	16	2	2	150	120	Flying	Erin Baldwin
12/03/2021	B	1	1	150	400	Flying	Erin Baldwin
12/03/2021	14	1	1	120	510	Flying	Rose Baulch
21/04/2021	19	2	2	600	700	Flying	Imogen Merlo
21/04/2021	13	1	1	30	200	Flying	Imogen Merlo
21/04/2021	13	1	1	700	200	Flying	Imogen Merlo
21/04/2021	17	1	1	700	700	Flying	Imogen Merlo
21/04/2021	B	1	1	200	150	Flying	Imogen Merlo
21/04/2021	17	2	2	200	500	Flying	Imogen Merlo
20/04/2021	11	1	1	200	300	Flying	Imogen Merlo
21/04/2021	13	1	1	50	200	Flying	Imogen Merlo
21/04/2021	17	1	1	150	200	Flying	Erin Baldwin

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
21/04/2021	19	1	1	120	500	Flying	Erin Baldwin
21/04/2021	12	1	1	25	30	Flying	Erin Baldwin
21/04/2021	17	2	2	100	500	Flying	Erin Baldwin
21/04/2021	19	1	1	150	500	Flying	Erin Baldwin
21/04/2021	13	1	1	80	200	Flying	Erin Baldwin
21/04/2021	16	1	1	18	50	Flying	Erin Baldwin
21/04/2021	16	1	1	45	500	Flying	Erin Baldwin
20/04/2021	15	1	1	80	500	Flying	Erin Baldwin
21/04/2021	13	1	1	35	500	Flying	Erin Baldwin
21/04/2021	13	2	2	70	600	Flying	Erin Baldwin
21/04/2021	13	2	2	80	600	Flying	Erin Baldwin
21/04/2021	13	1	1	60	30	Flying	Erin Baldwin
21/04/2021	16	1	1	160	300	Flying	Erin Baldwin
21/04/2021	17	1	1	115	80	Flying	Erin Baldwin
21/04/2021	13	1	1	170	20	Flying	Erin Baldwin
21/04/2021	17	1	1	16	20	Flying	Erin Baldwin
21/04/2021	19	2	2	50	170	Flying	Erin Baldwin
21/04/2021	19	1	1	135	500	Flying	Erin Baldwin
21/04/2021	12	1	1	40	600	Flying	Erin Baldwin
21/04/2021	12	1	1	40	600	Flying	Erin Baldwin
21/04/2021	13	1	1	150	150	Flying	Erin Baldwin
21/04/2021	17	2	2	170	450	Flying	Erin Baldwin
20/04/2021	15	2	2	145	150	Flying	Erin Baldwin
20/04/2021	15	1	1	125	100	Flying	Erin Baldwin
20/04/2021	14	1	1	125	400	Flying	Erin Baldwin

Start date	Site Name	Number of Wedge-tailed Eagles	Number of movements	Height above ground	Distance from Observer	Behaviour	Recorder
20/04/2021	14	1	1	90	120	Flying	Erin Baldwin
18/05/2021	16	1	1	250	2000	Flying	Imogen Merlo
18/05/2021	15	1	1	400	1000	Flying	Imogen Merlo
18/05/2021	15	1	1	700	850	Flying	Imogen Merlo
18/05/2021	13	1	1	300	700	Flying	Imogen Merlo
18/05/2021	13	1	1	250	300	Flying	Imogen Merlo
18/05/2021	17	1	1	150	200	Flying	Erin Baldwin
18/05/2021	17	1	1	30	350	Flying	Erin Baldwin
18/05/2021	17	1	1	45	350	Flying	Erin Baldwin
18/05/2021	19	2	2	125	550	Flying	Erin Baldwin
18/05/2021	17	2	2	150	300	Flying	Erin Baldwin
17/05/2021	16	1	1	140	300	Flying	Erin Baldwin
9/06/2021	17	1	1	70	400	Flying	Jules Farqhuar
9/06/2021	17	1	1	40	400	Flying	Jules Farqhuar
9/06/2021	19	1	1	20	600	Flying	Erin Baldwin
9/06/2021	16	2	2	35	200	Flying	Erin Baldwin
9/06/2021	13	1	1	35	200	Flying	Erin Baldwin
9/06/2021	B	1	1	50	400	Flying	Erin Baldwin
9/06/2021	19	2	3	15	500	Flying	Erin Baldwin
8/06/2021	15	1	1	35	250	Flying	Erin Baldwin
9/06/2021	16	1	1	25	150	Flying	Erin Baldwin
9/06/2021	12	2	2	32	80	Flying	Erin Baldwin
8/06/2021	15	1	1	35	200	Flying	Erin Baldwin

Appendix 3 Previous seasonal flight paths (Year 1 and Year 2)





Legend

- Turbine location
- Study area

Winter

- Year 1
- Year 2

Figure 12 Wedge-tailed Eagle flight activity in Winter

0 200 400 600 800 1,000

Metres

N

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis

Matter: 27507, Wedge-tailed Eagle flight activity
Date: 22 October 2020,
Checked by: ERB, Drawn by: SKM, Last edited by: smitchell
Location: P:\30200s\30298\Mapping\30298_F4-7_FlightPaths.mxd

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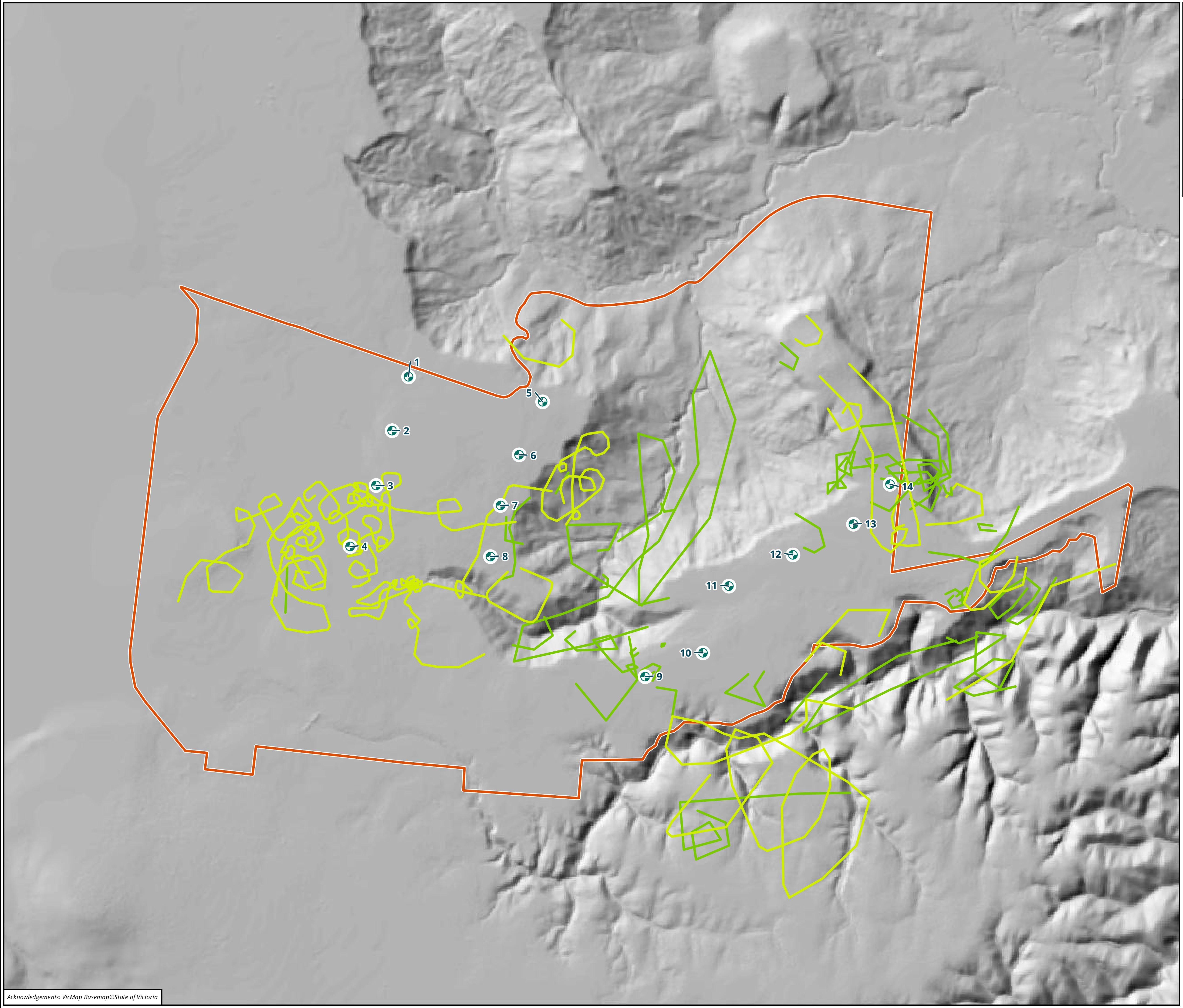

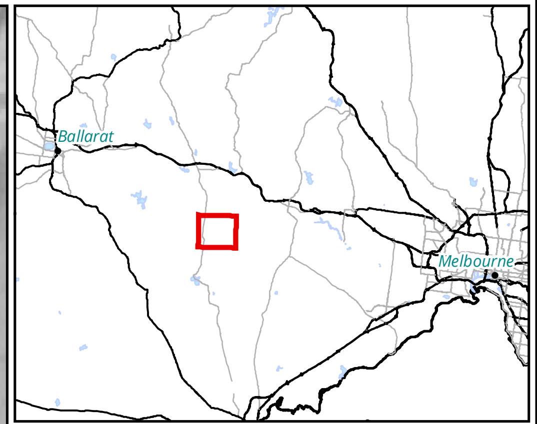

Legend

Turbine location

Study area

Spring

Year 1

Year 2

Figure 13 Wedge-tailed Eagle flight activity in Spring

0 200 400 600 800 1,000

Metres

N

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

Matter: 27507, Wedge-tailed Eagle flight activity
Date: 22 October 2020,
Checked by: ERB, Drawn by: SKM, Last edited by: smitchell
Location: P:\30200s\30298\Mapping\30298_F4-7_FlightPaths.mxd

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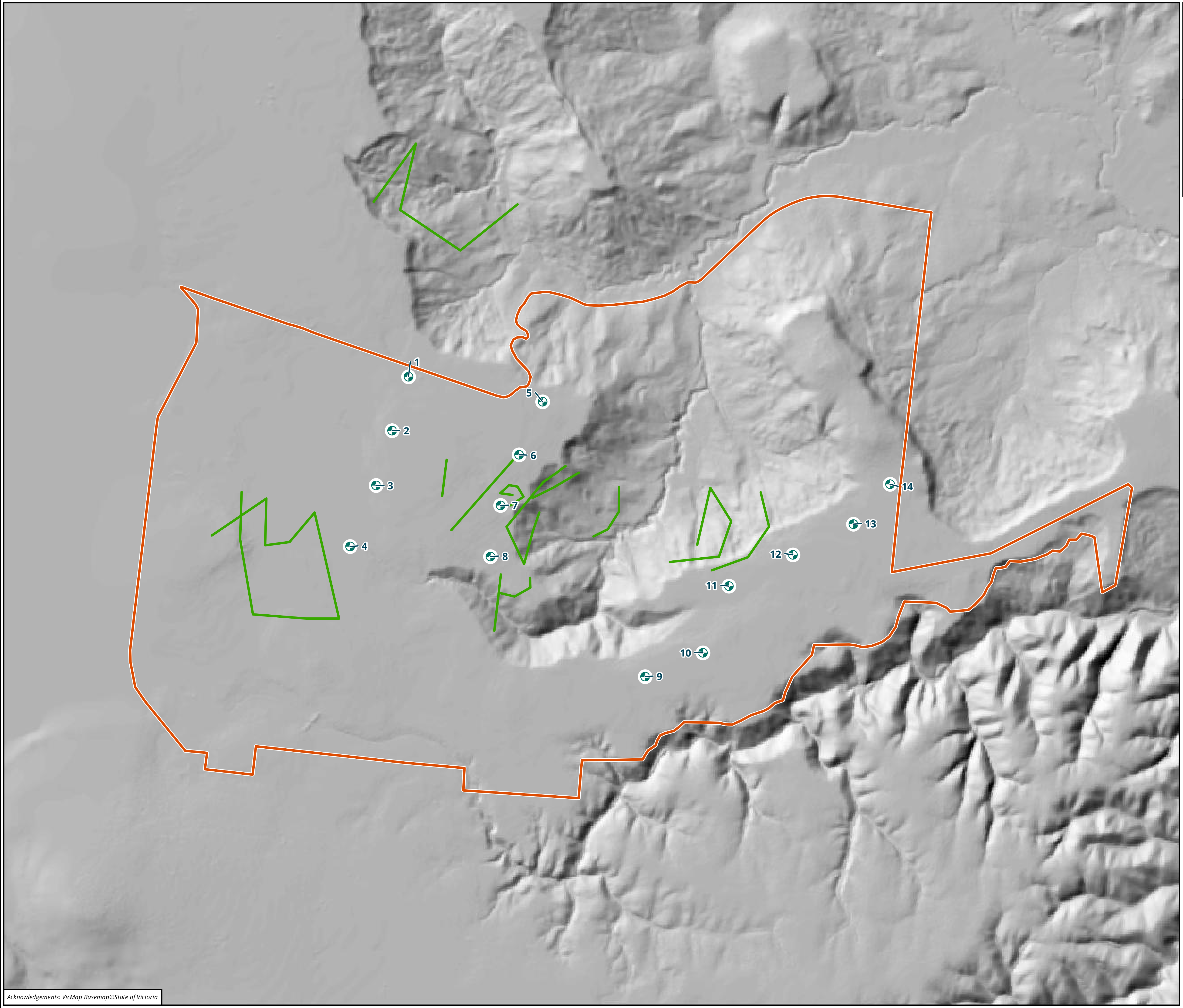

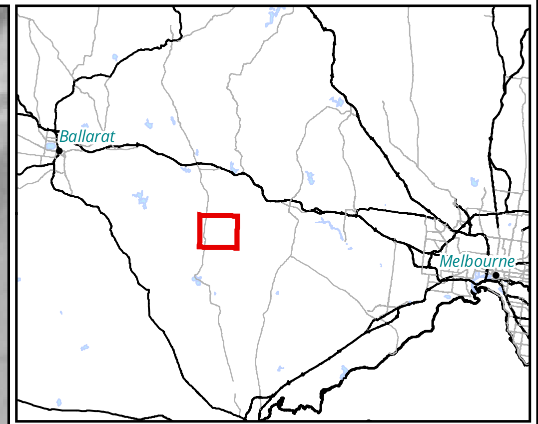

Legend

Turbine location

Study area

Summer

Year 2

Figure 14 Wedge-tailed Eagle flight activity in Summer

0 200 400 600 800 1,000

Metres

N

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

biosis.

Matter: 27507, Wedge-tailed Eagle flight activity
Date: 22 October 2020,
Checked by: ERB, Drawn by: SKM, Last edited by: smitchell
Location: P:\30200s\30298\Mapping\30298_F4-7_FlightPaths.mxd

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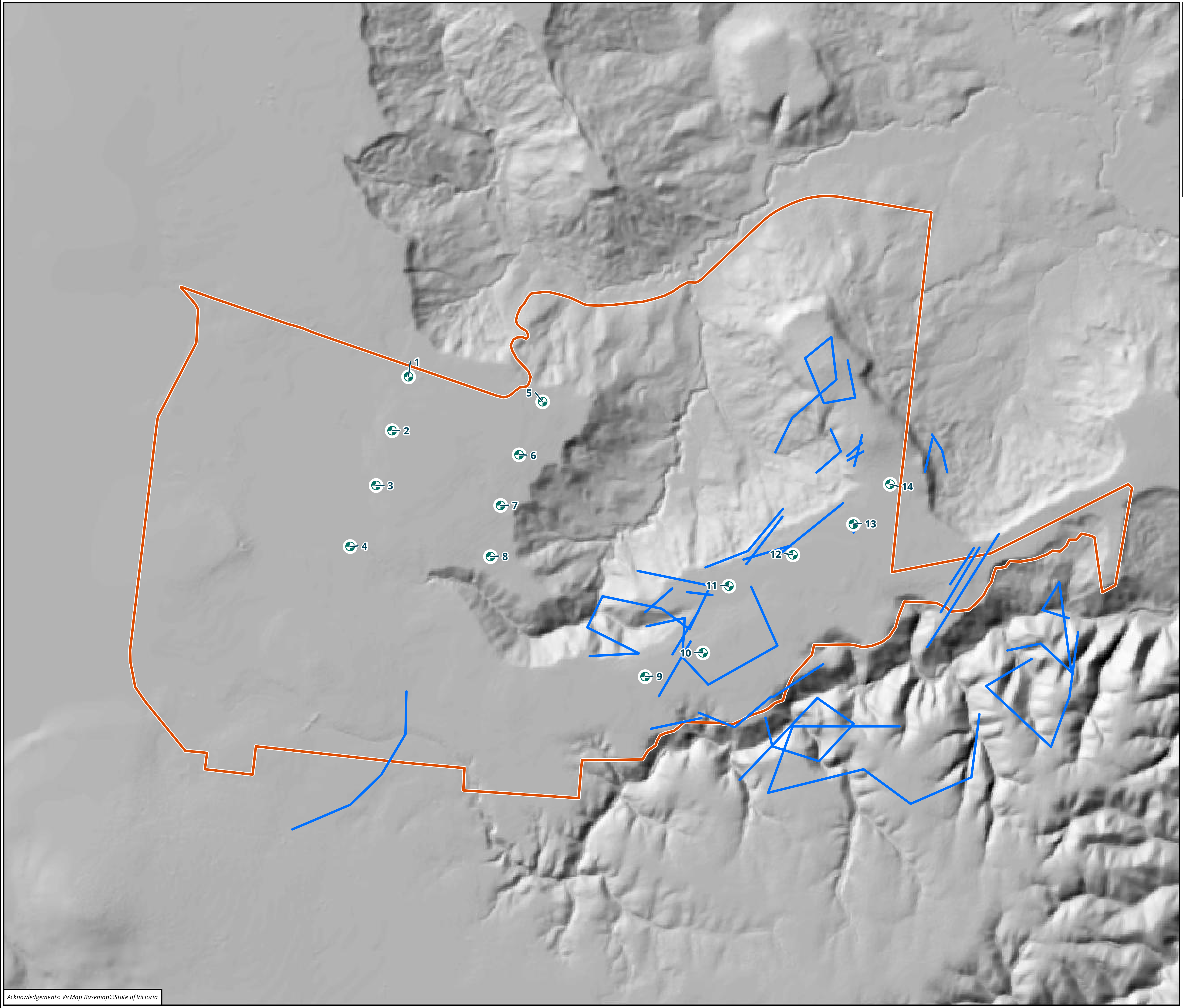

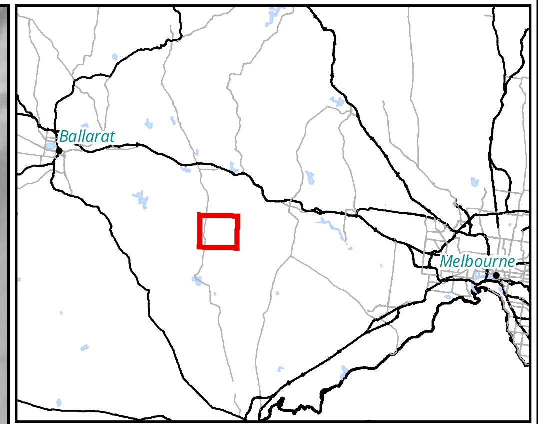

Legend

- Turbine location
- Study area

Autumn

- Year 2

Figure 15 Wedge-tailed Eagle flight activity in Autumn

0 200 400 600 800 1,000

Metres

N

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 55

Matter: 27507, Wedge-tailed Eagle flight activity
Date: 22 October 2020,
Checked by: ERB, Drawn by: SKM, Last edited by: smitchell
Location: P:\30200s\30298\Mapping\30298_F4-7_FlightPaths.mxd

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