PacificHydro

Appendix D

Appendix D: An assessment of bats at the proposed Keyneton Wind Farm (EBS Ecology)

An assessment of bats at the proposed Keyneton Wind Farm

An assessment of bats at the proposed Keyneton Wind Farm

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Prepared by EBS Ecology for Pacific Hydro

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Front cover photo: an example of bat foraging habitat targeted during the Keyneton surveys

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GLOSSARY AND ABBREVIATION OF TERMS

CFS	South Australian Country Fire Service
DEH	Department of Environment and Heritage
DENR	Department of Environment and Natural Resources (formerly Department of Environment and Heritage)
DEWHA	Department of the Environment, Water, Heritage and the Arts
DSEWPC	Department of Sustainability, Environment, Water, Population and the Arts (formerly Department of the Environment, Water, Heritage and the Arts)
DTEI	Department for Transport, Energy and Infrastructure
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
NPW Act	*National Parks and Wildlife Act 1972*
NRM Act	*Natural Resources Management Act 2004*
NVC	Native Vegetation Council
SEB	Significant Environmental Benefit
Project site	The entire area that was surveyed
Survey site	Particular locations within the project site where surveys were undertaken for bats

EXECUTIVE SUMMARY

EBS Ecology (EBS) was commissioned by Pacific Hydro to undertake multiple bat surveys at the proposed Keyneton Wind Farm located in the Mt Lofty/ Murraylands region of South Australia. A desktop assessment was undertaken and field surveys were conducted in November 2009, January 2010 and December 2010 to investigate bat species utilising the site. Survey methods involved a combination of passive and active AnaBat surveys, as well as an assessment of suitable bat roosting and foraging habitat within and surrounding the project site. Survey sites were situated in either open habitat or more preferred bat habitat (within the vicinity of woodland trees). Each of the three field surveys was conducted over four nights. Initially the focus of the surveys was to detect bat species utilising the site and gauge activity levels. During the first two surveys woodland habitat and open water sites such as creeks and dams were targeted for bat call activity. The project site boundaries were then reduced before the start of the third survey and the survey focus changed to compare bat activity at proposed wind turbine locations (predominantly along the open exposed ridgeline) to known bat habitats. In addition further survey nights were added at each site to reduce the influence of particular weather unduly influencing results.

Over the three surveys a total of 11,753 bat calls were recorded from all over the project site. The November 2009 surveys recorded the highest number of bat calls (5370 calls); January 2010 surveys recorded 4892 bat calls and December 2010 recorded 2295 bat calls. Despite fewer AnaBats being used during the November survey, overall more bat calls were recorded compared to the other two surveys, likely due to the AnaBats targeting good quality bat habitat, whereas subsequent surveys were largely focused on open sites as these are where the turbines will be sited. Eight bat species were positively identified at the Keyneton project site, including:

- Large Forest Bat (*Vespadelus darlingtoni*)
- Southern Forest Bat (*Vespadelus regulus*)
- Gould's Wattled Bat (*Chalinolobus gouldii*)
- Chocolate Wattled Bat (*Chalinolobus morio*)
- Southern Free-tail Bat (*Mormopterus* sp4)
- Inland Free-tail Bat (*Mormopterus* sp 3)
- White-striped Free-tail Bat (*Austronomus australis*)
- Lesser Long-eared Bat (*Nyctophilus geoffroyii*)

Although undetected, it is also expected that the Small Forest Bat (*Vespadelus vulturnus*) and Inland Broad-nosed Bat (*Scotorepens balstoni*) are likely to be in this region. It is possible that the Inland Forest Bat (*Vespadelus baverstocki*) may also use this site.

Two threatened bat species potentially occur at this site, but were undetected during the surveys:

- South-eastern Long-eared Bat (*Nyctophilus corbeni* – formerly known as *Nyctophilus timorensis* South-eastern form) (nationally vulnerable and state vulnerable)

- Yellow- bellied Sheath-tail Bat (*Saccolaimus flaviventris*) (state rare)

It is possible that these threatened species would occur, although only infrequently and in low numbers. Hence the potential risk of impact to these species is considered to be very low.

The project site provides roosting and foraging habitat suitable for a range of bat species. Mature eucalypts on-site contain numerous hollows, cracks, crevices and bark that would be suitable for the roosting of small groups of bats to large colonies. Dwellings, old sheds, fence posts and rock walls within the area also provide alternative roosting habitat that may be utilised. The site contains suitable foraging habitat for bats with a range of foraging strategies. Open water, scattered and dense woodland vegetation, roadside vegetation (native and exotic) and creeks/rivers provide good foraging habitat for open space aerial foragers, edge space aerial foragers, trawlers and gleaning foragers. Bat movement corridors such as the main roads and creeks were also identified during the survey. Activity was concentrated around these habitat features for the majority of species detected onsite. AnaBat sites within the vicinity of woodland areas, open water, main roads and river corridors recorded a higher level of activity overall across the surveys, compared to open areas.

The potential impacts of a wind farm development to bats have been outlined as habitat clearance, bat strike mortality from turbine blades, barotrauma mortality from air pressure changes, and turbines being possible barriers to movement. Avoiding development within habitat features onsite will minimize the impacts to the majority of bats detected onsite. Bat species that use an open space aerial foraging strategy are most likely to suffer impacts if the turbines are positioned in open areas. The Inland Free-tail Bat (*Mormopterus* sp 3) and Southern Free-tail Bat (*Mormopterus* sp 4) detected onsite use open space as part of their foraging strategy but it unknown whether they forage at potential rotor swept heights in open areas. The White-striped Free-tail Bat (*Austronomus australis*) detected onsite is the species most likely to suffer bat strike impacts as open space is their preferred foraging habitat and they are known to forage more than 50 m above the ground in open areas, which coincides with the potential rotor swept area. Although not recorded, the state rare Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris*) is also known to use the open space aerial foraging strategy, however the potential of this species to use the site is considered to be very low (occasional and seasonal) and hence the impacts to this species are expected to be minimal.

Throughout the site assessment process for the proposed Keyneton Wind Farm, EBS Ecology has provided recommendations that Pacific Hydro has followed and embedded as mitigation measures into the design of the wind farm. The turbine layout has been revised / reduced several times and now avoids high concentrations of bat activity and hence reduces the potential for ongoing impacts to bat species. The two key mitigation measures that have been embedded into the wind turbine layout design include:

1. Minimal clearance of vegetation considered to be bat roosting or foraging habitat (clearance will be limited to only the extent required to provide site entry/exit points along Pine Hut Road, existing site entry points will be used / widen if possible to minimise any clearance)

2. Established exclusion zones (buffers) around identified bat roosting and foraging habitat.

The vegetation onsite (and hence the bat roosting habitat) has been identified and avoided by the turbine layout and can be avoided by the associated wind farm infrastructure. Buffers (to exclude turbines) are planned to protect the foraging and roosting habitat of the majority of bat species where bat activity is concentrated. Woodlands and linear movement corridors will be buffered by a minimum of 100 m and open water will be buffered by 250 m. It is likely that many of the bat species recorded at the site will predominately stay within close proximity to these habitat features and hence will be at lower risk of turbine strike and barotrauma impacts.

These measures are considered to substantially reduce the potential ongoing impacts of turbines on bats as part of a wind farm proposal at this site based on our current knowledge. Any additional infrastructure proposed onsite (such as connecting roads, associated buildings and transmission lines) would need to be assessed separately and have the appropriate mitigation measures in place, in line with what has already been committed to. In general, any further infrastructure proposed onsite should similarly avoid clearance of bat foraging habitat (wooded vegetation and open water); and additional buffer distances should be established to exclude structures that may interfere with bat foraging and roosting habitat that is appropriate to the nature of disturbance of that structure.

The bat species detected onsite are thought to be common throughout the region and the majority of bats were recorded within the vicinity of habitat features such as woodlands, open water and linear movement corridors (which have been avoided). The project's revised layout of 42 turbines adopts buffers between turbines and identified bat habitat features. Given this and the general approach that has been adopted to avoid and minimise impacts on areas of native vegetation, significant impacts on bat species using the site are considered unlikely. Nevertheless, monitoring measures (including bat strike monitoring, scavenger and detectability trials and long term monitoring of bat diversity, activity and behaviours) have been recommended to further understand the response of bats to wind farms in this region and to confirm the adequacy of the mitigation measures.

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1 INTRODUCTION

EBS Ecology was contracted by Pacific Hydro to conduct an assessment of bat fauna at the proposed Keyneton Wind Farm. The assessment aims to identify the bat species that may use the site, record bats species present onsite, characterise bat utilisation of the project site and outline the potential impacts of the development on bats. This assessment also aims to produce a set of appropriate mitigation measures that can be employed to avoid and minimise the impacts of a wind farm on bats that use the site.

Three passive AnaBat surveys were conducted onsite during spring and summer seasons, over four nights each in November 2009, January 2010 and December 2010. The project site boundary changed over the survey timeframe; hence some results refer to survey sites which are now outside of the project site boundary. Methodology varied slightly between surveys as the focus was adapted to ensure the assessment was relevant to the development proposal. The first two surveys aimed to assess bat species presence, diversity and indicate activity levels across the site. The third survey focussed on comparing bat species diversity and activity between woodland areas and open areas (which were more likely to be potential turbine locations).

The assessment also included additional "active" methods to support the passive survey results and to contribute to the knowledge of how bats use the project area. Trapping was undertaken to confirm species identification in relation to species recorded on passive AnaBat recorders. Active surveys were undertaken to record longer calls that could be used for identification, and combined with spotlighting and light-tagging methods to record qualitative information on flight heights and flight behaviours of released bats.

1.1 Objectives

The objectives of this assessment were:

- Identify bat species using the project site, highlighting species of conservation significance and additional bat species that potentially use the project site;
- Assess bat activity at the project site;
- Assess bat habitat at the site;
- Record observations of bat behaviour, such as flight patterns and flight heights;
- Compare activity between different habitat types within the project area;
- Prepare GIS maps showing bat survey locations and bat activity;
- Recommend mitigation measures to avoid or minimise potential impacts to bat species occurring at the project site, particularly to any species of conservation significance.

2 COMPLIANCE AND LEGISLATIVE SUMMARY

2.1 National Parks and Wildlife Act 1972

The *National Parks and Wildlife Act 1972 (NPW)*, covers vegetation located within Conservation Parks, Conservation Reserves and any species listed under Schedules 7 (endangered species), 8 (vulnerable species) and 9 (rare species), located anywhere in the State (either reserved or private land).

2.2 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC) 1999* identifies seven matters of national environmental significance, including;

- World Heritage properties
- National heritage properties
- Wetlands of international importance (Ramsar wetlands)
- Threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)

Threatened bat species identified by the EPBC Protected Matters Search Tool, that may occur within the project area are shown in Table 2 (Section 5.1).

3 BACKGROUND INFORMATION

3.1 Site details

The proposed wind farm site is situated in the eastern hills of the Mt Lofty Ranges and occurs in an area roughly bounded by the Marne River to the south, the townships of Cambrai (to the south-east), Towitta (north-east), Moculta (north-west) and Eden Valley (south-west) (Figure 1).

The main land uses within the region are agricultural including grazing, cropping and viticulture. The project site consists predominantly of grazing land. Mature remnant Eucalyptus trees with hollows are scattered across the site, predominantly on the western flanks of the main ridgeline, although very little native understorey vegetation remains intact. Dams and watercourses are also prevalent. The environmental associations of the project site support 5-10% remnant native vegetation, much of which occurs in inaccessible parts of the landscape; in this case, the steep valleys and rocky outcrops associated with the range. The main ridgeline within the project site is characterised by open exotic grasslands with some scattered remnant Eucalyptus trees.

For more details regarding the general flora and fauna characteristics of the site, refer to *Proposed Keyneton Wind Farm Flora Survey and Fauna Assessment* (EBS Ecology 2010).

3.2 Climate

The nearest weather station for the site is at the township of Nuriootpa in the Barossa Valley region. Nurioopta is located about 14.5 km directly west from the top western corner of the site boundary. The proposed site is likely to be far windier, probably slightly warmer and certainly drier. However Nuriootpa is the logical surrogate considering that a site on the mallee plains to the east is far less comparative. An old saying in this part of the hills is that the rain drops '*an inch a mile'* as it travels east off the edge of the range.

Mean maximum temperatures range from 25-30 degrees in summer months to around 15 degrees during winter (Figure 2). Mean minimum temperatures range from 10-15 degrees during summer and down to around 5 degrees during winter (Figure 3). The highest rainfalls for the area are received in winter, with the highest mean monthly rainfall received in July (65 mm) and a mean annual rainfall of 500.5 mm (Figure 4).

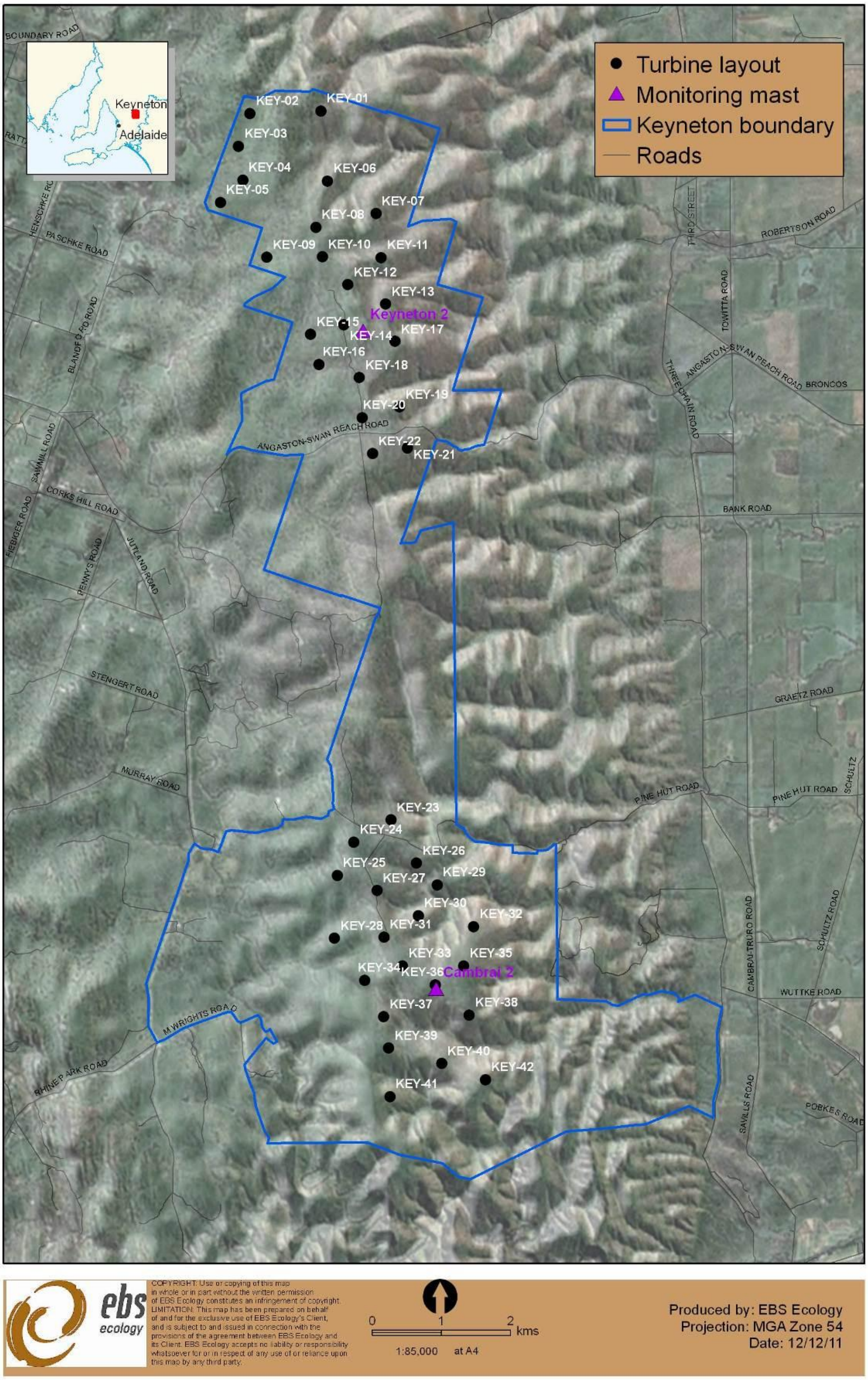

Figure 1 Map showing the location of the proposed Keyneton Wind Farm in the Mt. Lofty Ranges Region of South Australia.

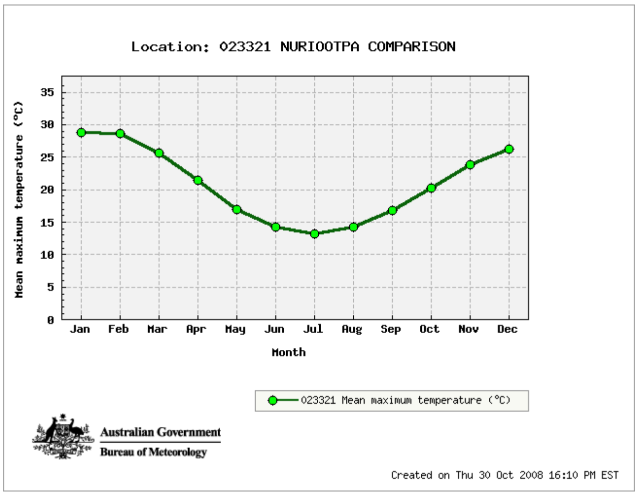

Figure 2 Mean maximum temperature

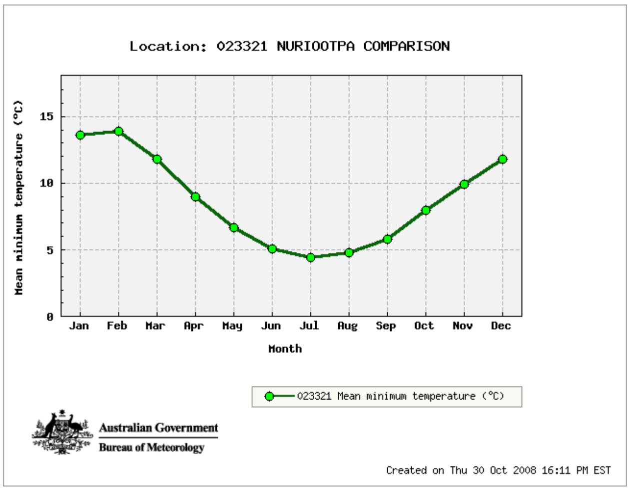

Figure 3 Mean minimum temperature

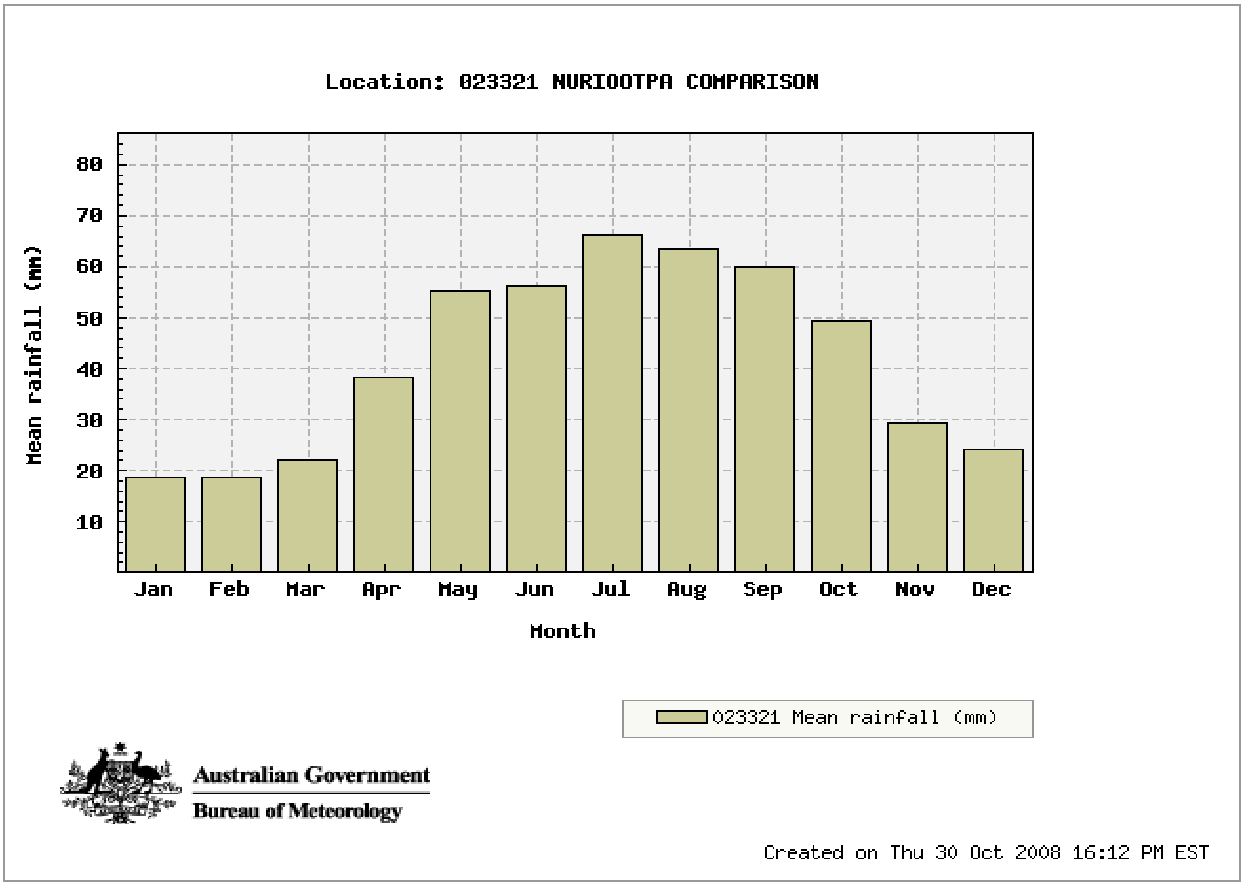

Figure 4 Mean monthly rainfall for Nuriootpa

3.3 Bats in the region

The proposed Keyneton Wind Farm is situated close to the junction of three bio-geographical regions; the Murraylands region, Adelaide Mt Lofty region and the Mid-North region. The distribution ranges of many bat species may overlap in this area. The bats of the Adelaide Mt Lofty region and the Murraylands region have been studied in more detail than the Mid-North region, which has been poorly surveyed. As a result there is limited information on the status of local bat populations in the Mid-North and little is known of the diversity, distribution and abundance of bat species. Species thought to be once common may now be regionally threatened.

The bat fauna within SA are almost exclusively micro-bats, however mega-bats such as the Grey-headed Flying Fox (*Pteropus poliocephalus*) and the Little Red Flying Fox (*Pteropus scapulatus*) are occasionally found within SA. To date, occurrences have been restricted to the metropolitan area of Adelaide and the South East of SA, therefore the potential for these species to occur within the project region is negligible.

Thirteen bat species (all micro-bats) could potentially utilise the proposed Keyneton Wind Farm Site (Table 1) based on known distributions. Threatened species potentially present include the nationally and the state vulnerable *Nyctophilus corbeni* (South-eastern Long-eared Bat) (formerly known as *Nyctophilus timoriensis* (*South-eastern form)* and the state rare *Saccolaimus flaviventris* (Yellow- bellied Sheath-tail Bat), these two species are discussed in greater detail below.

Table 1. Bat species potentially present at the proposed Keyneton Wind Farm (from Churchill 2008)

Species Name	Common Name	AUS	SA
Austronomus australis	White-striped Free-tail Bat		
Chalinolobus gouldii	Gould's Wattled Bat		
Chalinolobus morio	Chocolate Wattled Bat		
Mormopterus sp 3	Inland Free-tail Bat		
Mormopterus sp 4	Southern Free-tail Bat		
Nyctophilus geoffroyi	Lesser Long-eared Bat		
Nyctophilus corbeni	South-eastern Long-eared Bat, Greater Long-eared Bat	VU	V
Saccolaimus flaviventris	Yellow- bellied Sheath-tail Bat		R
Scotorepens balstoni	Inland Broad-nosed Bat		
Vespadelus baverstocki	Inland Forest Bat		
Vespadelus darlingtoni	Large Forest Bat		
Vespadelus regulus	Southern Forest Bat		
Vespadelus vulturnus	Little Forest Bat		

Aus ratings – VU = Vulnerable
SA rating – V = Vulnerable; R = Rare

South-eastern Long-eared Bat *(Nyctophilus corbeni) AUS- Vulnerable SA-Vulnerable))*

The South-eastern Long-eared Bat has a limited distribution that is restricted around the Murray-Darling Basin in south-eastern Australia. Even in this region its distribution is scattered and it is rarely recorded (Turbill & Ellis 2006). It occurs in far eastern South Australia, in areas north of the Murray River, east of Canegrass Station and south of the Barrier Highway. These areas include the Riverland Biosphere Reserve, Danggali Conservation Park and the Birds Australia Gluepot Reserve (Turbill et al. 2008). The South-eastern Long-eared Bat occurs in a range of inland woodland vegetation types, including box, ironbark and cypress pine woodlands. Little is known about the biology or social structure of these bats. It is likely, however, that they roost solitarily under exfoliated bark and in the crevices on trees. This species has been seen to forage close to vegetation, also using gaps between vegetation (Churchill 2008). South-eastern Long-eared Bats may potentially occur at the project site; however the project site is approximately 100 km beyond the western limits of its known distribution.

Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris* SA- Rare)

The Yellow-bellied Sheath-tail Bat is widely distributed across Australia, mainly in tropical northern Australia, but is rarely found in large numbers. This species migrates into southern Australia during summer and is a rare visitor to parts of South Australia. The species flies predominately above the tree canopy and hence it is rarely trapped or detected via AnaBat. They are found in most habitats and have been found roosting in large hollows. This species is considered an occasional seasonal visitor to SA that may roost temporarily in tree hollows within the project site. Yellow-bellied Sheath-tail Bats forage around the edges of vegetation and within open space (Churchill 2008).

3.4 Bat roosting and foraging strategies

All micro-bats expected to be present within the region of the project site are known to roost within tree hollows, in cracks, crevices and underneath bark. None of the expected species require caves for roosting, although bats may occasionally take advantage of this opportunity if available. With the widespread clearance of trees in agricultural landscapes, micro-bats have often been found to roost within buildings and sheds, in roofs, walls, under hung-up saddles, rolled up swags, old chimneys and anywhere that provides suitable shelter (Churchill 2008). The bats expected in the region may roost solitarily, in small groups of 2-5, or larger groups of 50-70, or up to 300-400 where maternity colonies may reside. There is limited information available on known colonies within the area; however it is likely that a number of colonies of common bat species reside in the area and potentially within the project site (however these are extremely difficult to detect). Many species will roost along with other bat species, and sometimes with other fauna. White-striped Free-tail Bats have been found roosting with Common Brushtail Possums (Churchill 2008). Bats expected within this region, such as Gould's Wattled Bat and

Chocolate Wattled Bats, utilise a small selection of roosting sites, alternating between them from night to night (Churchill 2008).

Micro-bats most commonly feed on moths, beetles, mosquitoes and other small insects. These bats are generally known to forage in the vicinity of vegetation and around water in higher concentrations than open areas, but different bat species use different foraging strategies to catch their insect prey. Micro-bats in South Australia belong to the following foraging guilds:

- Open space aerial foragers

These bats forage in open air spaces away from vegetation, finding their prey by echolocation. They are high-flyers, capable of intercepting prey 50 m or more above the ground (Churchill, S.K., 1998) and have a very loud call that detects prey at long distances. They are capable of very fast flight and use this combination of abilities to intercept their prey. Bats species known to use this foraging strategy include free-tail bats and sheath-tail bats.

- Edge space aerial foragers and trawlers

Many bats use this strategy to catch prey along the edges of vegetation and in the gaps between tree canopies. Bats using this strategy are not particularly fast fliers but use sharp turns to catch their prey and are very agile and manoeuvrable (Churchill 2008). Most of the bats found within the region would use this strategy, including *Chalinolobus* species, *Scotorepens* species and *Vespadelus* species.

- Gleaning foragers

The bats that use this strategy catch their prey by gleaning insects from vegetation and from the ground. Echolocation of prey within cluttered environments is achieved with rapid pulses of very high frequency calls, enabling more accurate identification of static insects on the surfaces of vegetation (Churchill 2008). *Nyctophilus* species are known to employ this foraging strategy.

3.5 Threatening processes and species loss

Threats to biodiversity within the wider project region as identified in the Biodiversity Plan for the Northern Agricultural Districts (Graham et al. 2001) include:

- fragmentation and isolation
- problem plants
- problem animals
- inappropriate fire regimes
- human recreation and population pressure.

More specifically, threatening processes for bats and bat habitats within the region relate to:

- clearance of woodlands and mature trees with hollows (including dead trees)
- use of pesticides and agricultural chemicals (effect on insect population and residual effect for bats)

Numerous wind farm developments are planned within South Australia, particularly within agricultural areas north of Adelaide. The cumulative impact of wind farms on bat populations may contribute to declines in certain species, however as regional distributions and flight behaviour of bats is relatively unknown, the actual impact is difficult to predict. The foraging behaviour and known flight path of bats needs more investigation, to determine their utilisation of the survey areas and hence estimate collision risk at wind farms. Similar to birds, bats can also have large flight ranges and data on bat fly-ways in the area should be collected to determine patterns (if any) and activity hotspots (i.e. Do bats fly along ridges in the region? Is bat activity concentrated in woodland habitat or open areas in the survey area?). The regional status of bat species is largely unknown (T Reardon pers comm. 2008) and it is considered that detailed studies such as this should be co-ordinated by an over-arching body (i.e. government) on a regional scale to provide the data required to assess the possible and actual cumulative impacts of wind farms in the area. Wind farm companies should contribute to a program of government co-ordinated studies to gather bat utilisation data at survey sites before and after construction as well as utilisation at similar sites that do not contain wind farm infrastructure.

4 METHODS

4.1 Database searches

Records obtained for the area within 10 km of the project site were sourced from the EPBC Protected Matters online database (DEWHA 2009) and the Biological Database of SA (BDBSA) (DEH, 2008) to identify any matters of national and state environmental significance or other matters protected by the *EPBC Act 1999*. The BDBSA is comprised of an integrated collection of corporate databases which meet DEH standards for data quality, integrity and maintenance. In addition to DEH biological data, the BDBSA also includes data “dumps” from external organisations. This external data is included under agreement with the relevant organisation for ease of distribution but they remain custodian of the data and should be contacted directly for further information.

External Dataset dumps:

- Birds Australia (SA records) -1996 to 2002
- South Australia Ornithological Association (SAOA) - field trips database - supplied mid-2005, supplementary load September 2007
- SAOA Parks Data - supplied mid 2005
- SAOA Member Personal Records – supplied 2007
- Threatened Birds of the South East – supplied September 2006
- Southern Fleurieu Bird Watchers – supplied February 2007
- Australasian Wader Study Group - supplied 2005
- SA Museum - Herpetology - up until August 2004
- SA Museum - Bird - Loaded May 2005
- SA Museum - Mammal - Data up until start 2005 more details of particular State Museum records are available through the South Australian Museum

4.2 Field survey

Three bat assessment surveys were conducted at the proposed Keyneton Wind Farm site; an initial survey in November 2009, second survey in January 2010 and the last survey in December 2010. Each survey campaign spanned over four nights with multiple sites surveyed each night. A total of 47 AnaBat nights, 19 harp trap nights and two mist net nights were conducted. (Refer to Appendix 1 for details). Initially the focus of the surveys was to detect which bat species were utilising the site and the activity levels of the bats across the site. For the first two surveys, bat habitat such as woodlands and open

water sites (such as creeks and dams) were targeted for bat call activity. The project site boundary was reduced before the start of the third survey. The third survey focused on comparing bat activity between proposed wind turbine locations and established bat habitat. Further survey nights at each site were undertaken to minimise the influence of specific weather conditions on the results. The locations of survey sites are mapped in Figure 5. Survey methods are described below.

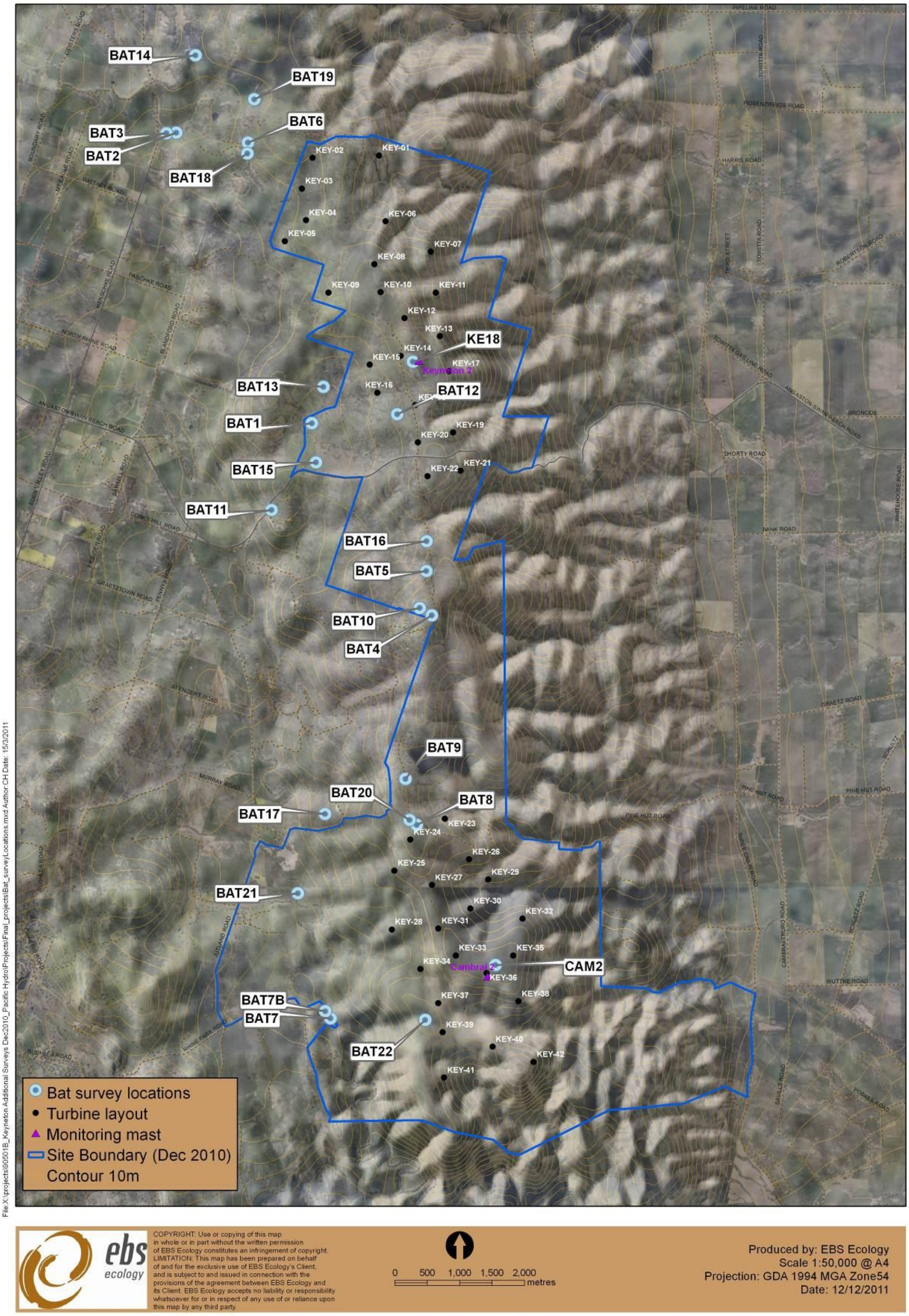

Figure 5 Map of bat survey site locations across the proposed Keyneton Wind Farm with current site boundary

4.2.1 Passive AnaBat survey

The initial survey (23 - 26 November 2009) focussed on likely bat habitat to identify bat species utilising the project site. Two automated bat detectors (AnaBat systems) were set out each night to record bat calls across the project site. Woodland areas containing hollows for roosting and 'fly-way' tunnels through the canopy were targeted for bat call activity. Any areas with open water such as creeks or dams were also targeted for bat activity. Over the four survey nights, seven different sites were surveyed with AnaBat detectors (refer to Appendix 1 for nightly details).

The second survey was conducted on 12 - 18 January 2010. Four AnaBats were used at 16 different survey locations across the project site, targeting both open grassland areas (Figure 6) and good quality bat habitat.

The third survey was conducted on 13 - 16 December 2010 focusing on the open grassland along the ridgeline. Six AnaBats were placed out each night of the four night survey period. Two AnaBats were placed within bat habitat for four nights (one woodland site and one by open water) and four were at open grassland sites along the ridgeline. Two of the open grassland sites were at mast sites (one placed 1 m off the ground and one up the mast at approximately 30 m high) (Figure 7). AnaBats were predominately placed at the same site each night (refer to Appendix 1 for survey effort), however one site was switched half way through the survey (from site 12 to KE18 top of mast) when it was apparent that it was possible to place a microphone 30 m up the mast.

Figure 6. Passive survey – AnaBat detector site

Figure 7 Mast site KE18 where AnaBats were placed 30 m up the mast (KE18 top) and bottom (KE18 bottom)

4.2.2 Trapping

Harp traps (Figure 8) were used over all three surveys to capture bats to assist the positive identification of bat species. Two harp traps were used at different sites throughout the surveys to capture bats. Mist netting was also used to trap bats on the first survey, but was not used during following surveys due to breezy conditions onsite which are not suitable for successful mist-netting (Refer to Appendix 2 for nightly trapping details). All bats were released after capture and ID and reference calls were taken.

Figure 8. Harp site 9 in Open woodland

4.2.3 Active survey and flight behaviour investigation

Active survey transects were conducted in conjunction with the passive survey during the third survey period (December 2010). This involved slowly walking along a transect with a handheld AnaBat detector, with attached PDA display and spotlight. The active surveys were conducted along selected transects for one hour each night, for three nights (one night active release recordings). Active survey transects were located within suitable bat roosting/foraging habitat to maximise the number of bat calls that could be recorded and thus the species present on the site. Active surveys allow for better call sequences to be recorded through the ability to follow the bat with the recorder. Observations such as flight pattern, flight height and foraging behaviour are also recorded during the active surveys.

A light tagging technique was used during the third survey where small glow sticks were temporarily attached to the bat fur with medical glue (Figure 9). The glow sticks eventually fall off or are preened off within a few days. This method enables the bat's flight path to be followed for a short time, and for some observations to be made regarding flight direction and height. The success of this method varies with the direction of bat flight, how long it stays in the area, the level of moon light and the ability to follow the bat. Spotlighting at the time of release can also be used as an alternative to follow released bats.

Figure 9. Light tagging

4.3 Survey Limitations

Survey effort varied between trips and the project site boundary changed during the assessment. Some of the original sites surveyed were outside of the revised boundary and new ones were selected. Each survey period consisted of four survey nights; however the level of effort for each night between trips varied. Results are not directly comparable between surveys but can be collated and summarised to characterise the bat use of the site. An average of calls per detector night is used to compare results between site types and between surveys. A 'detector night' is simply the survey effort of one AnaBat detector over one night. For example, the first trip employed two detectors each night, therefore each night of the trip records two 'detector nights', making a total of eight detector nights over a four night trip. The total number of calls for the trip is divided by eight detector nights to get an average number of calls per detector night.

The original survey was focussed on detecting as many bats as possible and hence good bat habitat was chosen for the survey sites. This may have influenced the number of calls recorded as compared to subsequent surveys, where open areas were a more equal focus for survey sites.

Passive AnaBat survey is an efficient non-invasive method that can yield good results, however AnaBat data will always have an unavoidable degree of uncertainty. A number of bat species are readily identified via AnaBat recordings, but many call files can be ambiguous, even to experts. Some bats are not able to be distinguished to species level via AnaBat recordings alone, such as *Mormopterus* species and *Nyctophilus* species. In some instances, known distributions can infer the most likely species, but where the call characteristics are not typical or the recorded quality of a call is poor, no identification is made (so as to avoid false positives). Call analysis is affected by many factors, these include the suite of species present, the quality of calls recorded (temperature, humidity, equipment settings, microphone quality, background noise from wind, insects, echoes), the quality of the reference call database for the region and the experience of the analyst. AnaBat recordings alone may only represent a proportion of species that are actually present onsite or visiting the area. The data collected in no way shows abundance of bat species, as the one bat may fly past the AnaBat recorder numerous times while feeding or in transit.

AnaBat detectors set up in more open areas are less likely to record a bat pass as they have to be within a certain distance of the microphone (detection distance is weather dependent) for the AnaBat detectors to pick up the call. The bat detector microphone will record a bat file when it is loud enough to trigger the electronics. Therefore in open areas there is less chance of a bat flying within the area of the AnaBat. Bat habitat survey sites were deliberately selected to focus on 'bottle-neck' areas where bats are likely to pass, i.e., a small water body, the edge of a woodland, a suitable gap between trees where bats may fly.

Active AnaBat survey is used to record superior quality bat calls, which assists call analysis and species identification. This method is used for a few hours per night and as such activity cannot be compared to passive survey results. Light tagging and spotlighting yields qualitative results based on observations. The success of both these methods during the third survey was varied and limited results were gained.

5 RESULTS

5.1 Database search

The EPBC Protected Matters Search identified one nationally threatened bat species as potentially occurring within the project area, the South-eastern Long-eared Bat (Table 2). While the BDBSA search has no records of threatened species for the area, there are twelve previous records of bats including four different species (Table 3).

Table 2. Threatened bat species identified by EPBC Protected Matters Search Tool as possibly occurring within the project area.

Species name	Common name	Conservation status		Likelihood of occurrence within survey area (Likely, Unlikely, Possible)
		Aus	SA	
Nyctophilus corbeni	South-eastern Long-eared Bat, Greater Long-eared Bat	VU	V	Possible

Aus: Australia (*Environment Protection and Biodiversity Conservation Act 1999*). **SA:** South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes: CE:** Critically Endangered. **EN/E:** Endangered. **VU/V:** Vulnerable. **R:** Rare.

Table 3. Bat species recorded within a 10 km radius of the project site by BDBSA data search

Species name	Common name	Conservation status		District	Region	Sighting Date
		Aus	SA			
Chalinolobus gouldii	Gould's Wattled Bat			Riverland	Murraylands	26/11/1991
Chalinolobus gouldii	Gould's Wattled Bat			Mallee	Murraylands	28/11/1991
Chalinolobus gouldii	Gould's Wattled Bat			Mallee	Murraylands	28/11/1991
Chalinolobus gouldii	Gould's Wattled Bat			Riverland	Murraylands	26/11/1991
Chalinolobus gouldii	Gould's Wattled Bat			Riverland	Murraylands	26/11/1991
Chalinolobus morio	Chocolate Wattled Bat			Mallee	Murraylands	28/11/1991
Mormopterus spp. (species complex) (NC)	Southern Free-tail-bats			Riverland	Murraylands	26/11/1991
Vespadelus regulus	Southern Forest Bat			Mallee	Murraylands	28/11/1991
Vespadelus regulus	Southern Forest Bat			Riverland	Murraylands	1/01/1936
Vespadelus regulus	Southern Forest Bat			Mallee	Murraylands	28/11/1991
Vespadelus regulus	Southern Forest Bat			Mallee	Murraylands	28/11/1991
Vespadelus regulus	Southern Forest Bat			Mallee	Murraylands	28/11/1991

5.2 Field survey

5.2.1 Weather

The most comprehensive available climate dataset near Keyneton is from Nuriootpa, 14 km from the project site. The data recorded in Table 4 is provided by the Bureau of Meteorology, South Australia (Commonwealth of Australia, 2010). A variety of weather conditions were experienced during the field surveys, including warm temperatures, periods of extreme wind, rainfall and lightening.

Table 4. Weather details, Min, Max and Rainfall for the three different surveys at Keyneton Site.

Date	Temperature (Min)	Temperature (Max)	Rainfall (mm)
23-Nov-09	9.8	21.8	0
24-Nov-09	7.2	25.6	0
25-Nov-09	14.3	30.7	0
26-Nov-09	16.5	25.1	3.8
27-Nov-09	12.0	31.5	4.0
12-Jan-10	22.6	22.6	0.4
13-Jan-10	12	23.8	10.2
14-Jan-10	11.7	26.5	0
15-Jan-10	13.0	31.5	0
18-Jan-10	10.9	22.6	0
19-Jan-10	5.6	28.3	0
13-Dec-10	8.3	25	0
14-Dec-10	12.6	30.3	0
15-Dec-10	13.9	20.5	0.4
16-Dec-10	8.4	21	0
17-Dec-10	12.1	21.6	0

5.2.2 Bat species detected

A total of eight bat species were positively detected across the proposed Keyneton Wind Farm site using the combination of bat detection methods (Table 5). Additional species may have been recorded, as a proportion of the calls were not able to be identified to species level. These calls may be from a species already positively identified at the site, or from an additional species. Examples of bat calls recorded during the surveys are presented in Appendix 7.

No threatened species were detected during the surveys. All bats identified on the site were expected to be present within the region. Most of the species detected by passive and active AnaBat survey methods were also confirmed by captures during the surveys. Only one species, recorded by AnaBat, the Large

Forest Bat (*Vespadelus darlingtoni*), was not confirmed by captures. The Inland Free-tail Bat (*Mormopterus* sp 3) and Southern Free-tail Bat (*Mormopterus* sp 4) were captured during the surveys but were not able to be distinguished from each other in passive or active AnaBat recordings.

Table 5. Bat species detected during the surveys

Species name	Common name	Conservation status		Survey Method			
		Aus	SA	AnaBat	Harp trap	Mist net	Active survey
Austronomus australis	White-striped Free-tail Bat			*	*		*
Chalinolobus gouldii	Gould's Wattled Bat			*	*		*
Chalinolobus morio	Chocolate Wattled Bat			*	*	*	*
Mormopterus sp	Free-tail Bat			*	*		*
Mormopterus sp 3	Inland Free-tail Bat			*	*		*
Mormopterus sp 4	Southern Free-tail Bat			*	*		
Nyctophilus geoffroyi	Lesser Long-eared Bat			*	*		*
Vespadelus darlingtoni	Large Forest Bat			*			*
Vespadelus regulus	Southern Forest Bat			*	*		*
Vespadelus sp	Forest Bat			*	*		*

5.2.3 Passive AnaBat survey results

Bat activity levels at the Keyneton project site are considered to be relatively high compared to other surveys within similar habitat in the surrounding region. To some extent this is to be expected due to the project site being at the junction of 2-3 regions and hence where the ranges of bat species overlap from the different regions. A total of 12,557 bat calls were recorded across the site during a total of 47 detector nights (an average of 267 bats calls per detector per night) (Table 6 and Appendix 2). A proportion of the calls were of bat origin but were not able to be identified (804 calls), leaving a total of 11,753 bat calls that were able to be identified as belonging to a particular bat genus.

Overall, the third survey (December 2010) had lower total calls compared to the first (Nov 2009) and second (Jan 2010) surveys (Table 6) however the focus of the December 2010 survey was different with more survey effort on the ridgeline. There were also some differences between the average calls per detector night for each survey. The first survey recorded the highest average of 671 calls per detector night, a figure that was highly influenced by the results from survey sites 7 and 8 which recorded approximately 2000 calls each in one night (Appendix 3). The second survey recorded an average of 306 calls per detector night and the third survey recorded an average of 100 calls per detector night. Influences on the averages for the second and third survey include an increase in number of detector nights and an increasing focus on open areas.

The highest number of calls recorded for a species over the three surveys were for Gould's Wattled Bat (*Chalinolobus gouldii*) (3853) and Chocolate Wattled Bat (*Chalinolobus morio)* (2633) (Table 6). The lowest number of calls was recorded for the *Mormopterus sp* category*;* however these calls are associated with the *Mormopterus* sp 3/ sp 4 and *Chalinolobus gouldii/ Mormopterus sp* categories and, if combined, present a higher level of activity.

Table 6. Number of calls recorded for each bat species detected during passive AnaBat survey

Species name	Common name	Conservation status		Nov 2009	Jan 2010	Dec 2010	Total calls
		Aus	SA				
Austronomus australis	White-striped Free-tail Bat			103	461	188	752
Chalinolobus gouldii	Gould's Wattled Bat			1111	1821	921	3853
Chalinolobus morio	Chocolate Wattled Bat			976	1295	362	2633
Chalinolobus gouldii/ Mormopterus sp	Gould's Wattled Bat/ Free-tail Bat			414	488	330	1232
Mormopterus sp	Free-tail Bat			-	-	243	243
Mormopterus sp 3/ sp 4	Free-tail Bat			128	146	-	274
Nyctophilus geoffroyi	Lesser Long-eared Bat			63	226	37	326
Vespadelus darlingtoni	Large Forest Bat			760	58	125	943
Vespadelus regulus	Southern Forest Bat			931	36	18	985
Vespadelus sp.	Forest Bat			474	14	24	512
Unidentified bat				410	347	47	804
Total calls				5370	4892	2295	12557
Detector nights				8	16	23	47
Average calls per detector night				671	306	100	267

The Inland Free-tail Bat and Southern Free-tail Bat *(Mormopterus* sp3 and *Mormopterus* sp4) are both likely to occur in the area but these species are difficult to separate by calls. There were no definite calls of Little Forest Bat (*Vespadelus vulturnus*) but some calls identified as *Vespadelus* sp. may in fact be this species. The Inland Broad-nosed Bat (*Scotorepens balstoni*) is likely to be in the area but no single call could be confirmed as this species. The Inland Forest Bat (*Vespadelus baverstocki*) was not detected but could also be in the region, however this species is mainly found within semi-arid to arid landscapes and the project site is on the southern edge of its known distribution.

The number of calls recorded at each site is given for each survey within Appendices 3-6 and mapped in Figures 17- 20. The highest bat activity levels overall were at site 1 (near water) with 1157 calls recorded over 5 survey nights, at site 7 (near water) with 2286 calls recorded over 3 survey nights, and at site 8 (very open woodland – along Pine Hut Rd roadside vegetation corridor) with 2101 calls recorded during one night.

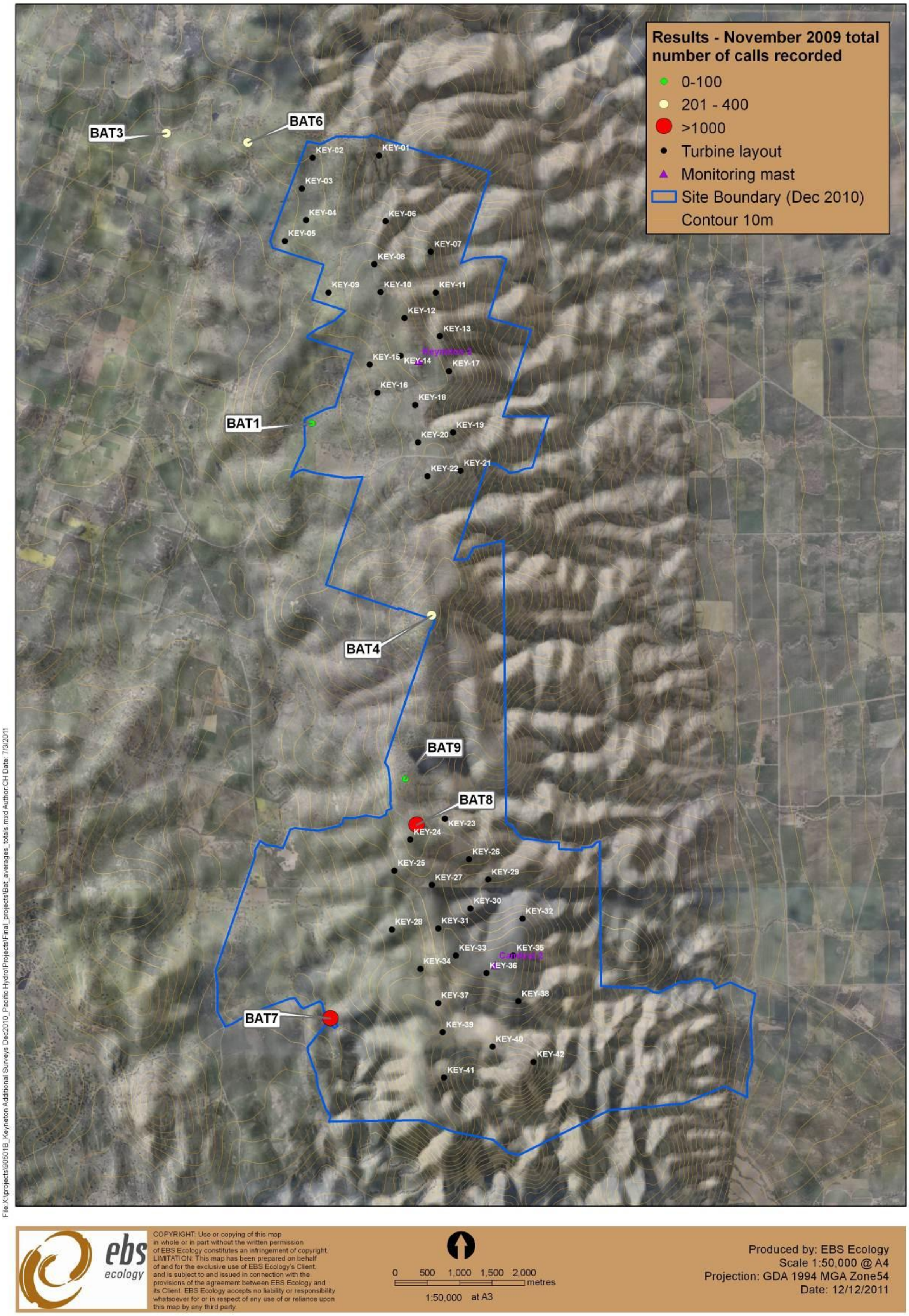

Figure 10 November 2009 total calls for each site.

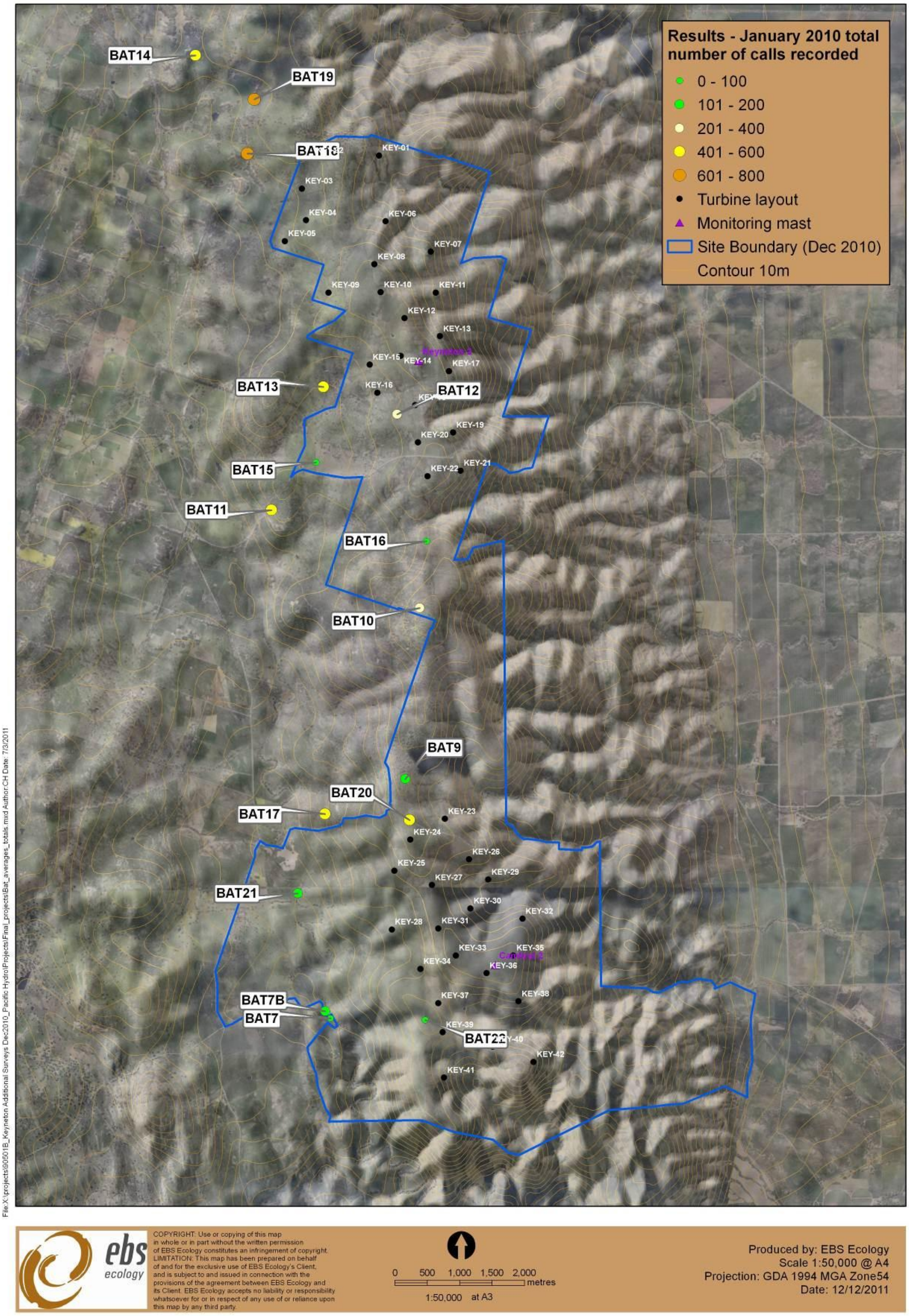

Figure 11 January 2010 total calls for each site.

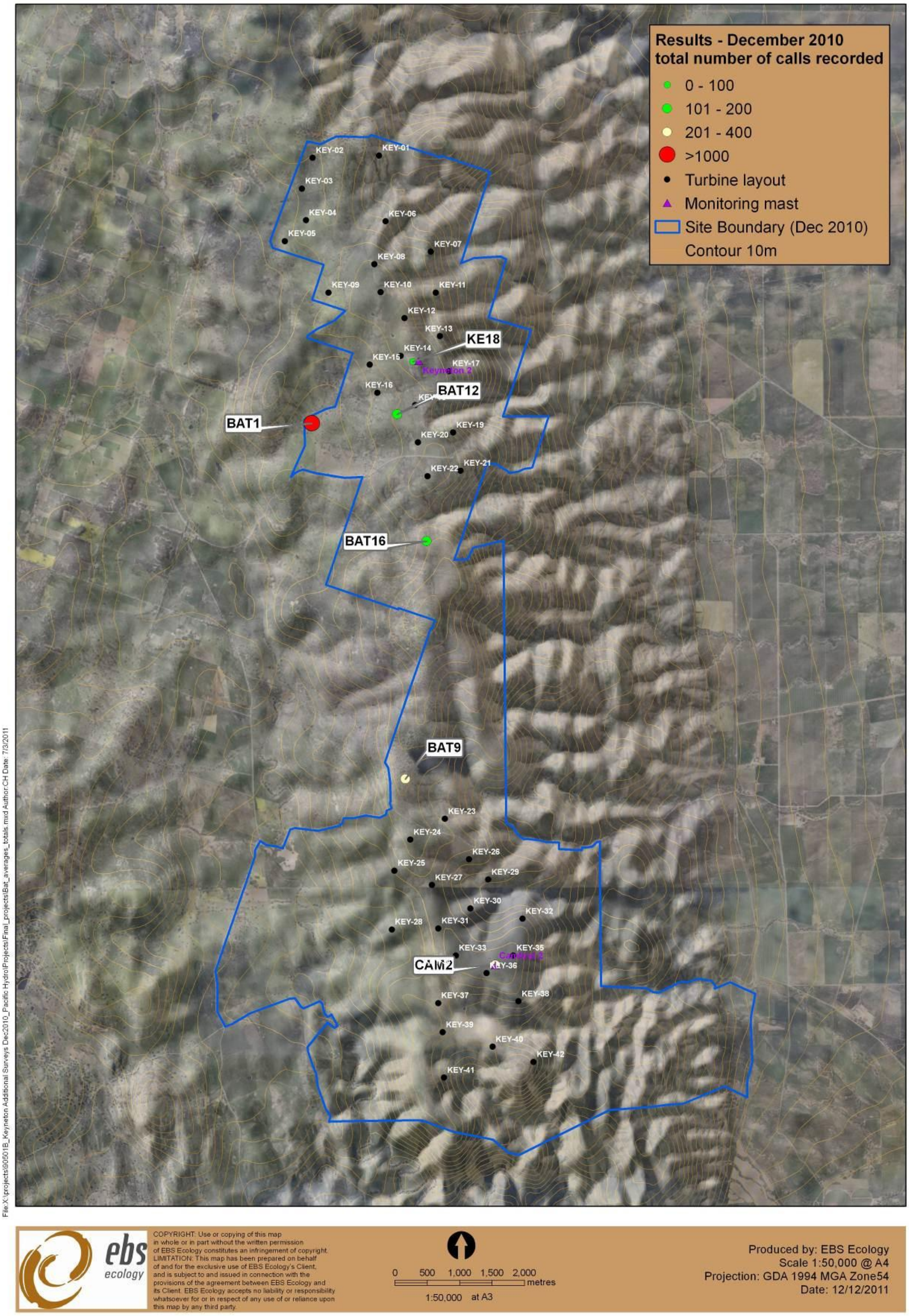

Figure 12 December 2010 total calls for each site.

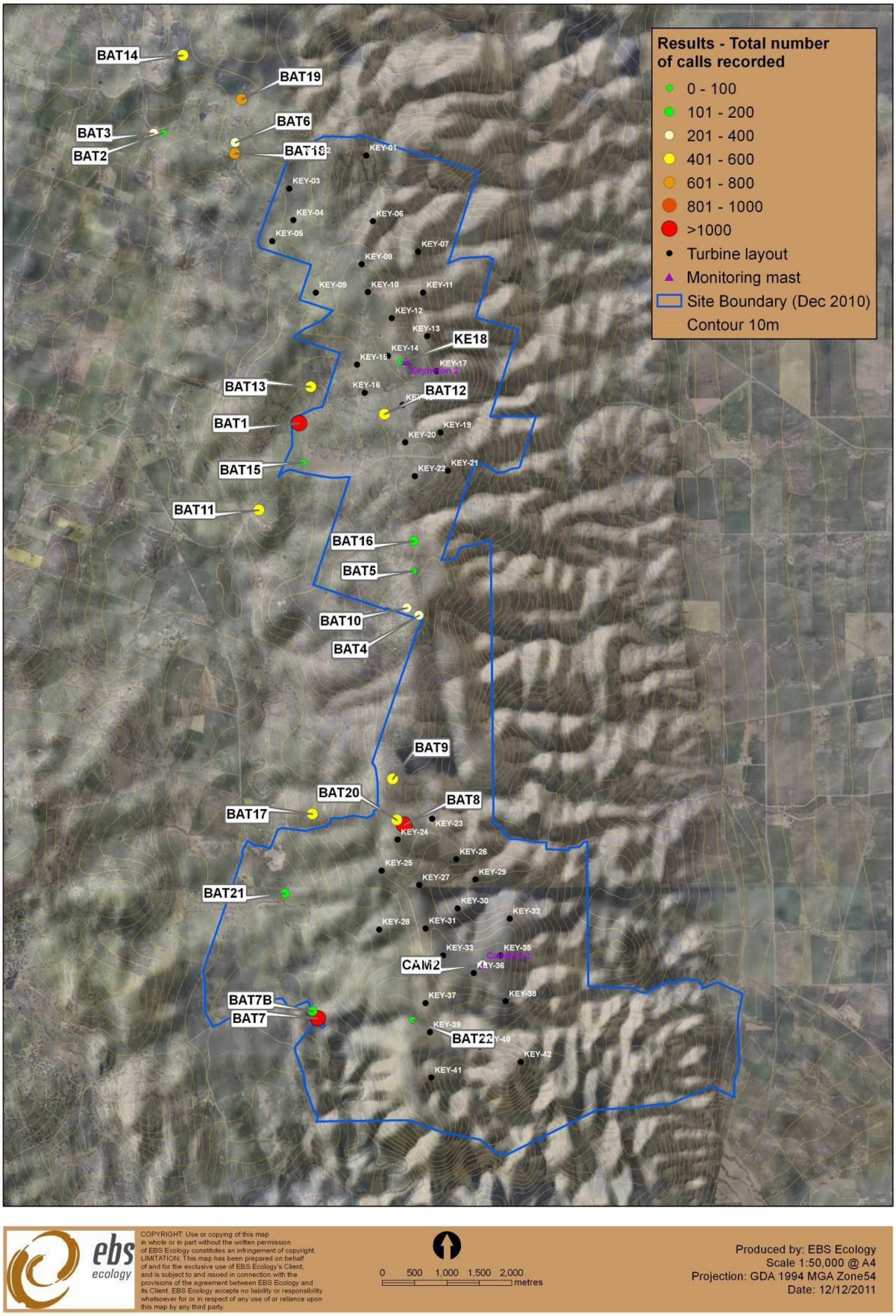

Figure 13 Total number of calls over all three surveys.

Each passive survey site was assigned a habitat type so that some comparison of bat activity could be made across the surveys between habitats. The bat habitats were classified as:

- near open or free-standing water (foraging habitat for bats)
- woodlands (foraging and roosting habitat)
- very open woodlands (foraging and roosting habitats); and
- open grasslands (foraging habitats)

Example photos of each bat habitat at the Keyneton site are given in Figures 14-19.

The survey effort in each habitat was unequal between surveys (as the focus was changed and adapted); hence the total calls for each habitat are a function of this. Instead, a valid comparison of bat activity levels can be made by looking at the average calls per detector night for each habitat (Table 7). The vegetation associations previously defined within the project area (Appendix 1) show the location of wooded and open habitat in relation to the turbines.

Table 7 Number of bat calls recorded for each habitat during passive AnaBat survey

Survey site habitat type	Survey sites included	Number of calls (number of survey nights used during that survey)			Total calls for the habitat type (Total number detector nights)	Average calls per detector night for the habitat type
		Nov 2009	Jan 2010	Dec 2010		
Open grassland	22, 16, 12, KE18, CAM2, KE18upmast	-	345 (3)	834 (15)	1179 (18)	66
Very open woodland	8, 11, 15, 20	2101 (1)	1138 (3)	-	3239 (4)	810
Woodland	4, 6, 9, 10, 13, 14, 17, 19, 21, 18	632 (3)	3199 (8)	363 (4)	3908 (15)	261
Near free-standing water	1, 3, 7, 7b	2636 (4)	210 (2)	1098 (4)	3975 (10)	398
Total calls for the survey		5370 (8)	4892 (16)	2295 (23)		

Figure 14 Example of bat foraging habitat near open water (site 1)

Figure 15 Example of bat foraging habitat near open water (site 7)

Figure 16 Woodland habitat used for bat roosting and foraging (edge space aerial foragers)

Figure 17 Another woodland habitat used for bat roosting and foraging (edge space aerial foragers)

Figure 18 Very open woodland habitat used for bat roosting and foraging (edge space and aerial space foraging strategies)

Figure 19 Open grassland habitat used for bat foraging (aerial space foraging strategy)

Very open woodland habitat registered the highest levels of activity with an average of 810 calls per detector night. The four sites classified as this habitat happen to occur close to the major roads that cross the site from east to west. A large proportion of the calls were recorded at site 8 over one night in January 2009 (2101 calls of the total 3239). This site was situated on the top of the range within a narrow strip of scattered roadside vegetation along Pine Hut Road (Figure 20).

Moderately high levels of activity were also registered at woodland habitats (average of 261 calls per detector night) and open water sites (average of 398 calls per detector night). A high level of bat activity was registered at Site 7 (located near free standing water) during November 2009, with 1916 bat calls recorded during one survey night and 324 calls recorded the following night. High levels of bat activity were recorded in woodland habitat during January 2010, with Site 18 recording a total of 692 calls and Site 19 recording 626 calls. These two sites are now beyond the current site boundary, but may correlate to woodland habitats still present within or adjacent to the project site boundary.

In contrast, open grassland habitats (where the majority of turbines will be) had the lowest activity levels with an average of 66 bat calls per detector night. Despite this, the bat activity recorded in open areas is comparatively higher than similar sites visited within the Mid-North region, based on survey experience in recent years (EBS 2012). Although the project area is not within the Mid-north region, it is just outside the boundary and habitat features are comparable to survey sites within the Mid-north.

Figure 20 Scattered roadside trees along the top of Pine Hut Road (site 8)

December 2010 surveys

This survey focussed on the passive survey of fewer sites for up to four consecutive nights, to remove the potential influence of weather conditions, to allow for averages to be calculated, and to specifically focus on open sites more representative of the areas where turbines will be located (with some comparison to bat habitat). Bat habitat sites recorded the highest number of bat calls for the December 2010 survey, including site 1 (near water) with 1098 calls and site 9 (woodland) with 363 calls (Table 8). The lowest numbers of bat calls were recorded at the mast sites with KE18 (down mast) recording 72 calls overall (over 4 nights) and KE18 (up mast) recording a total of 6 calls (over 2 nights).

The mast sites KE18 (up mast) and KE18 (down mast) were surveyed simultaneously for two nights during December 2010. Activity recorded at the sites were similar on the first night, when five bat calls were recorded at ground level and four bat calls were recorded up the mast. On the second night 15 bat calls were recorded at ground level, whereas only 2 were recorded up the mast. On both survey nights the 'up mast' site recorded less calls, but activity recorded at both levels was comparably low in any case.

Table 8 December 2010 bat calls recorded per survey site – passive survey results

Survey Date	**Survey sites and habitat type**						
	1	**9**	**12**	**16**	**KE18** Down mast	**KE18** Up mast	**CAM 2**
	water	**woodland**	**open**	**open**	**open**	**open**	**Open**
13/12/10	465	185	181	27	30	-	-
14/12/10	162	78	95	47	22	-	13
15/12/10	291	(0) AnaBat Error	-	45	5	4	59
16/12/10	180	100	-	20	15	2	269
Total bat calls recorded	**1098**	**363**	**276**	**139**	**72**	**6**	**341**
Average calls per detector night	**275**	**121**	**138**	**35**	**18**	**3**	**114**

When comparing average calls per detector per night, open sites such as site 16 and mast sites at KE18 recorded an average of less than 100 calls per detector night, whereas remaining open sites CAM2 and site 12 recorded an average of between 100- 200 calls per detector night. Woodland site 9 recorded an average lower than open site 12 and comparable to CAM2. Site 1 (near water) had a much higher average of calls recorded per detector night than any other site (Table 8). The average number of calls recorded per detector per night is mapped in Figure 21.

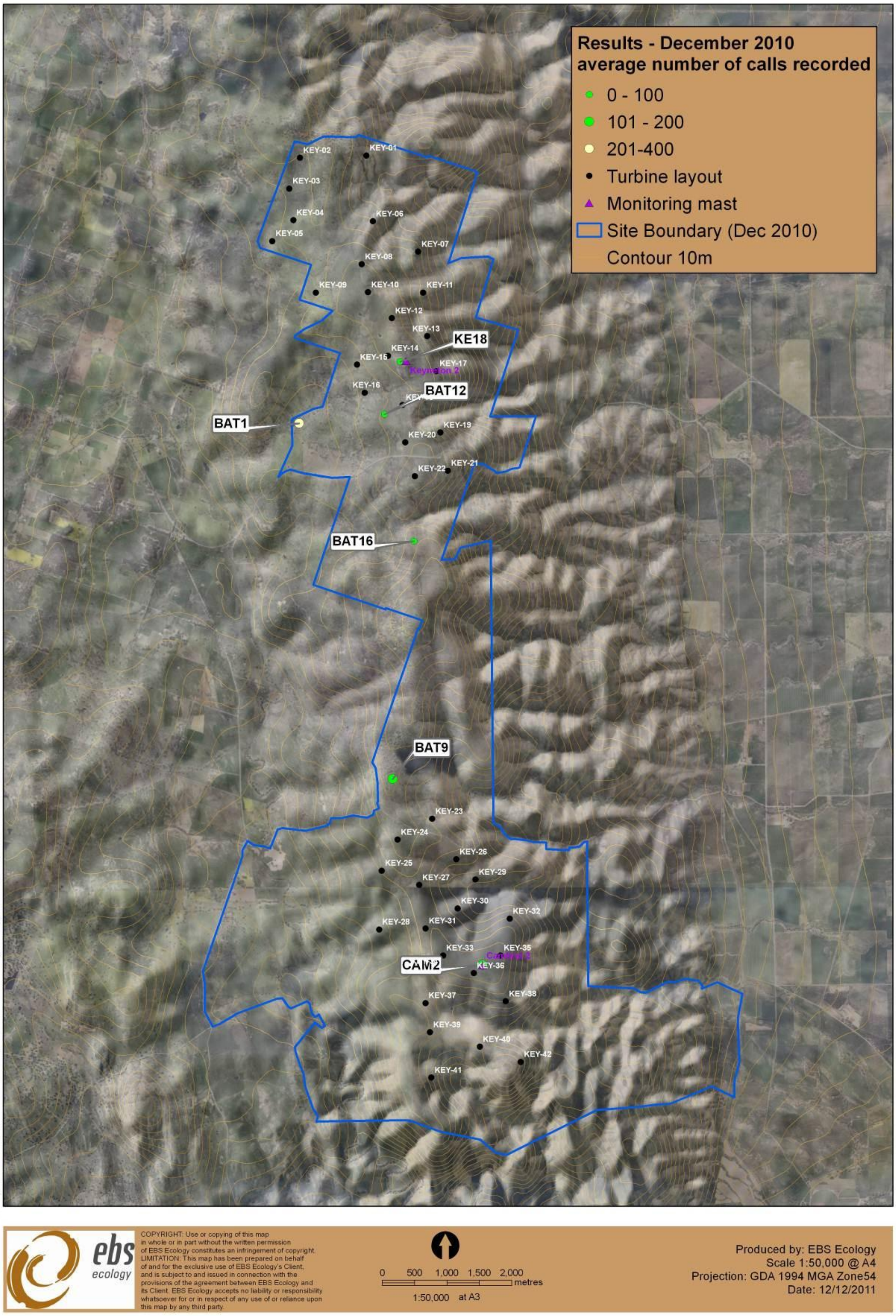

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Figure 21 December 2010 average number of calls per site.

Comparison of calls recorded in habitat types during December 2010 revealed a similar pattern to that evident from the comparison of calls over the three surveys. The average calls recorded per detector night for all the open sites combined was lowest, with woodland sites and sites near water recording higher averages (Table 9). This survey revealed a more pronounced difference between woodland habitat and habitat near water, with the average for water sites being more than twice the average at woodland sites.

Table 9 December 2010 bat calls recorded in each habitat type – passive survey results

Survey site habitat type	Survey sites included	Number of calls	Total number of survey nights during Dec 2010 survey	Average calls per detector night for the habitat type
Open grassland	12, 16, CAM2, KE18 down mast, KE18 up mast	834	15	55.6
Woodland	9	363	3	121
Near free-standing water	1	1098	4	275
Totals		**2295**	**23**	

Note: very open woodlands were not surveyed as a separate habitat type during the December 2010 survey

5.2.4 Trapping results

Over the three surveys 55 individual bats were caught and seven different species were positively identified with one bat, *Vespadelus* sp, only able to be identified to genus (Table 10). All of these species were also recorded on the passive AnaBats; the only other species recorded in the passive surveys that was not caught was the Large Forest Bat (*Vespadelus darlingtoni*). Chocolate Wattled Bats and Gould's Wattled Bats were the most commonly caught bat species with 22 and 19 captures respectively throughout the surveys. Captures were made of both the Inland Free-tail Bat and Southern Free-tail Bat as these species were able to be distinguished from each other by morphological features.

Seven White-striped Free-tail Bats (*Austronomus australis*) were caught which is quite unusual as this species is a high-flyer and is rarely caught or seen, even though it is commonly heard (one of the few bat calls in SA audible to humans). All captures of this species were female, mostly adults during the December 2010 survey with also a couple of sub-adult females during the January 2010 survey. White-striped Free-tail Bats use an open space aerial foraging strategy and since these captures were made within woodland areas at site 9, site 13 and site 18, it is likely that these individuals were caught close to their roosting location within these woodland areas.

Table 10 Bat species captured during the surveys

Species name	Common name	Conservation status		Nov 2009	Jan 2010	Dec 2010	Total
		Aus	SA				
Austronomus australis	White-striped Free-tail Bat			-	3	4	7
Chalinolobus gouldii	Gould's Wattled Bat			1	14	4	19
Chalinolobus morio	Chocolate Wattled Bat			9	10	3	22
Mormopterus sp. 3	Inland Free-tail Bat			1	-	-	1
Mormopterus sp. 4	Southern Free-tail Bat			-	-	1	1
Nyctophilus geoffroyi	Lesser Long-eared Bat			2	1	-	3
Vespadelus regulus	Southern Forest Bat			1	-	-	1
Vespadelus sp.	Forest Bat			-	1	-	1
	Total			**14**	**29**	**12**	**55**

5.2.5 Active survey and flight behaviour observations

Six bat species were positively identified from recordings during the active surveys in December 2010, with 230 bat calls recorded (Table 11). Free-tail bats were detected during the active surveys but were not able to be distinguished between the Inland Free-tail Bat and Southern Free-tail Bat. Gould's Wattled Bats and Chocolate Wattled Bats were again the most commonly recorded species. Similar to the passive survey, no threatened bat species were detected and there were no confirmed calls of potentially present species Little Forest Bat (*Vespadelus vulturnus*), Inland Broad-nosed Bat (*Scotorepens balstoni*) and Inland Forest Bat (*Vespadelus baverstocki*).

Table 11. Bat calls recorded during the active Survey- Dec 2010

Species Name	Common Name	15/12/2010	16/12/2010
Austromomus australis	White-striped Free-tail Bat	0	5
Chalinolobus gouldii	Gould's Wattled Bat	36	85
Chalinolobus morio	Chocolate Wattled Bat	65	4
Mormopterus sp 3/ sp 4	Free-tail Bat	2	4
Nyctophilus geoffroyi	Lesser Long-eared Bat	1	3
Vespadelus darlingtoni	Large Forest Bat	0	7
Vespadelus regulus	Southern Forest Bat	0	0
Chalinolobus gouldii/ Mormopterus sp	Gould's Wattled Bat/ Free-tail Bat	8	3
Unidentified Bat		3	4

Note: call files classed as 'unidentified bat' were files seen to have some features of a bat call as distinct from background noises (e.g. rustling grass, insects and interference), however the call file was either of very low quality or not able to be distinguished to any of the above categories.

Active surveys were conducted from site 20 moving east along the Pine Hut Road vegetation corridor on the ridgeline (Table 13) and from woodland site 9 down the valley to the east, through grasslands to a dam (Table 14). Bats were observed flying between 5-15 m above ground level during the active surveys. It's unclear as to whether this was the limit of detection both visually and acoustically, or whether they confined their flight to within these heights, but few bats were detected on the AnaBat that could not been seen at some point, except for the high-flying White-striped Free-tail Bat. Captured bats were light-tagged and observations of flight heights and behaviour were made upon their release. Observations are provided in Table 12, 13 and 14. Although the flight behaviour of released bats is not necessarily indicative of a natural foraging pattern of flight, observations were recorded for the short time that bats were visible to give some information of their utilisation of the airspace.

Flight heights of released bats ranged between 5 and 20 metres from ground level, commonly around 10 m and many flew into or just above the canopy of nearby trees (Table 12). Some bats were observed to circle around in the area, but most often they were only able to be observed for less than 10 seconds.

From the active survey observations made along Pine Hut Road (Table 13), it is clear that bats are using this corridor as edge habitat for foraging and transit. Bats were observed at approximately 5-10 m in height flying along the road and along the outer edges of the roadside vegetation. The majority of the bats detected along this active survey transect were identified as Chocolate Wattled Bats. This species is known to forage in the gap between understorey and canopy and along forest trails (Churchill 2008). Chocolate Wattled Bats forage up to 5 km from their roosting site and use the same small foraging areas every night (Churchill 2008).

The second active survey transect crossed a number of different habitats, travelling from woodlands to open grasslands and finishing at open water. The majority of bats detected during this transect were identified as Gould's Wattled Bats. This species is known to commonly forage 5-10 km from its roosting site and occasionally up to 15 km (Churchill 2008). Gould's Wattled Bats forage within the lower levels of the canopy, along the edges of vegetation, along creeklines and around isolated paddock trees (Churchill 2008).

Table 12 Observations of released bats during December 2010

Date	Species	Method	Description of observations
14/12/2010	*Austronomus australis*	released	Flew 15 m high, flew straight ahead and circled back
14/12/2010	*Austronomus australis*	released	Flew into trees towards harp trap- 10 m high
14/12/2010	*Austronomus australis*	released	Flew straight, turned left and up over canopy
14/12/2010	*Chalinolobus gouldii*	released	Flew into trees about 10 m high
14/12/2010	*Chalinolobus morio*	released	Flew in arch around 5-10 m high
14/12/2010	*Chalinolobus morio*	released	Flew low around trees approximately 5 m
14/12/2010	*Chalinolobus morio*	released	Flew low, circled around a few trees, went into canopy about 5 m, dipping
14/12/2010	*Mormopterus sp.4*	released	Went from low to high- 15 m-20 m and flew around the area
14/12/2010	*Chalinolobus gouldii*	released	Flew low towards the woodland
14/12/2010	-	opportunistic	unidentified bat was flying in circles above us
15/12/2010	*Chalinolobus gouldii*	released	Flew low towards tree, lost after a few seconds
17/12/2010	*Chalinolobus gouldii*	released	Circled for a few seconds then flew off around 5-10 m high

Table 13 Descriptions of flight observations from active survey 15/12/2010

Time	**8.40 pm to 10:40 pm**
Date	**15/12/2010**
Weather	**Cool night, slight breeze, clear skies**
Transect Description	**Pine Hut Road- lined with trees and shrubs on each side on top of ridge line, Mainly small Eucalypts 4-5 m high, *Allocasaurina verticillata* 4-5 m, one larger Eucalypt 10 m high where the bats seemed to pass over**
Observation number	**Description of observation**
1	Circled us and over canopy at around 5 m high- flying over grassland- hard to see as flew very quickly
2	Flew at 10 m in a straight line along fence in between trees and grassland
3	Fly along road at 5 m high- straight
4	Flew over our head 8 m and dipped down through trees- possibly chasing a bug
5	Flew along road- about 8 m high
6	looping around above canopy 8 m- over into grassland 8 m
7	Flew over canopy 5 m high- and dipped down into trees/shrubs
8	circled over us 5 m- flew straight, in middle of the road
9	Flew down road- followed road 5 m high- small bat

Table 14 Descriptions of flight observations from active survey 16/12/2010

Time	**8:40 pm to 10:40 pm**
Date	**16/12/2010**
Weather	**Cool night, slight breeze, clear skies**
Transect Description	**Start within Eucalypt woodland 5 m canopy with limited understory, traveling east through to open exotic grassland, then ending at a dam with open grassland surrounding.**
Observation number	**Description of observation**
1	Bats very active within woodlands
2	2 bats flying together in circular motion
3	Open areas – no activity
4	Lots of bat activity around dam to the east of site 9
5	Bats circling water and dropping down to water level to drink
6	Bats circling close over our heads 4 m high in open dam area
7	Bats flying from dam up the valley NW over tree canopy 15 m high circling back down valley towards dam.

5.2.6 Habitat assessment

The project site provides ample suitable roosting and foraging habitat for bats (Figure 22 and Figure 23). Mature eucalypts onsite contain numerous hollows, cracks, crevices and bark that would be suitable for the roosting of small groups of bat to large colonies. Dwellings, old sheds, fence posts and rock walls within the area also provide alternative roosting habitat that may be utilised. The site contains suitable foraging habitat for bats with a range of strategies. Open water, scattered and dense woodland vegetation and strips of roadside vegetation provide good foraging habitat for open space aerial foragers, edge space aerial foragers, trawlers and gleaning foragers.

Most of the roosting and foraging habitat within the project site is situated within the valleys and creeklines, however some of these features exist along the ridge top. Proposed turbine locations previously sited within the vicinity of bat habitat along the ridge top, have now been located so as to avoid open water, woodlands and roadside vegetation, by establishing the buffers recommended by EBS (See Section 6 and 7). Woodland associations occur generally to the west of the main ridge, and all proposed turbines have avoided these areas.

A cluster of five turbines within the north-western part of the project site is situated within an association that is not formally classified as a woodland association (Vegetation association 1 – Scattered *Eucalyptus leucoxylon ssp. leucoxylon* (South Australian Blue Gum) over Exotic Grassland / Cropping Land) due to its level of modification and sparse nature of overstorey. It is considered that proposed turbines within this area can be micro-sited in an appropriate manner so as to adequately avoid bat habitat features. A qualified ecologist would be required onsite to oversee the final locations of these turbines, with the ability to adjust the locations of the turbines to be sited close to the currently proposed locations.

Figure 22 River Red Gums in creeklines that provide roosting habitat in hollows, cracks, crevices and under bark as well as foraging habitat around water and along the edges of trees in this creekline

Figure 23 Foraging and roosting habitat along the ridgelines in *Eucalyptus odorata* and *E. leucoxylon* woodland

6 DISCUSSION

6.1 Survey results

The bat species detected at the proposed Keyneton wind farm site consisted of species expected to occur within the region based on their known distributions. These species are generally thought to be common species, however limited information is available on the diversity, distribution and abundance of bat species within the region of the project site and species thought to be once common may now be regionally threatened (T Reardon *pers comm*). Eight of the thirteen species that could potentially be present at the project site were detected during the three surveys. No national or state threatened bat species were detected at the project site. Although the threatened bat species highlighted as potentially present were not detected during the surveys, it is possible that they utilise the site. The two threatened bat species are discussed in detail in section 3.3.

Bat activity at the project site was considered to be high based on the volume of calls recorded during the surveys. The level of activity is also relatively high in comparison to surveys in recent years recent at other sites within the general region that consist of similar vegetation and bat habitat (based on EBS's experience). The project site provides foraging habitat for a number of bat species. Open water, woodlands, scattered trees and roadside vegetation corridors consistently recorded moderate to high levels of activity as compared to more open areas. All bat species detected, or expected to utilise the site, would likely roost within tree hollows, cracks and crevices or within buildings, sheds and associated infrastructure. Numerous areas of suitable bat roosting habitat were present in the woodland associations within the project area and beyond the project boundaries.

Very open woodlands recorded high levels of bat call activity, higher on average than woodlands (albeit based on four nights of AnaBat survey compared to at least 10 nights of all other habitats). This may suggest that scattered open woodlands and small patches of trees are as important as woodland sites. Woodland sites are important for roosting and foraging, however scattered open woodlands may represent areas of more activity for foraging and social activity. The proximity of the 'very open' woodland sites with higher levels of bat activity to the two major roads crossing the project site (Pine Hut Road and Sedan-Angaston Road) also raises the possibility of bats potentially using main roads as corridors for movement and navigation. The narrow corridor of roadside vegetation in these areas is often adjacent to bare paddocks, providing suitable edge-space foraging habitat for the majority of bat species that are known to occur at the project site.

From the observations made along Pine Hut Road, it is clear that bats are using this corridor as edge habitat for foraging and transit. Bats were observed flying along the road and along the outer edges of the roadside vegetation. This may also be the case along road corridors crossing the ridge further north, such as Angaston-Sedan Road, where moderately high activity was also recorded. Road corridors and

any vegetation corridors within the project site should be buffered to exclude turbine placement to reduce the potential for impacts on bats using road corridors for dispersal, navigation and foraging.

Most of the areas of concentrated bat activity (woodlands and open water) are either outside of the revised project boundary or within the valleys of the project area. Some of these habitat features do exist in the vicinity of the original proposed infrastructure (i.e. the highest ridgeline) such as open water (small dams), main road corridors and pockets of woodland. After the revisions of the turbine layout to 42 turbines, the distance between these habitats and any of the current turbines has been increased, leading to a reduction in the potential for impacts on bat species.

The majority of the 42 turbines currently proposed are within open areas on the top of the ridgeline. These areas recorded the lowest bat activity levels during the surveys at the project site. December surveys showed that three of the open sites recorded a low average number of calls per detector night, however two open sites had comparable activity levels to the woodland site surveyed each with an average around 120 calls per detector night. The lowest numbers of bat calls were recorded at the monitoring mast (open sites) with KE18 (down mast) recording 72 calls overall (over 4 nights) and KE18 (up mast) recording a total of 6 calls (over 2 nights). Whilst over just two nights, the very low number of calls recorded at KE18 (up mast), suggests lower activity levels at increased heights within open areas.

Although generally less activity and less diversity were recorded in open areas, this airspace is the preferred foraging habitat for bat species that are open space aerial foragers. Hence there is potential for some level of impacts to these bat species. While most bats will transit through open areas on a nightly basis on their way to and from foraging habitat, bat species with open space aerial foraging strategies are considered to be more likely to be at risk of ongoing impacts from the operation of turbines at the site. Species with this strategy known to utilise the Keyneton site include:

- White-striped Free-tail Bat (*Austronomus australis*)
- Inland Free-tail Bat (*Mormopterus sp 3*)
- Southern Free-tail Bat (*Mormopterus sp 4*)
- Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris*) (SA rare, potentially present but rarely)

The White-striped Free-tail Bat was detected onsite and is commonly found throughout the region. This species is fast-flying but not designed for manoeuvrability, mainly catching prey in open airspace from 50 metres above ground height (Churchill 2008). The Inland Free-tail Bat and Southern Free-tail Bat detected onsite also use open space aerial foraging strategies and is therefore considered to be more likely at risk of bat strike interactions with turbines. The known flight heights of these species are less defined, however the Inland Free-tail Bat is thought to use open space such as the paddocks within the project area more than the Southern Free-tail Bat that has been associated with open spaces between trees (Churchill 2008). Although not recorded, the Yellow-bellied Sheath-tail Bat (SA rare) may utilise the site and is known also to use the open space aerial foraging strategy. The risk of impact to this species is

lower than the Free-tail bats which have been detected onsite, as the potential for the Yellow-bellied Sheath-tail Bat to use the site is low.

6.2 Potential impacts

Habitat clearance is one of the primary threats to bats when considering the impact of a development. Any clearance of woodland habitats within the project area would result in direct removal of roosting habitat for bats, the removal of foraging habitat and possibly the fatality of roosting bats. In addition, clearance of woodland habitat should be avoided due to the extent of native remnant vegetation (available habitat) within the region being very low (Graham et al. 2001). The turbine layout of the Keyneton Wind Farm largely avoids wooded areas, particularly after the reduction to 42 turbines, and hence will avoid any significant clearance of roosting and foraging habitat. Any proposed clearance of bat habitat associated with additional wind farm infrastructure, such as access roads, transmission lines and buildings (e.g. to site entry / exit points along Pine Hut Road), should avoid larger and older trees that are more likely to provide significant bat habitat features such as hollows, cracks or crevices.

Bat strikes (blunt-force trauma when a bat contacts the turbine blade or infrastructure) are most likely if turbines are positioned where there are concentrations of bat activity, i.e. within roosting habitat, foraging habitat and movement corridors. North American wind farm studies have also suggested that bats may be impacted by a sudden change in localised air pressure created by turbines, after bats had been found with fatal injuries consistent with *Barotrauma* (Baerwald et al. 2008). *Barotrauma* is said to result in the death of a bat when their lungs are stretched beyond capacity by the sudden change in air pressure. The study suggests that bats are impacted without contacting infrastructure, however it is unclear what proximity to turbines constitutes a threat to bats from air pressure impacts. A recent study in North America (Grodsky et al 2011) evaluated the cause of bat deaths at a wind farm and discovered that 74% of bat carcasses detected had sustained bone fractures that were likely to be consistent with turbine contact. They also found that 50% of all carcasses found had suffered mild to severe ear drum ruptures. This research has also raised the possibility of bats that may sustain air pressure impacts (such as the ear drum injuries) that are not immediately fatal but cause the impairment of navigation and foraging, and result in the bat's demise. Whilst this possibility is poorly understood, it has been suggested that this type of impact may lead to the under-estimation of bat deaths related to wind farms, since the affected bats may fly (and die) outside the carcass search area in bat impact monitoring programs.

The 'strike' impact of wind farms on bats is difficult to predict and quantify, as the behaviours and interactions between bats and turbines are not fully understood. Most research to date has been undertaken in Europe and North America where wind farms have been installed for a number of years. As an initial step, many wind farms have established buffer zones around identified foraging and roosting habitat to reduce the interactions of bats and turbines. While most bats in Britain have been known to stay within close proximity of habitat features when commuting, others in Europe commute along linear

features such as vegetated roads in open areas (Mitchell-Jones and Carlin 2009). A review of bat deaths at wind farms in Germany revealed turbine placement as a key factor in the mortality of bats (Durr and Bach 2004). A total of 89% of all bat fatalities were found to be near turbines that were within 100 m of a wooded area. Many bat species found in South Australia use an 'edge-space' aerial foraging strategy focussed on treed habitat and water bodies, and are expected to stay within close proximity to these features. Linear features such roads and drains have also generally been recorded to have high bat activity (often associated with vegetation or water) and bats have been observed to navigate and forage along the length of these features (T Reardon *pers comm* 2011). Durr and Bach's research suggests that the adoption of exclusion zones or buffers from key habitat features such as wooded areas can significantly mitigate potential bat impacts.

The operation of wind turbines at the Keyneton Wind Farm has the potential to impact bats that utilise the site on an ongoing basis. Areas of concentrated bat activity have been highlighted within the project site and largely avoided by the turbine layout design. The adoption of habitat buffers (See Section 7) reduces the likelihood of bat impacts (via either direct contact or *Barotrauma*). The majority of bat species detected within the project site are expected to utilise the habitat features (wooded areas and open water) that have been avoided by the turbine layout, hence based on our current understanding of how these species use the site, impacts would only be expected infrequently when commuting between foraging and roosting habitat. A minimum buffer distance of 100 m should be established around all relevant bat habitat features to minimise the risk of bat collisions with turbines at the site.

Four bat species (White-striped Free-tail Bat, Inland Free-tail Bat, Southern Free-tail Bat and Yellow-bellied Sheath-tail Bat) have been outlined as most likely to use the open space habitat where turbines will be positioned. It is recognised that bats are only at risk of striking a turbine blade when within close proximity of the rotor swept area (i.e. flying above approximately 40 m in height, subject to the turbine configuration. Although limited information is known about how these species behave at these heights within open areas, it is expected that they would have some interactions with the turbines. Three of the bat species most likely to use the potential rotor swept areas (White-striped Free-tail Bat, Inland Free-tail Bat and Southern Free-tail Bat) are considered to be common species. However considering that these species' preferred foraging habitat is open areas (particularly the White-striped Free-tail Bat) the impacts will be biased towards them. The state rare Yellow-bellied Sheath-tail Bat is considered to have a very low potential use of the site and hence the impacts to this species are expected to be unlikely.

Little is known about the effect of operating turbines on bat behaviour, whether bats avoid turbines or not, and the actual number of bat-strikes that have been caused by operational wind farms in Australia (T Reardon pers. comm.). Speculation exists in the scientific community as to whether bats are able to avoid turbines, get used to turbines, or whether they are in fact attracted to turbines. Busy motorways have been shown to present a barrier to the movement and foraging behaviour of some bat species (Kerth and Melber 2009) however published information regarding the barrier effect of turbines is very

limited. Some impact may be possible similar to the 'barrier effect' noted for birds at wind farms, however this is largely unknown in the context of foraging and commuting bats.

6.2.1 Other impacts on bats

All energy generating sources can impact on bats. When considering the potential impacts on bats associated with wind farms, it is also important to consider the existing and on-going impacts on all forms of wildlife from other energy sources.

An assessment was conducted of known and documented effects of electricity generation on vertebrate wildlife in the New York/New England region by Newman and Zillioux (2009). Results were used to construct a Comparative Ecological Risk Assessment in order to make objective comparisons amongst six types of electricity generation important to the region. Overall, non-renewable electricity generation sources, such as coal and oil, pose significantly higher risks to wildlife than renewable electricity generation sources, such as hydro and wind (Newman and Zillioux 2009).

7 MITIGATION MEASURES AND MONITORING

A number of mitigation measures have been built into the design of the proposed Keyneton Wind Farm infrastructure, in particular the adoption of exclusion zones (or buffers) around identified bat habitat. The extended time frame of the bat surveys and wind farm design process has allowed for the integration of these recommendations over the last few years, and has significantly influenced the reduction in turbine numbers from 57 to 42 turbines.

- **No clearance of vegetation that may provide bat roosting or foraging habitat**

  In order to avoid impacting bat roosting and foraging habitat Pacific Hydro have committed to siting wind farm infrastructure so that no removal of wooded areas is required. Avoiding the clearance of wooded vegetation (native and exotic) is the simplest method available to protecting the habitat that bats currently use at the site as well as preventing the direct mortality of roosting bats.

- **Established exclusion zones (buffers) around identified bat roosting and foraging habitat**

  Turbine exclusion buffers have been adopted within the wind farm design, around identified bat roosting and foraging habitat to minimise the ongoing collision risk to roosting and foraging bats. The areas immediately surrounding these habitats have the most concentrated flight and call activity, and placing turbines outside of these buffers is expected to substantially reduce the incidence of bat strike impacts for the majority of bat species that use the site.

  A minimum buffer of 100 m (and in some instances buffers of up to 200 m) has been adopted around all identified woodlands, roadside vegetation movement corridors (particularly Pine Hut Road and Angaston-Sedan Road) and river movement corridors (Figure 24). Open water will be buffered by a minimum of 250 m due to the increased activity of a number of species at open water habitat.

  Previous layouts had turbines in or within the close vicinity of preferred habitat and these have generally either been deleted or re-located to cleared areas to further reduce potential impacts to bats, with the exception of Turbines (KE-02, KE-03, KE-04, KE-06 and KE-08) which remain within an area of scattered Blue Gums over exotic grasslands/crops in the north-west corner of the project site. Given the very sparsely scattered nature of the Blue Gums within the vegetation association in this area, it is considered that turbines located within this are able to suitably avoid bat foraging and roosting habitat. Each of these turbines has been specifically sited within the layout to avoid the large trees that remain in this area (J Adams *pers comm* 2012). In addition to this design stage the turbines can be further micro-sited (by a qualified ecologist during an additional site visit) close to their proposed locations so as to confirm avoidance of the foraging habitat within this area.

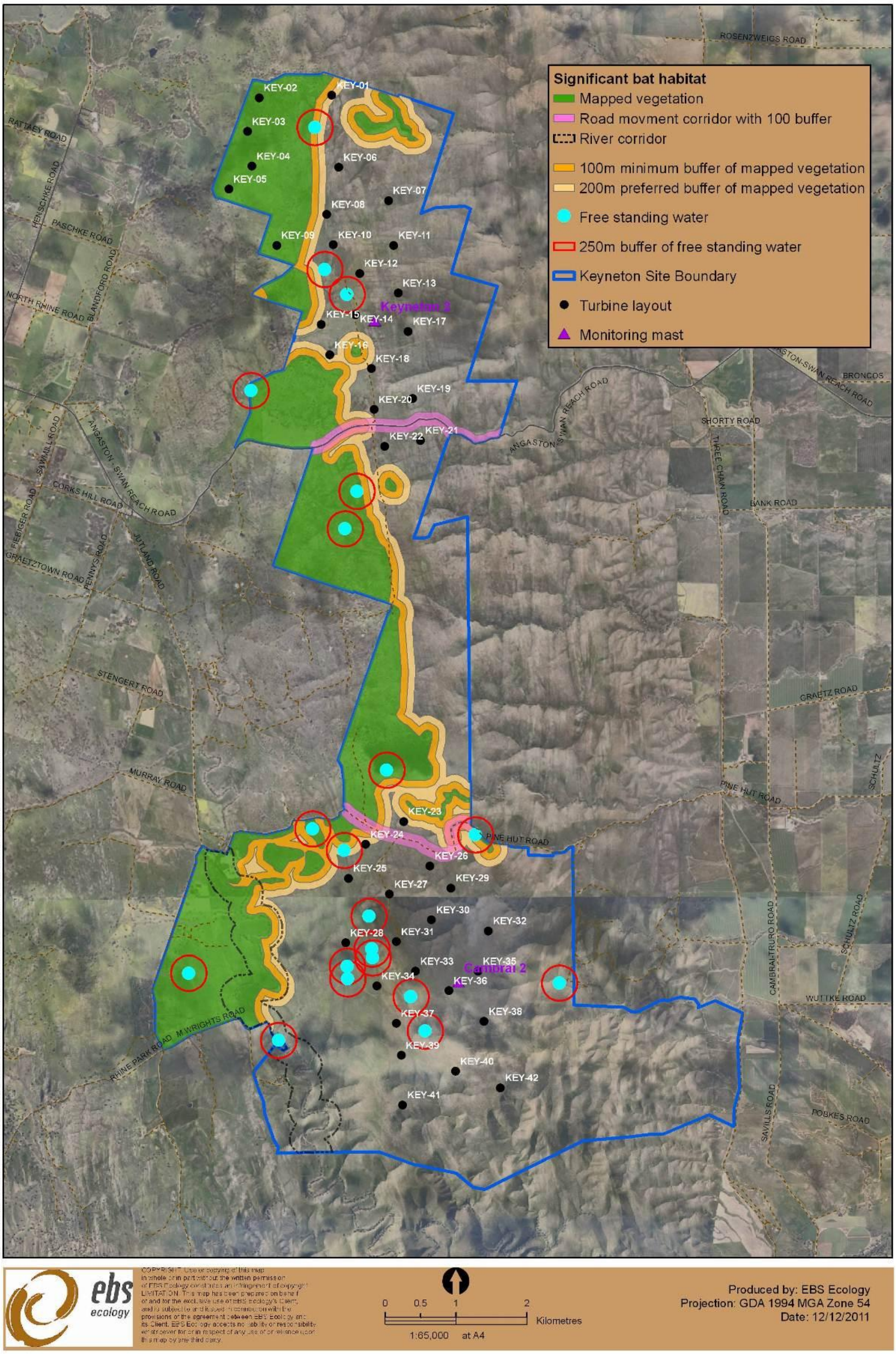

Figure 24 Bat habitat and established buffers within the proposed Keyneton wind farm site.

In addition to the above mitigation measures the following monitoring measures are recommended to measure the impact of the wind farm on bats utilising the site:

- **Establish bat-strike monitoring to measure actual impacts of the wind farm on bats utilising the project site.**

  Bat-strike monitoring methods should be adopted and searches conducted on a regular basis to identify bat mortalities as a result of the proposed wind farm. Bat-strike monitoring programs should be conducted by suitably trained on-ground staff, however a formal reporting procedure to an external environmental agency is recommended. The level of bat activity across the Keyneton project site denotes some impacts will be likely (even when mitigation measures are taken into account) but measuring the actual impacts will help to assess whether the mitigation measures have been appropriate.

- **Perform scavenger and detectability trials to correct bat-strike monitoring results**
  It is recommended that scavenger and detectability trials are performed at the proposed Keyneton wind farm prior to the construction and operation of turbines. These trials measure the influence of scavenging activity and the detectability of bat carcasses at the Keyneton site. Results from bat-strike monitoring programs conducted during the operation of a wind farm would not be accurate without pre-construction determination of the detectability of carcasses (in certain landscapes) and the extent of scavenging activity at the site. These rates of detectability and scavenging are factored into the bat-strike monitoring results to form an accurate picture of bat mortalities.

- **Establish long-term monitoring of bat diversity and activity at the project site.**
  A long-term monitoring program is recommended to assess the ongoing utilisation of the wind farm by bats. Activity levels and species diversity within and surrounding the site would provide valuable information about how bats react to wind farms and form part of the assessment of mitigation measures employed at this site. Monitoring could also include the study of turbine avoidance behaviour, bat flight paths, and bat flight heights in relation to the rotor swept area.

It is recommended that a Bat (and Bird) Monitoring Plan is prepared for the approval of Department of Environment and Natural Resources prior to the commencement of construction. The methodology, parameters and timeframes for a monitoring program could be established through this plan.

8 CONCLUSION

This assessment has identified thirteen bat species as potentially present on the proposed Keyneton Wind Farm site. Three separate survey campaigns have positively identified eight of these species on site. These eight species are all common and no threatened species were identified on site. It is acknowledged that without a more detailed knowledge of the bat species present, their distribution and their actual specific behaviours within the project area, it is difficult to accurately assess the impacts of the proposed wind farm on bats. However it is considered that the survey effort has enabled a reasonable assessment of the expected bat impacts at this site.

The surveys at the project site have demonstrated that bat activity is concentrated around bat habitat features (wooded areas, open water and main road corridors) which have been avoided. Bat activity levels are lower in open areas where turbines are currently proposed. It is expected that bat activity levels may be even less at potential rotor swept areas in open space, however this remains unclear.

During the assessment process of the proposed Keyneton Wind Farm, EBS Ecology has provided recommendations, subsequently adopted by Pacific Hydro during the design of the wind farm in order to avoid and minimise potential flora and fauna impacts. The turbine layout has been reduced and now avoids high concentrations of bat activity and hence ongoing impacts to bat species.

The mitigation measures that have been adopted are considered to substantially reduce the potential ongoing impacts of turbines on bats as part of a wind farm proposal at this site based on our current knowledge. Any additional infrastructure proposed onsite (such as connecting roads, associated buildings and transmission lines) would need to be assessed separately and have the appropriate mitigation measures in place, in line with what has already been committed to. In general, any further infrastructure proposed onsite should similarly avoid clearance of bat foraging habitat (wooded vegetation and open water); and additional buffer distances should be established to exclude structures that may interfere with bat foraging and roosting habitat that is appropriate to the nature of disturbance of that structure.

Provided the mitigation measures that have been committed to are implemented, significant impacts on bat species using the site are considered unlikely. In summary:

- No threatened bat species have been detected onsite. Two threatened species may potentially use the site, (nationally vulnerable South-eastern Long-eared Bat (*Nyctophilus corbeni*) (formerly known as *Nyctophilus timoriensis* (*South-eastern form))* and the state rare Yellow- bellied Sheath-tail Bat (*Saccolaimus flaviventris*). If present they are likely to occur infrequently and in low numbers. Hence the risk of impact to these species is considered to be very low and would not constitute a significant impact.

- The bat species detected onsite are thought to be common throughout the region and the majority of bats were recorded within the vicinity of habitat features such as woodlands, open water and linear movement corridors (which have been avoided).
- Minimal clearance of vegetation considered to be bat roosting or foraging habitat will be undertaken (only to the extent required to provide site entry/exit points along Pine Hut Road, existing site entry points will be used / widen if possible to further any clearance)(K Derriman *pers comm* 2012).
- Buffers are planned to protect the foraging and roosting habitat of the majority of bat species where bat activity is concentrated. Woodlands and linear movement corridors will be buffered by a minimum of 100 m and open water will be buffered by 250 m. It is likely that many of the bat species recorded at the site will predominately stay within close proximity to these habitat features and hence will be at low risk from turbine strike impacts.
- Free-tail and Sheath-tail bats that forage in open space are most likely to suffer bat strike interactions. The Inland Free-tail Bat (*Mormopterus* sp 3) and Southern Free-tail Bat (*Mormopterus* sp 4) detected onsite use open space as part of their foraging strategy but it is unclear as to whether they forage at potential rotor swept heights in open areas. The White-striped Free-tail Bat (*Austronomus australis*) detected onsite is predicted as the species most likely to suffer bat strike impacts as they are known to forage more than 50 m above the ground in open areas, which coincides with the potential rotor swept area.
- In addition to the mitigation measures embedded in the design, the following monitoring measures have been recommended:
  - Bat strike monitoring
  - Scavenger and detectability trials
  - Long term monitoring of bat (diversity, activity and behaviours).

Finally it is recommended that a Bat (and Bird) Monitoring Plan be prepared for the approval of Department of Environment and Natural Resources prior to the commencement of construction. The methodology, parameters and timeframes for a monitoring program could be established through this plan.

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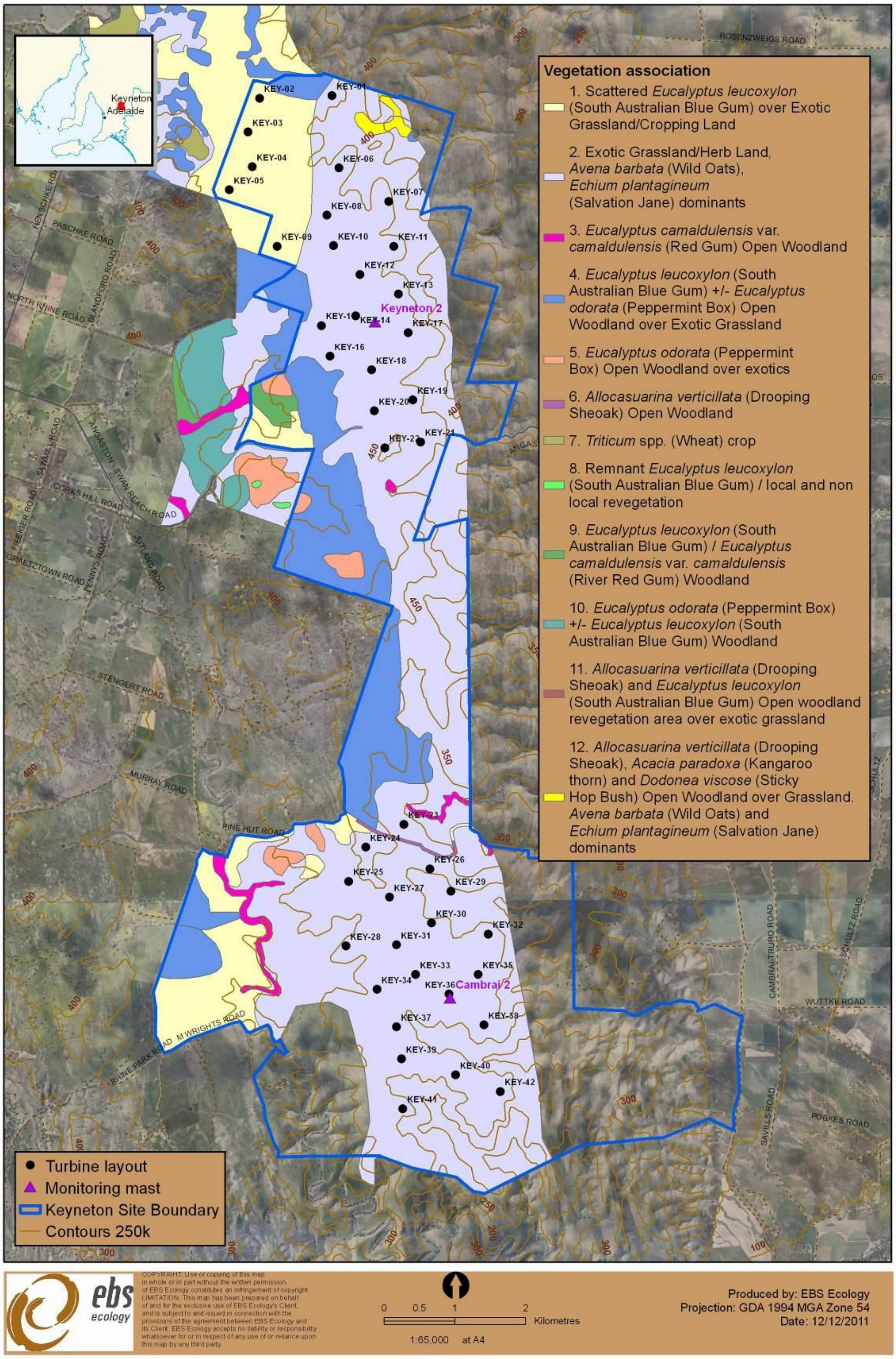
10 APPENDICES

Appendix 1. Vegetation associations at the project site (EBS 2011)



Appendix 2. Passive AnaBat and trapping survey effort

	Survey Site																										
Survey Date	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**7B**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**KE 18**	**KE18 Up mast**	**CAM 2**
23/11/09	A	H	A M	-	-	-	-		-	-																	
24/11/09	-	-	-	A	H	A	-		-	-																	
25/11/09	-	-	-	-	-	-	A		A	-																	
26/11/09	-	-	-	-	-	-	A M		-	A H																	
12/01/10											A H	A	A	A H													
13/01/10										A H					A H	A	A										
14/01/10																		A H	A H	A	A						
18/01/10							A H	A														A H	A				
14/12/10	A H									A H			A				A								A		
15/12/10	A									A H			A				A							H	A		A
16/12/10	A									A H							A							H	A	A	A
17/12/10	A									A H							A							H	A	A	A

KE18= Northern Mast Site

CAM 2= Southern Mast site

Methods used: A = AnaBat H = Harp Trap M = Mist net

Appendix 3. Number of bat call files recorded during November 2009 survey

	Survey Site																								
Survey Date	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**KE 18**	**KE18 Up mast**	**CAM 2**
23/11/09	**59**	**H**	**337**																						
24/11/09			**H**	**354**		**195**																			
25/11/09							**1916**	**2101**																	
26/11/09							**324** **M**		**83** **H**																

H=Harp

M=Mist nets

Appendix 4. Number of bat call files recorded during January 2010 survey

	Survey Site																										
Survey Date	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**7B**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**KE18**	**KE18 Up mast**	**CAM 2**
12/01/10											**219 H**	**473**	**282**	**460 H**													
13/01/10										**141 H**					**439 H**	**99**	**40**										
14/01/10																		**471 H**	**692 H**	**626**	**566**						
18/01/10							**46 H**	**164**														**151 H**	**23**				

H= harp

Appendix 5. Number of bat call files recorded during December 2010 survey

	Survey Site																										
Survey Date	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**7B**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**KE 18**	**KE18 Up mast**	**CAM 2**
13/12/10	**465 H**									**185 H**			**181**				**27**								**30**		
14/12/10	**162**									**78 H**			**95**				**47**							**H**	**22**		**13**
15/12/10	**291**									**(0) AnaBat Error H**							**45**							**H**	**5**	**4**	**59**
16/12/10	**180**									**100 H**							**20**							**H**	**15**	**2**	**269**

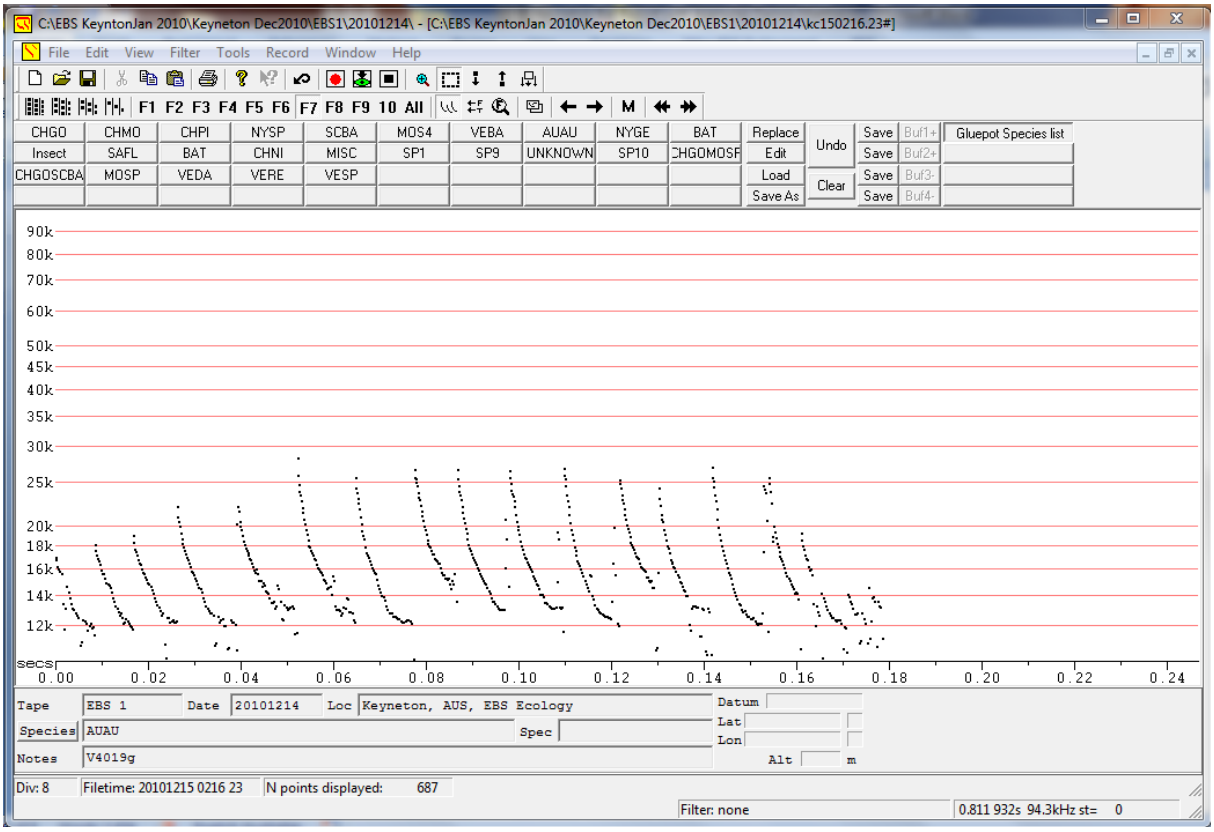
H=harp

Appendix 6- All sites Total calls

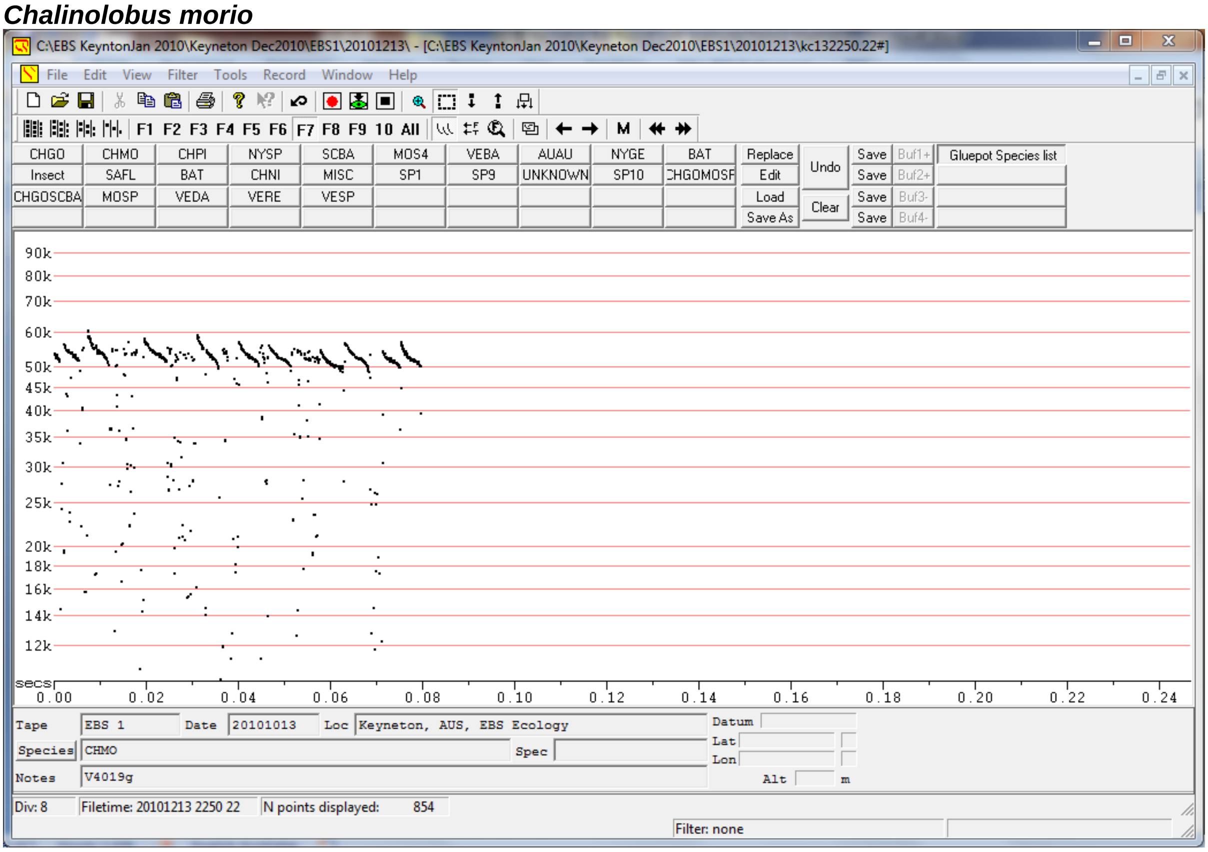
Site	Map ID	Nov 09 Survey 1 Total calls	Jan 2010 Survey 2 Total calls	Dec 2010 Survey 3 Total calls	*Dec 2010 Survey 3 Average calls per night at that site*	Overall Total per site
1	BAT1	59		1098	*274.5*	1157
2	BAT2	Harp trap only				
3	BAT3	337				337
4	BAT4	354				354
5	BAT5	Harp trap only				
6	BAT6	195				195
7	BAT7	2240	46			2286
7B	BAT7B		164			164
8	BAT8	2101				2101
9	BAT9	83	141	363	*121*	587
10	BAT10		219			219
11	BAT11		473			473
12	BAT12		282	276	*138*	558
13	BAT13		460			460
14	BAT14		439			439
15	BAT15		99			99
16	BAT16		40	139	*34.75*	179
17	BAT17		471			471
18	BAT18		692			692
19	BAT19		626			626
20	BAT20		566			566
21	BAT21		151			151
22	BAT22		23			23
23	BAT23	Harp trap only				
KE18	KE18			72	*20.5*	72
KE-up mast	KE-up mast			6	*3*	6
CAM2	CAM2			341	*113.66*	341
Total calls per survey		**5370**	**4892**	**2295**	**-**	**12557**
Detector nights		**8**	**16**	**23**	**-**	**47**
Average calls per detector night		**671**	**306**	**100**	**-**	**267**

Appendix 7 Example calls from the survey for each species recorded.

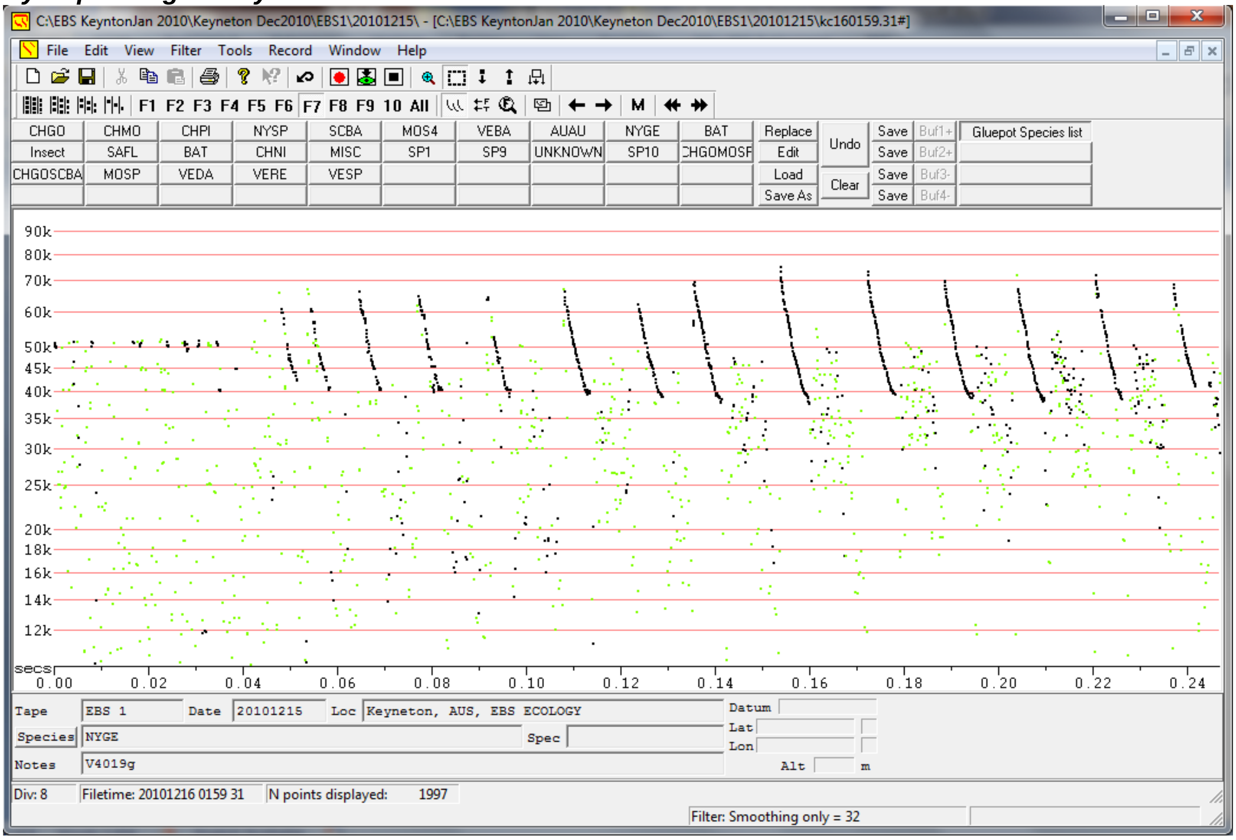
Austronomus australis



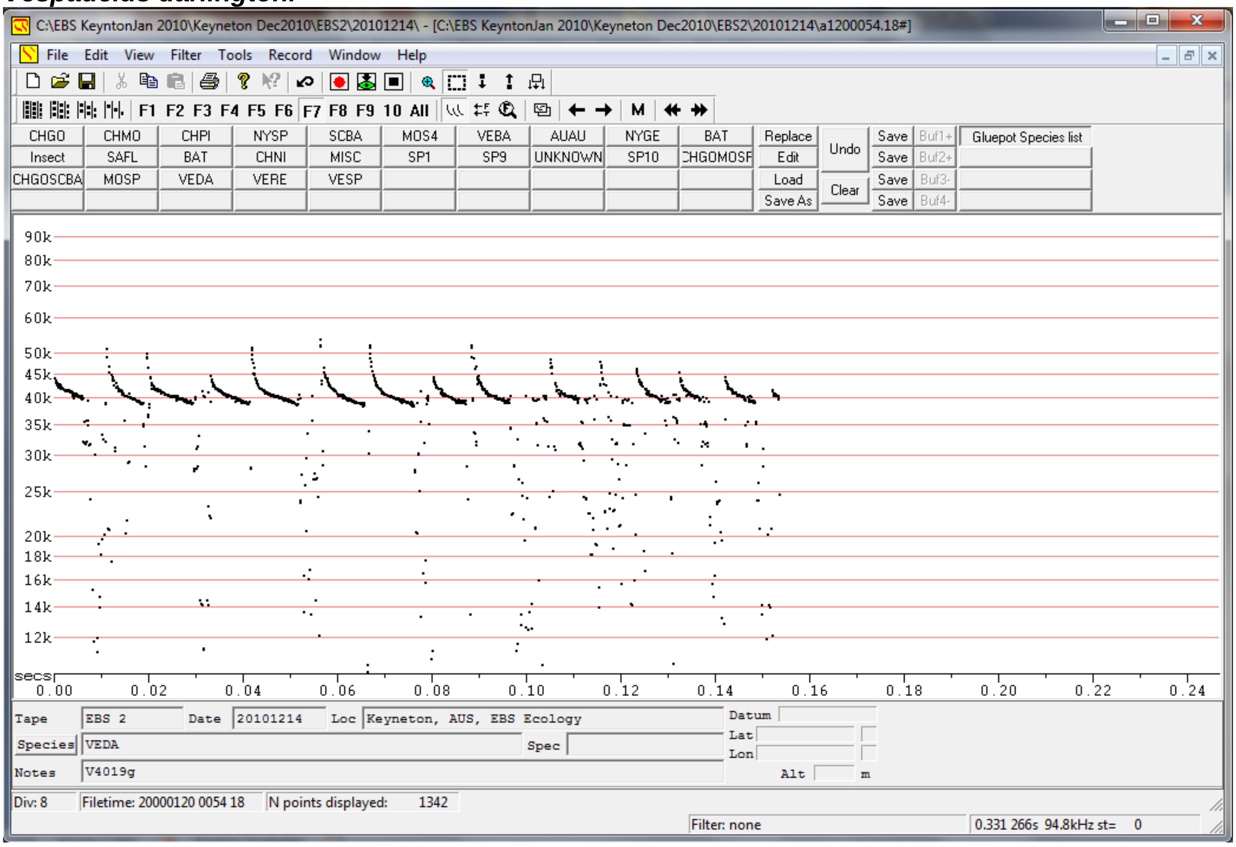
Chalinolobus morio



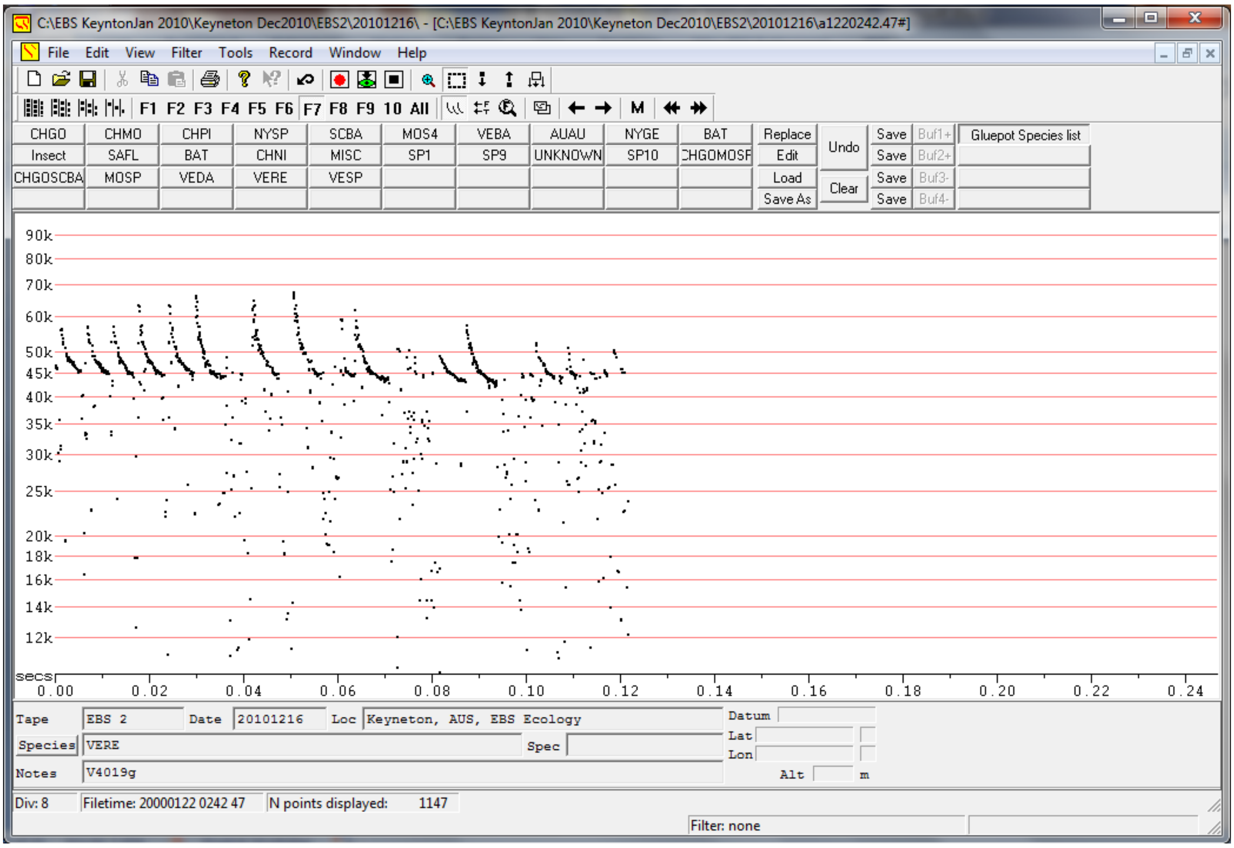
Nyctophilus geoffroyi



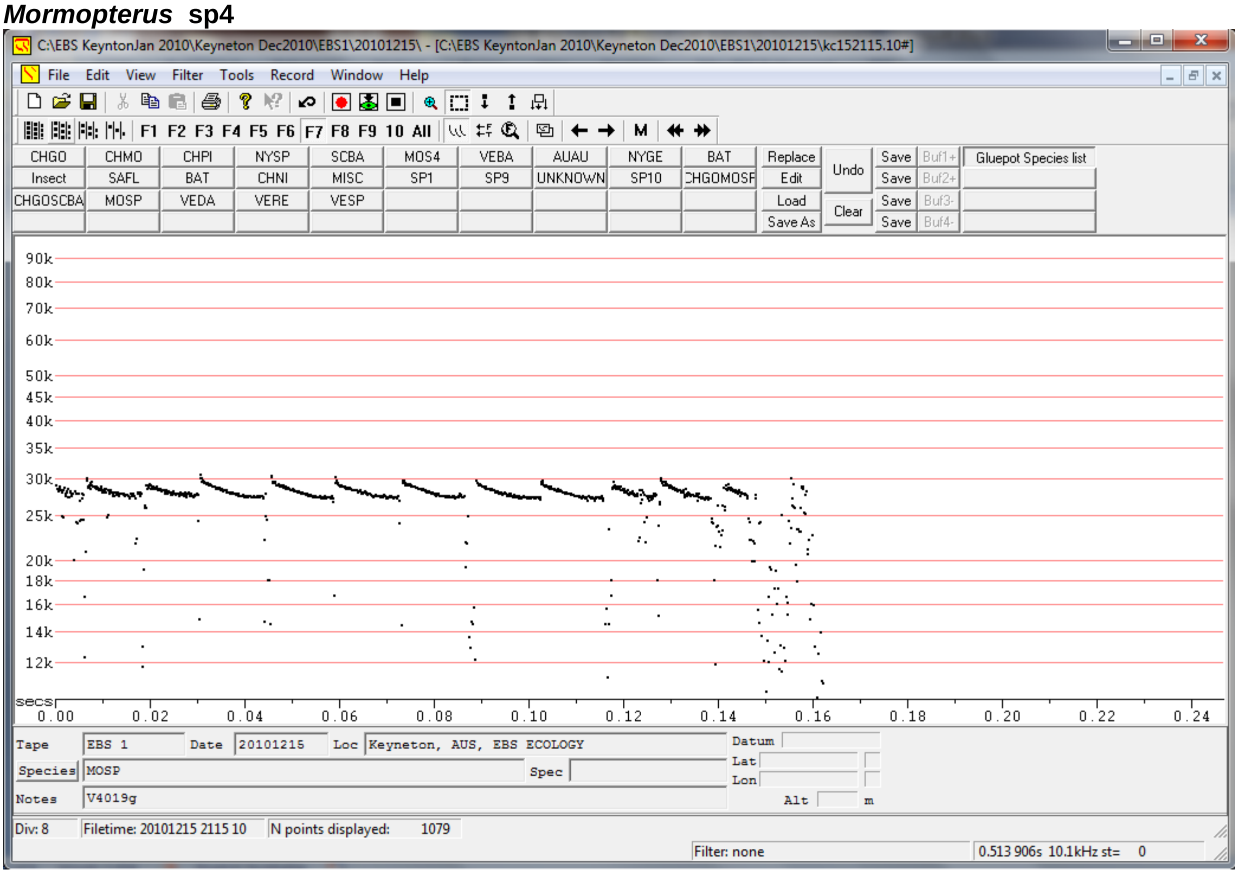
Vespadelus darlingtoni



Vespadelus regulus



***Mormopterus* sp4**



EBS Ecology
4/48 Barwell Avenue
Kurralta Park, SA 5037
www.ebsecology.com.au
t. 08 7127 5607
f. 08 8297 3768