Appendix 19

Mount Emerald Wind Farm – EIS – *Dasyurus hallucatus* Habitat Utilisation Study

Prepared by RPS

Mount Emerald Wind Farm – EIS

Dasyurus hallucatus Habitat Utilisation Study

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1.0 Introduction

1.1 Background

The proposed Mount Emerald Wind Farm (MEWF) project consists of construction and operation of a wind farm located approximately 20km SSW of Mareeba on the Atherton Tablelands including of approximately 63 wind turbines, associated access tracks and an electricity substation that will feed into the main electricity grid (the Chalumbin – Woree transmission line). The general characteristics of wind turbines being considered include the following:

- Upwind pointing horizontal axis wind turbine;
- Three-bladed design with blade lengths between 50m and 54m (100m to 108m diameter);
- Turbine capacity of approximately 3.0mw;
- Cylindrical steel towers providing a hub height of 78m to 80m;
- Blade length of approximately 50m; and
- Total height to blade tip between 130m and 134m.

This project is intended to supply approximately 500,000 megawatt hours which should supply sufficient renewable energy to power the equivalent annual needs of approximately 75,000 North Queensland homes over a 20 year period. The site has been selected primarily as it displays an excellent wind resource, there are few residences in close proximity to the site, and the site is traversed by existing Powerlink transmission line infrastructure (providing ease of connection).

1.2 Site Description

The wind farm project site, hereafter referred to as the “site” or “project area” is a single rural property, formerly described as Lot 7 on Plan SP235244, and covering an area of approximately 2422 ha (**Figure 1**).

The site is situated at the northern most end of the Herberton Range, which forms part of the Great Dividing Range. The site varies in altitude from 540 m ASL at the northern-most point along Kippen Drive to 1089 m ASL in the south-eastern most section closest to Mt Emerald. The north-western section of the site is dominated by Walsh’s Bluff (907 m ASL) (**Figure 1**).

The site is dominated by a series of three, approximately parallel high rhyolite ridges running in a south-east to north-west direction. There is a large area (~500 ha) of relatively flat country located in the western section. The site is dissected by a series of steep rocky ephemeral drainage lines and gorges, including the headwaters of a tributary of Granite Creek (**Figure 1**).

The site is intersected by a 5-10 m wide, 6.7 km long access track for Powerlink’s Chalumbin to Woree 275 kV transmission line that roughly traverses the property. Two other vehicle tracks, 750 m and 2.95 km in length respectively, connect the two test wind towers with the main power line access track (**Figure 1**).

The site is not currently grazed by domestic stock and aside from the cleared areas of access tracks and test wind monitoring tower pads, consists entirely of remnant vegetation. The site is located on the boundary of the Einasleigh Uplands and the Wet Tropics Bioregions, both of which are characterized by high levels of bioregional endemic flora and fauna species.

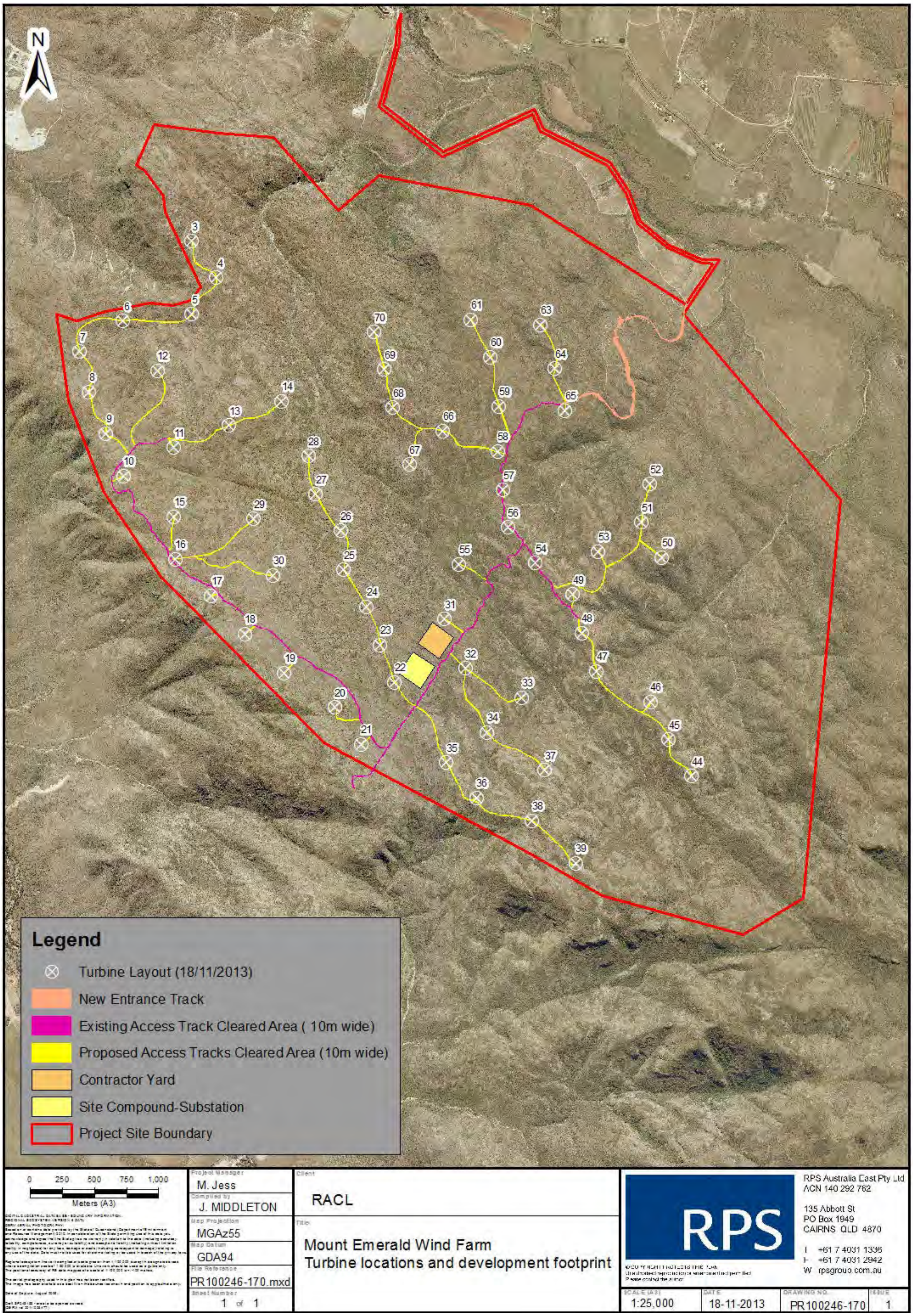

Figure 1 Development Footprint

1.2.2 Previous Surveys

Northern Quolls (*Dasyurus hallucatus*) are listed as a critically endangered under the EPBC Act. The species was first confirmed on the proposed Mt Emerald Wind Farm site in May 2011 (when a single scat was discovered in the vicinity of proposed Turbine 35 (previously Turbine 30) (RPS 2011). Following this detection, an intensive, large-scale camera trapping survey was conducted across the project site in June 2011, targeting ridge habitats, where the majority of turbines are proposed to be located, and creek lines (non-impact areas). The objective of the survey was to assess the broad habitat preferences of the species and to trial the use of camera traps to estimate population size through the identification of individuals by their unique spot patterns. The results of this survey indicated that the project site supported a substantial population, although it was not possible at the time to quantify the number of individuals from spot-pattern recognition due to limited resources. The camera trapping survey indicated that *D. hallucatus* were widely distributed across both ridge and creek line habitats at the time of the survey.

1.2.3 Study Scope

The objective of this study was to examine the spatial and temporal fine-scale habitat utilisation of *D. hallucatus* on the project site to assist with assessing the likely impact of the project on the local population. This information would also be used to to develop effective and feasible management strategies to avoid and/or reduce impacts of the project on the local population,particularly during breeding periods that overlap with the construction phase.

Oakwood's (1997) study of the ecology of Northern Quolls in lowland tropical savannah at Kakadu National Park, Northern Territory showed that females display marked seasonal variation in den site habitat selection, with a preference for rocky areas during the non-breeding season and open forest habitats during the breeding season. Females were found to den in rocky areas more frequently than males and those females whose home ranges contained a greater proportion of rocky habitat were likely to live longer and therefore experience greater lifetime reproductive success (Oakwood, 1997).

The small body weight of *D. hallucatus* (300-1000 g) precluded the use of satellite or GPS temeletry to examine fine-scale habitat utilisation at the time of the study design (October 2011), and therefore the only option to collect fine scale habitat utilisation data over a long-period (at least 7-9 months) was VHF radio telemetry. However, the rugged topography of the site and the requirement to collect accurate position locations over a long period meant that traditional methods of obtaining position fixes of active animals using manual triangulation were considered to be unfeasible. It was decided to examine the effectiveness of an automated radio-telemtry system (ARTS) (Kays *et al.,* 2011; Ward *et al.,* 2013) which had been demonstrated to be effective on a wide range of species in tropical conditions.

The survey methods used in the study are described in the following section.

2.0 Methods

2.1 Live-trapping

A trapping survey was completed between the 5th February 2013 and the 23rd August 2013 and is summarised below in **Table 1**.

Table 1 Summary of Trapping Effort

Live-trap Types	Trap Lines	No. Traps	Start Date	End Date	Duration (days)	Trap Nights
Elliots	A, B, C lines	116	5/02/2013	11/02/2013	6	696
Wire Cages	A & C lines	28	13/05/2013	17/05/2013	4	112
Wire Cages	G	50	11/06/2013	15/06/2013	4	200
Elliots	D	30	20/03/2013	22/03/2013	3	90
Elliots	E	30	21/03/2013	22/03/2013	2	60
Elliots	F	30	27/03/2013	28/03/2013	2	60
Wire Cages	K	47	16/07/2013	18/07/2013	3	141
		56	23/07/2013	24/07/2013	2	112
		56	19/08/2013	23/08/2013	4	224
					TOTAL	**1,695**

2.1.2 Targeted Juvenile Trapping (February – April 2012)

Live-trapping to specifically target juvenile quolls was conducted within the signal coverage area of the southern Automated Radio-Telemetry System (ARTS) site using type-A Elliot collapsible box-style treadle traps (Elliott Scientific, Upwey, Victoria).

Three trap lines were established, along a creek line (C-line: 30 traps), a vehicle track (B-line: 50 traps) and following the base of the western escarpment respectively (A-line: 25 traps) (**Figure 2**). Traps were spaced at ~20 m intervals and the locations marked and labelled with reflective tape to assist with location during the evening. All trap locations were recorded with a hand-held GPS.

Trapping was conducted for seven continuous nights between the 5th and 11th February 2013. Each day, traps were opened and baited with three chicken necks in the late afternoon (1600-1700) and checked three times per night at 3-4 hourly intervals (i.e. 2000-2200, 0000-0200, and 0300-0500). Traps were closed following the final early morning check prior to sunrise and rebaited the following afternoon. Traps were inserted within plastic bags during rainy conditions and dry leaves and grass provided for bedding material.

Each captured animal was fitted a radio-collar (juveniles with 1.5 g Holohill and adults >300 g with 15 g Sirtrack collars), photographed to assist with identification, and the following data was collected:

- Sex;
- Body weight;
- Head-body length;
- Pes (foot) length; and
- Tail length.

Up until June 2013, digital photographs were taken of the dorsal surface of each captured animal whilst it was held in a calico handling bag to assist with subsequent identification. From June to August 2013, each captured animal was placed within a 80 cm x 30 cm x 30 cm white plastic container and photographed to ensure that the images more closely resembled those captured with vertical mounted camera traps to enable survivorship to be calculated from future camera trapping based monitoring.

On the 7th February 2013, it was discovered that the Holohill elastic thread radio-collars (described in **Section 2.2.1**) had an intrinsic design flaw that caused the elastic thread to ratchet progressively tighter around the animal's neck resulting in deep abrasion injuries to the skin. Each collared juvenile was then recaptured and the the collars removed. Collars were then modified (expand the bore of the tube in the epoxy casing through which the elastic was threaded through and covering the elastic thread with heat shrink tubing so that it could not tighten) for future collaring to prevent further injuries to animals. Targeted den site trapping was continued until such time all collared juvenile animals were recaptured or the day time den site was no longer able to be located.

A single collared male (NQ-T4-1) was no longer able to be located by radio-tracking after the 14th March 2013 and an aerial search with a helicopter was undertaken. Additional trap lines were established in the vicinity of the remaining collared animals' day time den sites in an attempt to recapture the animal and remove the faulty Holohill collar (**Figure 2**);

- D-line, consisting of 30 Elliot traps spaced at 20 m intervals was set on the 20th March 2013 and trapping was conducted for three consecutive nights.
- E–line, consisting of 30 Elliot traps spaced at 20 m intervals was established on the 21st March 2013 and trapping was conducted for two consecutive nights.
- F-line, consisting of 30 Elliots spaced at 20 m intervals was established on the 27th March 2013 and trapping was conducted for two consecutive nights.

In addition to the targeted Elliot trapping, a total of five Reconyx HC550 visible flash camera traps were set in the vicinity of the last known day time den site location between the 22nd March and 16th May 2013 to determine whether the individual was still active in the area. The cameras were set in a vertical orientation, attached to a tree at ~90 cm above the ground with an angle bracket and baited with chicken necks placed within a bait holder affixed to the ground directly beneath the camera. Following the detection of animal NQ-T4-1 on the camera traps on the 16th May 2013, targeted trapping using wire cage traps was conducted along G-line as described below.

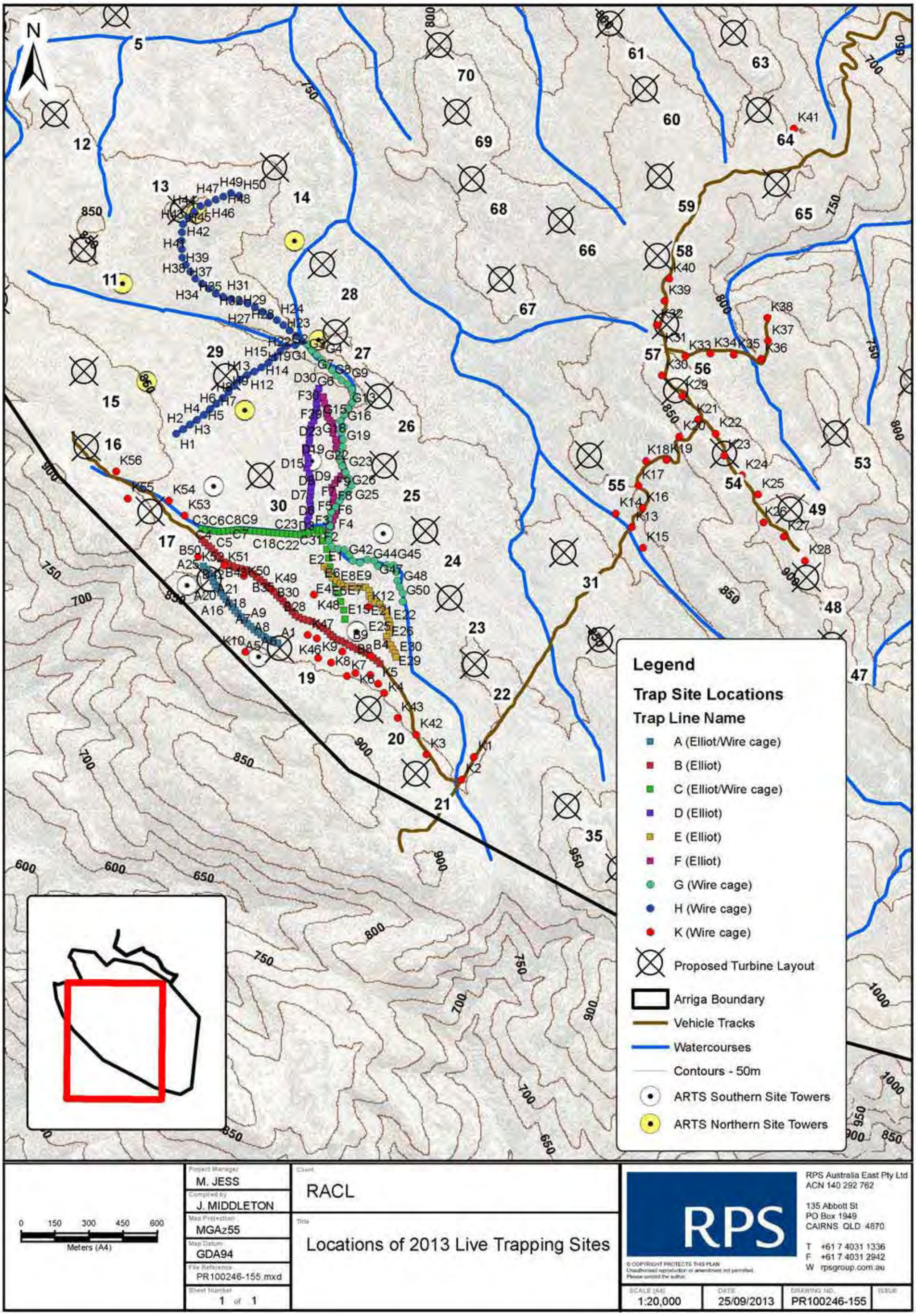

Figure 2 2013 Live Trapping Sites

2.1.3 Targeted Sub-adult/ Adult Trapping (May to August 2013)

Two lines of collapsible wire cage traps (15 cm x 15 cm x 45 cm, Mascott Wire Works, Homebush West, NSW) were established along the previous A and C-lines and consisted of 12 and 16 traps respectively, spaced at ~40 m intervals (2). Trapping was conducted for four consecutive nights from the 13th to the 17th May. A line of 50 collapsible wire cage traps was established along the major creek line transecting the eastern edge of the southern ARU site and heading N to the SW corner of the northern ARU site (G-line - 2). Traps were spaced at approximately 40 m intervals. Trapping was conducted for three consecutive nights from the 20th-22nd May 2013. A line of 50 wire cage traps, spaced at 40 m intervals was established within the northern ARTS site (H-line, 2). Traps were set for four consecutive nights from the 11th-15th June 2013 **(Figure 2).**

All cage traps along the A, C, G and H-lines were baited in the late afternoon with half a chicken frame and checked twice a night, between 2200-0000 hrs and 0400-0600 when the traps were closed until the following afternoon. All cages were covered in an inner layer of cut grass to provide bedding material and a water-proof outer layer of polyethylene film. All cage trap locations were marked and labelled with reflective tape to assist with locating them at night and their positions recorded with a hand-held GPS unit.

A total of 47 wire cage traps, spaced at approximately 100 m intervals were established immediately adjacent to vehicle tracks with the primary purpose of capturing animals for collaring both within the ARTS sites and along major ridges (K-line, 2). Trapping was conducted at the K-line trap for three consecutive nights between the 16th to the 18th July 2013. An additional nine traps were added to the K-line (total of 56 traps) and trapping was conducted for two consecutive nights between the 23rd and 24th July 2013 and for four consecutive nights between the 19th and 23rd August 2013 (**Figure 2**).Traps along the K-line were first baited during day-light hours, checked between 0530 and 1000 hr the following morning and rebaited if necessary (e.g. if bait had been eaten, removed or was too ant-infested). Traps were covered in a thick inner layer of cut grass for bedding and a water/windproof outer layer of polyethylene film. All cage trap locations were marked and labelled with reflective tape to assist with locating them at night and their positions recorded with a hand-held GPS unit.

2.2 Radio-tracking

2.2.1 Radio-collar Specifications

Few researchers have previously attempted to radio-track juvenile Northern Quolls, especially males due to their rapid growth rate (Teigan Cremon, PhD Candidate, USC, *pers. com*.). A total of twenty light weight (10 x 0.5 g & 10 x 1.5 g) Holohill VHF radio-collars with whip aerials were obtained for use on juvenile quolls. The transmitters were encased in epoxy, pulsed at 30 pulses/minute and the battery life was estimated to be 28 days for the 0.8 g units and 49 days for the 1.5 g units. The collar itself consisted of elastic thread (1.5 mm diameter on the 1.5 g units and 0.5 mm diameter on the 0.8 g units) secured by a knot through a tube attached to the epoxy case. The elastic thread collar was selected over leather or PVC collar materials in order to allow expansion. The 0.8 and 1.5 g packages were matched to juvenile individuals to ensure that they weighted no more than 3% of their body weight.

A total of 50 SIRTRACK VHF suede radio-collars with whip aerials (9 g) were obtained for use on adult quolls with body weights exceeding 300g. The transmitters were encased in epoxy, pulsed at 30 pulses per minute and battery life was estimated to be 234 days. The Sirtrack collars were matched to individuals to ensure that they weighted no more than 5% of their body weight i.e. minimum body weight of 300 g. The actual material consisted of soft suede cut to size and secured with a nylon nut and bolt, which once tightened, was then covered in head shrink to reduce skin abrasion. After periods of rainfall or heavy dew, the suede material of some of the Sirtrack collars on recaptured animals was found to have stretched and required readjustment. The detection range of the Sirtrack and Holohill radio-collar transmitter signals was stated by the manufacturers to be approximately 1000 m. The pulse width and pulse interval of all of the radio-transmitters was independently measured by using an oscilloscope (Austek, Cairns).

Following the recapture of the juveniles injured by the Holohill collar, it was decided to immediately cease collaring until May 2013 (to continue collaring with the Sirtrack permanent suede collars) when animals had approached their adult body weight and their neck circumference growth had slowed or ceased.

2.2.2 Radio-tracking with the Automated Radio Telemetry System (ARTS)

The use of traditional radio-tracking methods (i.e. triangulation using hand-held yagis and radio-receivers) to quantify night-time movements and fine-scale habitat usage of a sufficient sample size of Northern Quolls was not feasible for a number of reasons, but in particular due to the sites exensively rugged terrain (83% of slopes over 15^o) and human health and safety.

An alternative tracking method was devised, in consultation with Scott Burnett (USC), to use an automated radio telemetry system (ARTS) similar to that used by Crofoot *et al.* (2010), Kays *et al.* (2011) and Ward *et al.* (2013). ARTS systems use multiple directional antennas for each receiver and rely on differences in signal strength to detect movement and to estimate an animal's location (Ward *et al*., 2013). These studies identified that when an animal was within the range of three or more antenna array towers, its location could be estimated through triangulation. According to White (1985), the optimal spatial arrangement for six radio-detection towers is for them to be arranged equidistantly around a circle with a diameter equal to the detection range of the radio-transmitters, assumed to be approximately 1000 m (**Figure 5** and **Figure 5).**

Locations where at least one *D. hallucatus* were determined by camera trapping in July-August 2011 were identified (**Figure 3**). View-shed analysis using Global Mapper ver. 14.0.3 (Blue Marble Geographics) was used to examine various positions of the optimal ARTS tower set-up with the tower height set at 6 m and using a 5 m digital elevation model of the study site within the areas of high *D. hallucatus* abundance. The areas of overlapping tower coverage were calculated and visualised with ARGIS 10.1 (ESRI, 2012). Locations were chosen so as to maximise the total detection area covered by three or more antenna array towers.

The final locations of the two selected ARTS sites are shown in **Figure 4** and **Figure 5**. Both ARTS sites included ridge habitats where turbines are proposed to be located and creek lines as both habitats have been shown to be important for *D. hallucatus* at different times of the year in tropical savannah (Oakwood, 1997). The total area where triangulated fixes were possible (visible by three or more towers) within the northern and southern ARTS sites was approximately 115 ha and 149 ha respectively, based on a 900 m detection range for each tower (**Figure 5** and **Figure 5**).

Due to the remote and rugged nature of the site, the lack of vehicle tracks in the vicinity of the selected areas and the size and weight of the tower and antenna equipment, a helicopter was used to sling in the equipment to the nearest suitable landing area. The towers were erected in December 2012. Each radio-receiver array tower comprised a four m tall galvanised metal pipe (50 mm diameter) attached to a one m long T-bar with an attachment to fit a three m long jenny-bar to assist with the raising and lowering the tower (**Plate 1**). The T-bar was secured to the ground with U-brackets screwed into rock. When erect, the tower was stabilised by four guy wires (four m wire rope) attached to the tower at four m above the ground and affixed to the ground using star-pickets or rock bolts.

Each tower supported six horizontally oriented yagi antennas (Sparrow Systems) arranged with their azimuth directions separated by 60° to give 360° coverage (**Plate 1**). A Bantam automated receiving unit (ARU) (Sparrow Systems) was connected to the antenna array on top of the tower by coaxial cables. The ARUs were located within a water-proof enclosure located at the base of the tower and shaded from direct sun using air-cell aluminised bubble-wrap roof insulation as the unit's ability to lock onto the radio-signal is highly sensitive to temperature (Jim Cochran, pers. comm.).

Each Bantam ARU was programmed to tune to the radio frequency of each transmitter and record the signal strengths (in dB) from each of the 36 yagi antennas at intervals of 15 minutes. The search interval is programmed using custom software (provided by the manufacturer) as a text file on a standard secure digital (SD) card. An ARU can store two gigabytes of data on its SD card. Data was collected from each ARU unit on average every 14-20 days by replacing the SD card and downloading data onto a ruggedized tablet. Power for each ARU was provided by a 12- volt deep cycle marine battery powered by a 30W solar panel. At each initialisation, the internal clocks of each ARU unit had to be synchronised to ensure that all units tuned to the correct frequency at the same time. A detailed description of the method used to estimate signal bearings from data obtained from an ARU and a six antenna array is provided in Kays *et al.* (2011).

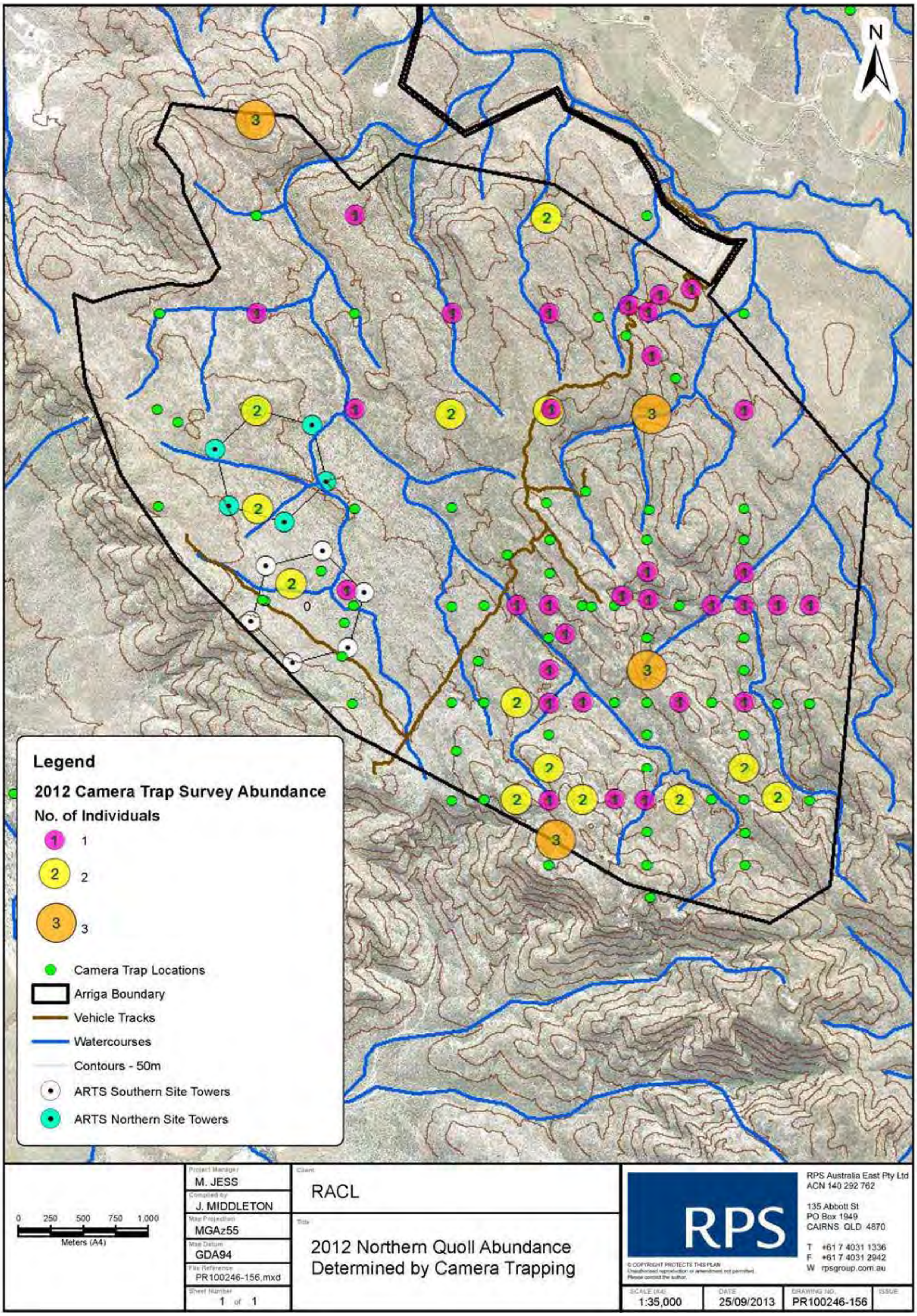

Figure 3 ***D. hallucatus*** **Abundance from 2012 Camera Trapping Study and 2013 ARTS site locations**

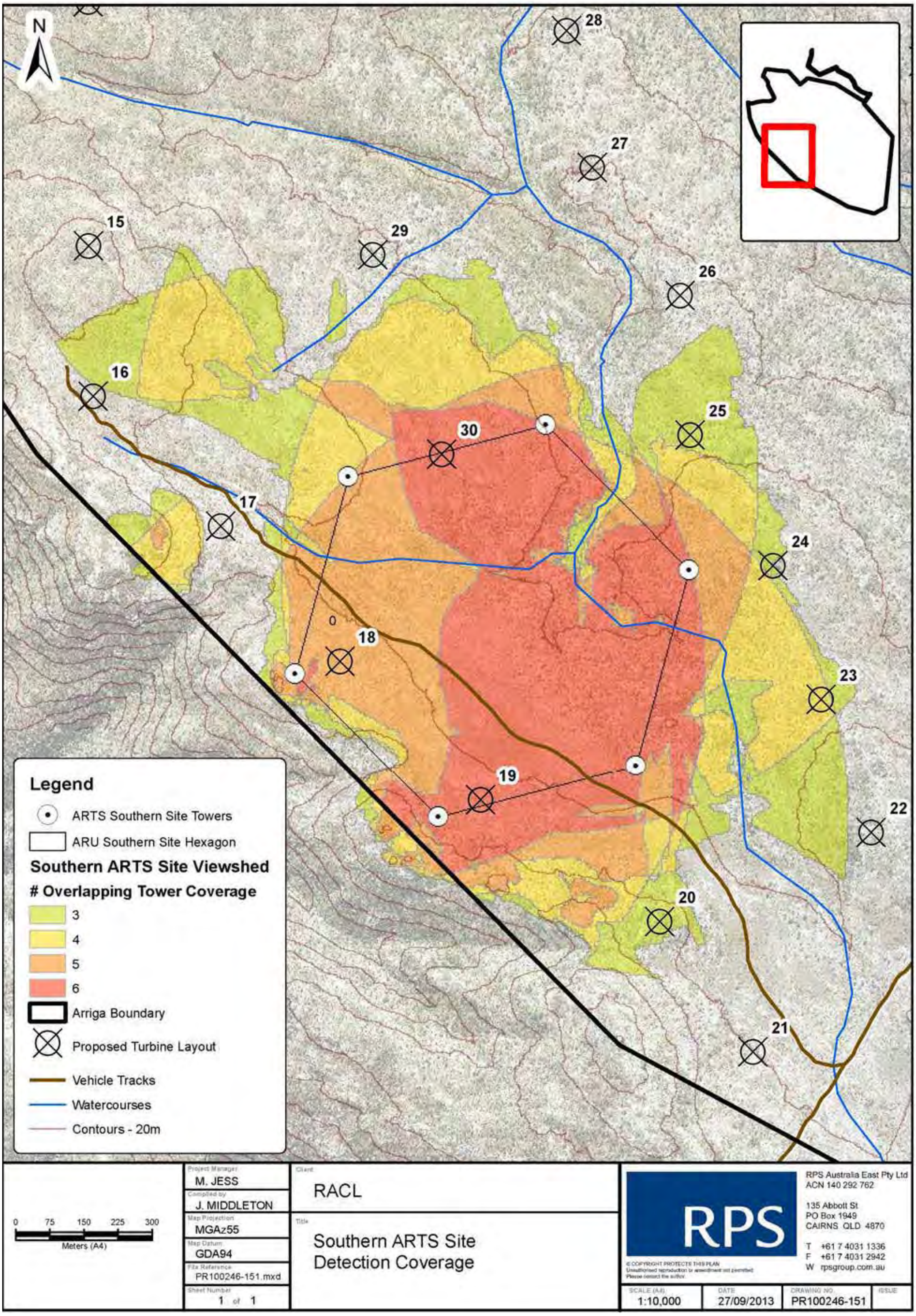

Figure 4 Southern ARTS Detection Coverage Area

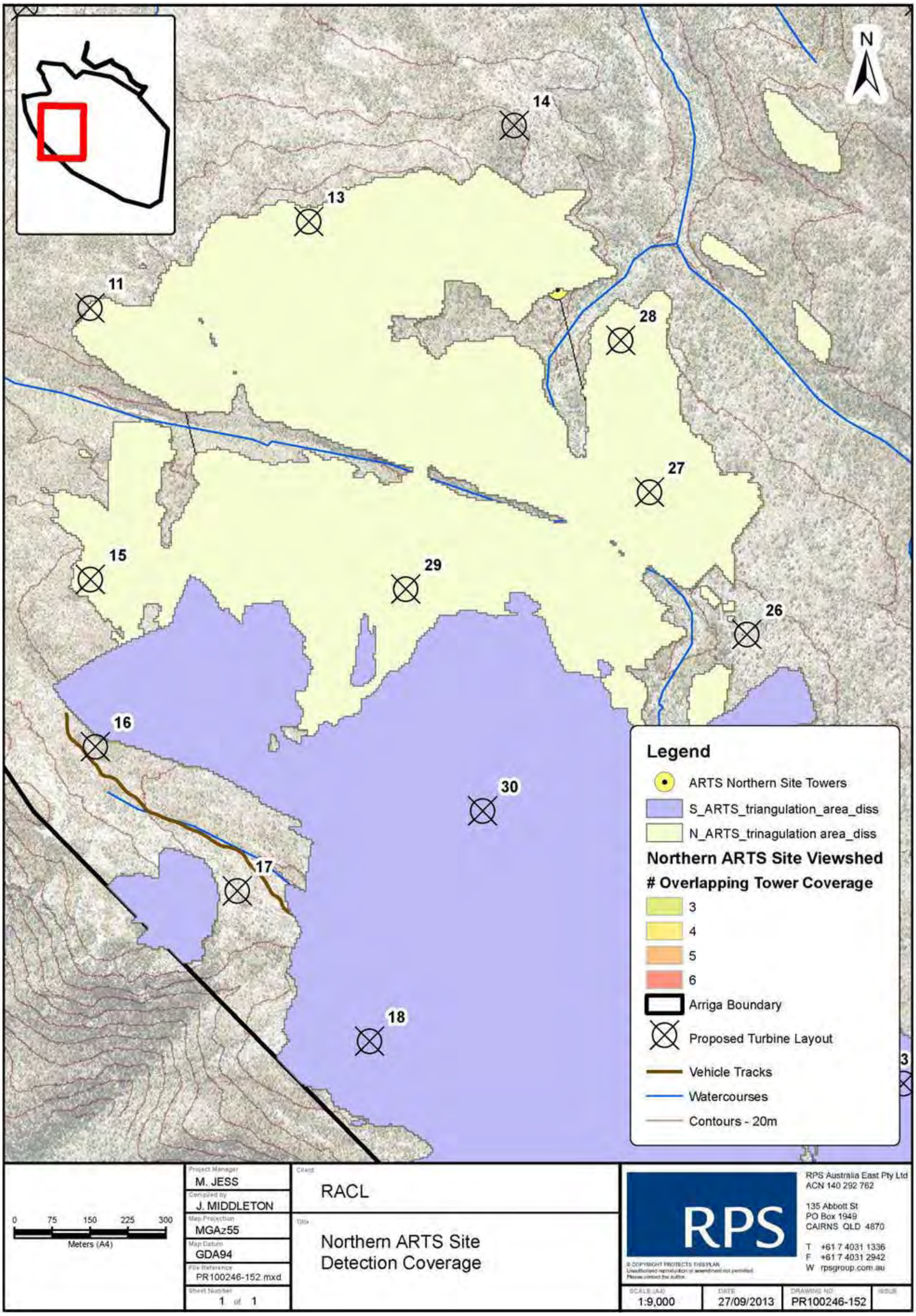

Figure 5 Northern ARTS Site Radio Coverage Area

Plate 1 ARTS Tower Prior to Erection

It was initially proposed to relocate the yagi arrays and ARU units between the southern and northern ARTS sites approximately every two weeks to maximise the spatial coverage. However, it became apparent after the initial set-up of the antenna arrays and ARU at the southern ARTS site in January 2013, that it would be more cost efficient to purchase another 36 yagi antennas for the northern ARTS site and simply transfer the

ARU units between the sites rather than having to lower the towers, dismantle the yagis, transport them up to 1 km on foot over uneven rocky terrain to the new sites, lowering the new towers, reassemble and attach the yagis and coaxial cables, raise the towers and tension the guy wires and remeasure the new antenna bearings twice every two weeks (estimated cost $26,000/month). The periods the ARU units were deployed at each of the two ARTS sites is shown in **Table 2**.

The bearing direction of the #1 and # 4 yagi antennas was determined by attaching a 2 kg plumb bob to 5 m long cords affixed to the main elements of the two yagis, then sighting between the two vertical lines made by the cords with a Suunto KB-77 hand-bearing compass.

Table 2 ARTS Sites Survey Periods

ARTS Site	Deployment Dates
Northern Site	26/6/13 TO 15/7/2013
Southern Site	30/1/13 TO 8/2/13; 24/4/13 TO 28/5/13; 17/7/13 TO 8/8/13

The *BantamView* software that was provided with the purchase of ARU units did not have a user's manual (the original programmer failed to complete a manual and then the funding for the development of the software was discontinued) nor was any software support available from the manufacturer (Jim Cochran, Sparrow Systems) to assist with the extraction of locations from the ARU signal strength data using this software. Therefore, the signal strength data from the ARU units recorded on the southern ARTS site was send to Michael Ward (University of Illinois) who has been engaged by Sparrow Systems since July 2013 to develop ARU data analysis software using *R* (freeware statistical software http://www.r-project.org/). Michael Ward has extensive experience with the use of the Bantam ARU units for automated radio-tracking of snakes and birds (see Ward *et al*., 2013).

A test transmitter beacon (150.2700 KHz) was attached to a tree with a cable tie at a height of ~ 2 m above the ground at c. 326853 8100367 on the 16/7/13 to assist estimating the spatial error of the location fixes obtained by the ARU units.

2.2.3 Day-time Den Site Radio-tracking

To assist with validating the position locations of collared animals obtained using the automated radio-telemetry system, and to quantify den site characteristics, all day time den sites were manually located with the use of a Titley Electronics Australis K2600 receiver and a hand-held collapsible yagi antennae during the following periods: 6-15/2/13; 18-22/2/13; 25-28/2/13; 1/3/2013; 6/3/2013; 12/3/13 to 14/3/13; 18- 20/3/13; 14-16/5/2013; 21/5/13; 17-19/6/13; 27/6/13; 16/7/2013; 22-24/7/13; 8/8/13; 22-23/8/13; 28/8/13; 30/8/13; 2/9/13; 4/9/13; 6/9/13; 9/9/13.

Triangulation methods were frequently used to determine the general location of resting animals during day-light hours. Once the approximate general location was established by triangulation, the exact location of the day time den sites was determined by walking-in and isolating their collar signal to a specific structure (e.g. hollow log, rock pile etc). Where possible, each den site was investigated with a burrow-scope or directly with the aid of a torch to determine whether the collar was still attached to a living animal (**Plate 2**).

Although it was demonstrated that some radio-signals could be detected on foot from distances of up to 1.8 – 2 km when positioned on high ridges, the detection range for the majority of the collars was much more constrained, especially if the animals were denning in rugged rocky gullies, underneath the ground or within rock piles. Many of the collared animals were not able to be detected within several days of their first capture

Each den site was marked and labelled (collar frequency, date and time) with pink fluorescent survey tape, photographs taken of the den site and the surrounding area (one photo at each cardinal point) and a description of the location and type of den site recorded (e.g. in dead standing *Eucalyptus reducta* with a d.b.h of 30 cm, ~ three m above the ground; under rock slab uplifted by *Callitris intratropica*). Den sites were classified into four general microhabitats:

- Beneath ground (e.g. burnt out root hollow);
- Hollow log on ground;
- Hollow standing tree (live or dead); and
- Rock fissure (e.g. beneath rock slab/boulder pile, within rock crevasse etc)

Determination of the approximate locations of active collared animals that were unable to be located on foot was also attempted from the air using a helicopter on the 20th March, 17th June and 21st August 2013. Although it was difficult to obtain accurate locations, the general vicinity could be determined and followed-up with ground-based searching.

Plate 2 Adult male *D. hallucatus* NQ-T5-7 in day time den located under a large horizontal rock slab on 23rd August 2013.

3.0 Results

3.1 Live-trapping

A total of 26 individual *D. hallucatus* were captured between the 6th February and the 21st August 2013. Of these 26 individuals, five were females.

All males that were captured had descended testes. On the basis of body weight and general condition, it is likely that all of the captured males were less than one year old.

A female (NQ-T1-6) weighing 620 g was captured on the 10th February 2013 and it is likely this individual was greater than 1 year in age as it possessed an enlarged stained pouch. All of the remaining females that were captured between February and August 2013 were likely to have been less than a year old (based on their body weight and pouch condition). A female (NQ-T5-1) weighing 575 g was captured on the 16th July 2013 and possessed a stained pouch and slightly enlarged nipples indicated it was approaching breeding condition. When NQ-T5-1 was recaptured on the 23rd August 2013, six hairless young (~10 mm head-body length) were present in the pouch (**Plate 3**).

None of the males that were trapped between July 2013 and August 2013, after the first female that appeared to be in breeding condition was captured, showed any obvious signs of reduced condition (e.g. sores, thinning or loss of hair etc) characteristic of the males towards the end of the breeding season.

3.2 Day-time Denning Sites

A total of 146 day time locations of collared Northern Quolls were located on foot during the study period (February to August 2013). It was assumed that these locations represented day time den sites; however it was only possible to confirm the presence of the living animal in a few cases. An additional three day-time fixes for three animals were obtained only from a helicopter on the 17th June 2013, however the spatial accuracy of these fixes was not able to be confirmed as they were located in remote rugged section in the northwest of the site and were not able to be checked on foot.

The duration between successive fixes varied considerably between individuals as not all individuals could be located on every radio-tracking attempt

The location of day time dens was undertaken most frequently during February 2012 because the Holohill collars that were deployed had a limited battery life (27-49 days depending on the unit size) and also, after it was discovered the collars were causing injuries to the animals, the locations had to be determined every day until such time as the animal was recaptured or the signal was not able to be found.

Limited ground-based manual radio-tracking was undertaken between the 21st March and the 13th May 2013 as only two individuals (female NQ-T1-6 and male NQ-T1-4) remained collared and neither was able to be located on foot despite intensive searching throughout the site.

Despite Sirtrack indicating that the radio-collar only had a range of up to 1000 m, it was possible to detect the signal of a test beacon (150.2700 Hz) up to two km from some elevation vantage points.

The location of the day time den sites for all of the collared juvenile males (5), adult males (14) and adult females (4) and as determined by manual radio-tracking are shown in **Figure 6**; **Figure 7** & **Figure 8** respectively.

The average and median number of day time den site locations obtained for all collared animals was five and four sites respectively (**Table 3**).

The periods over which den sites were located for all of the collared animals are shown in **Table 3**. The mean and median duration of the period over which all collared animals den sites were located was 30 days and 28 days respectively (n=19 animals).

Table 3 Day-time Den Site Summary Table

Quoll ID	Sex/ Estimated Age	Date First Collared	Date First Den Site Obtained	Date Last Den Site Obtained	Duration Between 1st & Last Fixes (days)	Number of Fixes Obtained	Number of Unique Den Sites Located
NQ-T1-1	M/juvenile	6/2/13	6/2/13	18/3/13	42	16	10
NQ-T1-2	M/juvenile	6/2/13	8/2/13	27/2/13	19	13	3
NQ-T1-3	M/juvenile	6/2/13	7/2/13	11/2/13	4	6	3
NQ-T1-4	M/juvenile	6/2/13	7/02/13	14/3/13	37	21	13
NQ-T1-5	M/juvenile	8/2/13	8/2/3	19/3/13	41	16	9
NQ-T1-6	F/2nd year adult	8/2/13	8/2/13	17/6/13	129	22	14
NQ-T2-1	F/1st year adult	13/5/13	14/5/13	19/6/13	35	6	5
NQ-T2-2	M/1st year adult	21/5/13	17/6/13	27/6/13	10	3	2
NQ-T3-1	M/1st year adult	11/6/13	17/6/13	17/6/13	0	1	1
NQ-T3-2	M/1st year adult	12/6/13	17/6/13	19/6/13	2	2	2
NQ-T3-3	M/1st year adult	12/6/13	12/6/13	23/8/13	71	6	5
NQ-T3-5	M/1st year adult	12/6/13	14/6/13	27/6/13	13	4	2
NQ-T4-2	F/1st year adult	11/7/13	16/7/13	8/8/13	22	4	2
NQ-T5-1	F/1st year adult	16/7/13	23/7/13	20/9/13	57	12	8
NQ-T5-2	M/1st year adult	16/7/13	21/8/13	21/8/13	0	1	1
NQ-T5-7	M/1st year adult	18/7/13	20/8/13	20/9/13	30	7	6
NQ-T6-1	M/1st year adult	23/7/13	23/08/2013	23/08/13	0	1	1
NQ-T6-2	M/1st year adult	23/7/13	20/08/2013	20/09/13	30	5	4
NQ-T7-1	M/1st year adult	21/8/13	22/08/2013	20/09/13	28	7	4

Of the 153 day time den sites locations recorded by radio-tracking, 131 had microhabitat information recorded. The majority of den sites were located within rock fissures (64), followed by tree hollows (44), hollow fallen logs (14) and beneath the ground (2), although each individual showed significant variation in the selection of den microhabitats (**Table 4**).

Table 4 Den Site Microhabitat Types For Each Collared Individual

Quoll ID	Sex/Estimated Age	Microhabitat Type				Total
		Hole Under ground	Hollow Log	Hollow Tree	Rock Fissure	
NQ-T1-1	M/juv	1	4	2	9	**16**
NQ-T1-2	M/juv	0	1	9	3	**13**
NQ-T1-3	M/juv	0	0	3	3	**6**
NQ-T1-4	M/juv	0	0	7	12	**19**
NQ-T1-5	M/juv	0	0	0	10	**10**
NQ-T1-6	F/2nd year adult	1	3	10	5	**19**
NQ-T2-1	F/1st year adult	0	0	1	2	**3**
NQ-T2-2	M/1st year adult	0	0	2	0	**2**
NQ-T3-1	M/1st year adult*	0	0	0	0	**0**
NQ-T3-2	M/1st year adult	0	1	0	0	**1**
NQ-T3-3	M/1st year adult	0	0	0	1	**1**
NQ-T3-5	M/1st year adult	0	2	0	0	**2**
NQ-T4-2	F/1st year adult	0	0	0	3	**3**
NQ-T5-1	F/1st year adult	0	0	8	2	**10**
NQ-T5-2	M/1st year adult	0	0	0	0	**0**
NQ-T5-7	M/1st year adult	0	1	0	5	**6**
NQ-T6-1	M/1st year adult	0	1	0	0	**1**
NQ-T6-2	M/1st year adult	0	1	1	3	**5**
NQ-T7-1	M/1st year adult	0	0	1	6	**7**
	Grand Total	**2**	**14**	**44**	**64**	**124**

*Note: * denotes no description was recorded for this individual's one den site.*

3.2.2 Tracked Females

Radio-tracking revealed that the mean Euclidian distance between consecutive den sites (i.e. those used on successive days only) for the three individuals, NQ-T1-6, NQ-T2-1 and NQ-T5-1, between 8th February and the 24th July 2013 was 306 m (range = 0 m to 532 m, n=15). None of the den sites locations for female NQ-T4-2 were obtained on consecutive days.

The majority of den sites for females were located with hollow trees and rock fissures (refer **Table 4**).

NQ-T1-6 (2nd-year adult)

The second-year adult female, TQ-1-6, was first captured on 8th February 2013 and fitted with a Holohill 1.5 g which was then replaced with a permanent Sirtrack suede collar on the 10th February 2013.

Den sites were located for this female every 1-2 days between 8th February 1st March 2013 and then every 2-6 days up until the 14th March 2013. The final approximate den site location was determined from a helicopter on the 20th March 2013 (**Figure 6**) and no subsequent locations were obtained despite frequent (at least weekly) surveys.

The adult female denned in a variety of different microhabitats including in standing and fallen tree hollows, in rock piles and under rock slabs (**Figure 6**). During the period between the 8th to the 15th February when den sites were located every day, the mean Euclidian distance (i.e. the ordinary distance between two points that one would measure with a ruler), as opposed to the actual physical distance over the undulating landscape surface) that was moved between successive dens was 229 m (range = 0 m to 532 m, n=7) (**Figure 6**). A total of 14 unique den site locations were obtained for this individual by foot-based tracking. A single den site located 5 m above the ground in a large standing Eucalyptus tree at c. 3269801E 8101148N was used on seven separate occasions (**Table 3**; **Figure 6**). Only one other den site located in a hollow log on the ground at c. 327153E 8101485N was used twice. The remainder of the den sites for this individual that were located on foot were all used only once (**Figure 6**). During the period between the 18th and the 22nd February 2013 when den sites were located every day, the mean Euclidian distance that was moved between dens was 393 m (range = 373 m to 446 m, n = 4). The mean Euclidian distance moved between all den sites that were located on sequential days was 339 m (range = 0 m to 532 m, n = 12). The final located den site (17th June 2013 from helicopter) was approximately 3.4 km from the initial point of capture (**Figure 6**).

NQ-T2-1

This 1st-year female was first captured on the 13th May 2013 and was recaptured on seven other occasions between the 13/5/13 and the 21/5/13; often twice in a single evening. A total of five unique day time den sites were located on foot for this female between the 14th May 2013 and the 17th June 2013 (**Table 3**; **Figure 6**). The severed head of this female with the collar still attached and active was located on the 19/6/13 at c. 327248E 8100024N. The Euclidian distance beween the two den site located on consecutive days was ~167 m for this individual.

NQ-T4-2

This 1st year female was first captured on the 12th July 2013. Only two den sites were located for this individual, both within ~100 m of each other. This individual was tracked to a den site located underneath a fractured rock slab at the base of a *Callitris intratropica* tree near the top of a ridge at c. 326518E 8 099 793N on four occasions before on the 16th August 2013, the collar was retrieved having apparently fallen off (**Table 3**; **Figure 6**).

NQ-T5-1

This 1st year female was first captured on the 16th July 2013 at c. 328476E 8101047N and was tracked from the 23rd July 2013 until the 20th September 2013. On the 23rd August 2013, the individual was recaptured and found to have a total of 6 hairless pouch young (**Plate 3**). A total of nine day time den sites were located on foot for this individual (**Table 3**; **Figure 6**). One den site located in a live hollow standing eucalyptus was used on three separate occasions, and two dens located within dead standing hollow trees were used twice each (**Figure 6**). The Euclidian distance beween the two den site located on consecutive days was ~109 m.

Plate 3 Female*D. hallucatus* (NQ-T5-1) with 6 pouch young captured on 23/8/13

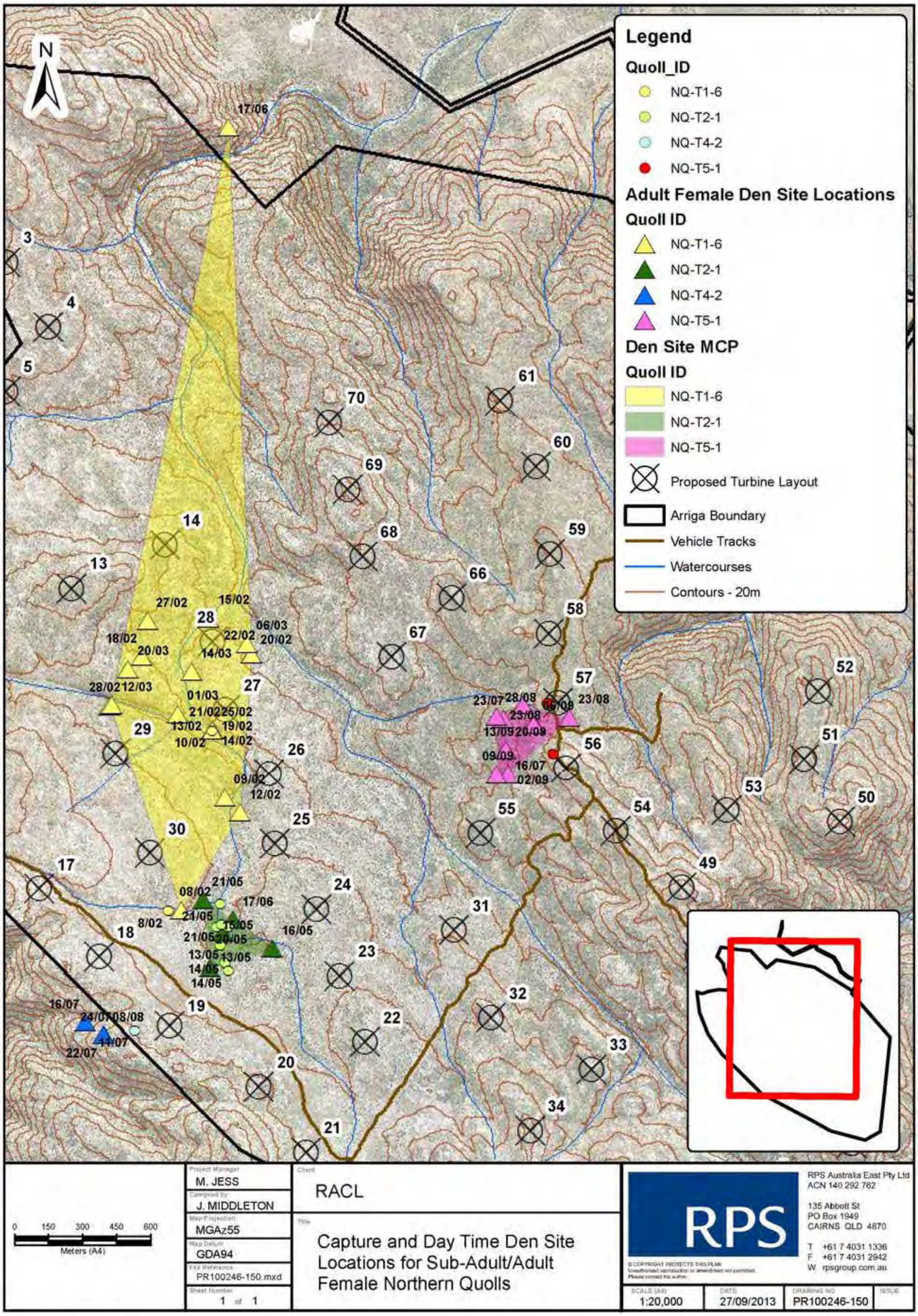

Figure 6 Capture and Day Time Den Site Locations for Sub-Adult/Adult Female Quolls.
MCP = minimum convex polygons

3.2.3 Tracked Juvenile Males

A total of five males were captured on the A, B & C Elliot-trap lines (**Figure 7**) and all were fitted with Holohill elastic thread collars between 6th and 14th February 2013. All five males were considered to be juveniles based on their body weights which were all below 400 g. All collared juvenile males were tracked to their day time dens until such time as they were recaptured and the collars removed or they were not longer able to be located.

NQ-T1-1

A total of 10 unique den site locations were recorded for this individual between the 6th February 2013 and the 18th March 2013, when it was recaptured at c. 327339E 8099976N and the collar removed. During the period the collar was fitted, the animal was tracked for four consecutive days between the 19th and the 22nd February and again between the 25-28th February. The mean Euclidian distance moved between the 19-22nd february was 329 m (range = 257 m to 364 m, n=3). The mean Euclidian distance moved between the 25-28th February was 78 m (range=52 m to 134 m, n=3).

NQ-T1-2

Only a total of four unique den site locations were obtained for this animal between the 8th and 27th February 2013 when the detached collar was located within a standing hollow tree at c. 326972 8099606N, the same location it had been since the 18th of February (**Figure 7**). It is not certain when exactly the collar was detached inside the den site.

NQ-T1-3

Only a total of four unique den sites were obtained for this animal between the 7th and 11th February, when the animal was recaptured in the vicinity of the den site located at c. 326994E 8100338N (**Figure 7**). The mean Euclidian distance between successive den sites for this individual during this period was 171 m (range = 23 m to 260 m, n=4).

NQ-T1-4

A total of 20 unique den sites were located for this individual between the 7th February and the 14th March (**Figure 7**). The mean Eucludian distance moved during this time was ~263 m (range = ~2 m to ~662 m). The maximum Euclidian distance moved between den sites on successive days was ~662 m.

NQ-T1-5

A total of 13 unique den sites were located for this individual between the 8th February and the 19th March 2013 (**Figure 7**). The mean Eucludian distance moved between these dates was ~147 m (range = 0 m to ~513 m). The maximum Euclidian distance moved between den sites on successive days was ~513 m.

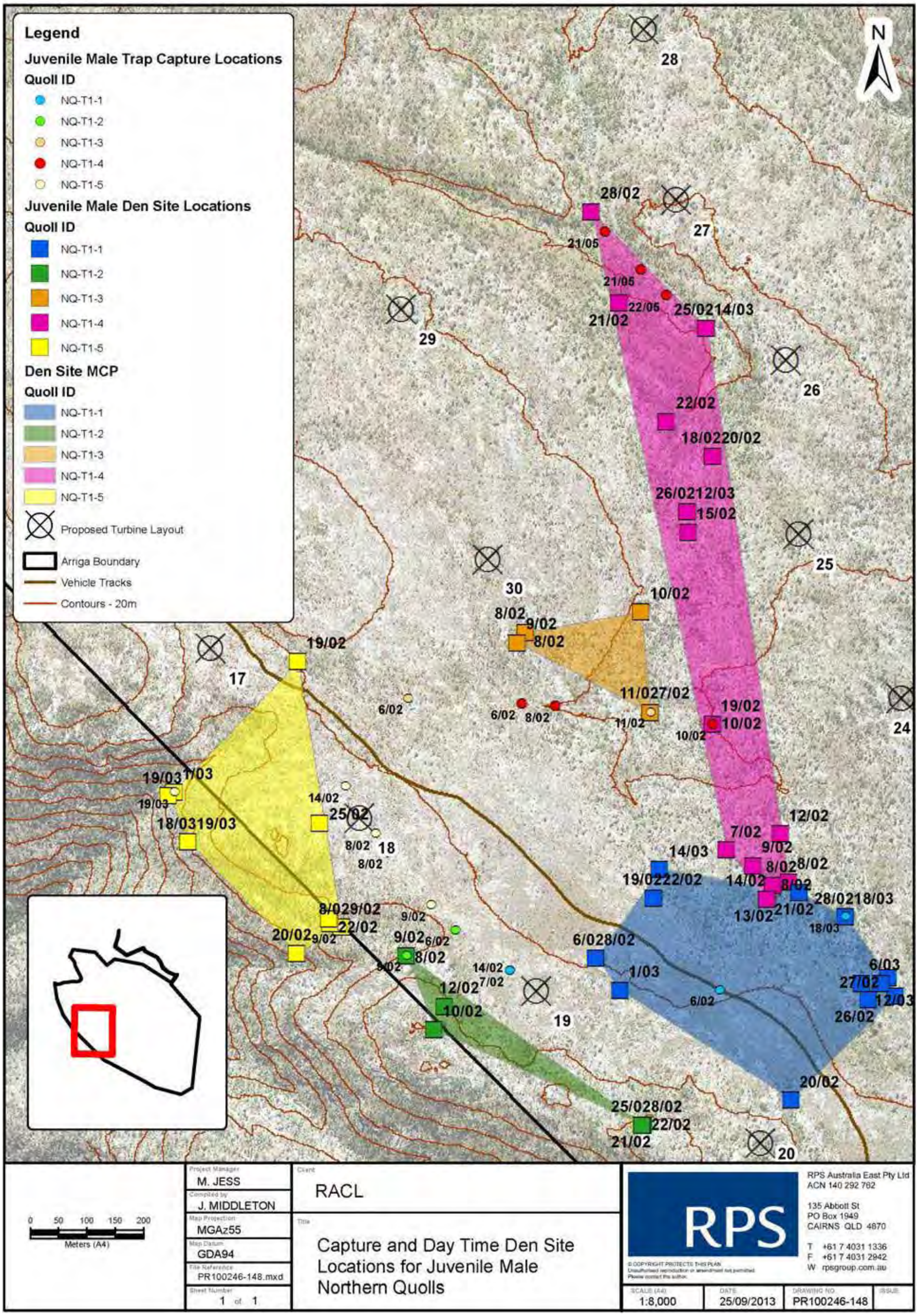

Figure 7 Capture and Day Time Den Site Locations for Juvenile Male Northern Quolls.
MCP = minimum convex polygons

3.2.4 Tracked Adult Males

No den sites were located on consecutive days for any of the collared adult male *D. hallucatus.*

NQ-T2-2

A total of two unique den site locations were recorded for this 1st year adult male between the 17th and 27th June 2013, although the animal was only tracked on three occasions (**Table 3**; **Figure 8**). Two of the fixes were recorded at the same den site (3-4 m above the ground within a hollow *Eucalyptus cloesiana*) eight days apart which may indicate that the collar had become detached. The two den sites were located approximately 753 m and 780 m from the location where the animal was captured on the 21st May 2013 (**Figure 8**). Both den sites for this animal were located in close proximity to creek lines (**Figure 8**). No further signal detections were recorded for this collared individual despite extensive searching on foot and by helicopter.

NQ-T3-1

Only a single den site located on the mid-slopes of a deep wide gully, approximately 1.2 km NNE of the initial capture point was recorded for this 1st year adult male (**Table 3**; **Figure 8**). The location was only approximate as it was detected from the air in a helicopter and time and resources did not permit the precise location to be confirmed on foot. No further signal detections were recorded for this collared individual despite extensive searching on foot and by helicopter.

NQ-T3-2

Only two unique den site locations were recorded for this 1st year male over a two day period between the 17th and 19th June, approximately 970 m and 2 km from the location where it was captured and collared on the 13th june 2013 (**Figure 8**). Both den sites for this animal were located in close proximity to creek lines (**Figure 8**). No further signal detections were recorded for this collared individual despite extensive searching on foot and by helicopter.

NQ-T3-3

A total of six unique den site locations were recorded for this 1st year male between the 12th June 2013 and the 23rd August 2013 (**Figure 8**).All of the den sites for this animal were located in close proximity (<50 m) to gullies, some of which contained rock pools with free water up until late July (**Table 3**; **Figure 8**).

NQ-T3-5

Only two unique den sites were recorded for this 1st year male between the 17th and 27th June 2013 (**Table** 3; **Figure 8**).

NQ-T5-2

Only a single den site was recorded for this 1st year male on the 21st August 2013 ~ 300m to the SW of the initial location where it was trapped on the 16th July 2013 (**Table 3**; **Figure 8**).

NQ-T5-7

A total of six unique den site locations were recorded for this male between the 20th August 2013 and the 20th September 2013 (**Table 3**; **Figure 8**). The animal was recorded on two occasions, four days apart, at the same den site located under a rock slab.

NQ-T6-1

Only a single den site was located for this male on the 23rd August 2013, approximately one month and 460 m S of the capture location (**Table 3**; **Figure 8**).

NQ-T6-2

A total of four unique locations were recorded for this male between the 20th August 2013 and the 20th September 2013, with a single den site being used twice (**Table 3**; **Figure 8**). All den sites for this male which was trapped along the power line access road near the SW boundary of the site on the 23rd July 2013 (**Figure 8**). All of the den sites for this species were located in the rugged south-eastern section of the site (**Table 3**; **Figure 8**).

NQ-T7-1

A total of six unique den sites were recorded for this male between the 22nd August and 20th September 2013, with a single site used on two successive days in close proximity to the proposed turbine site # 49 (**Table 3**; **Figure 8**).

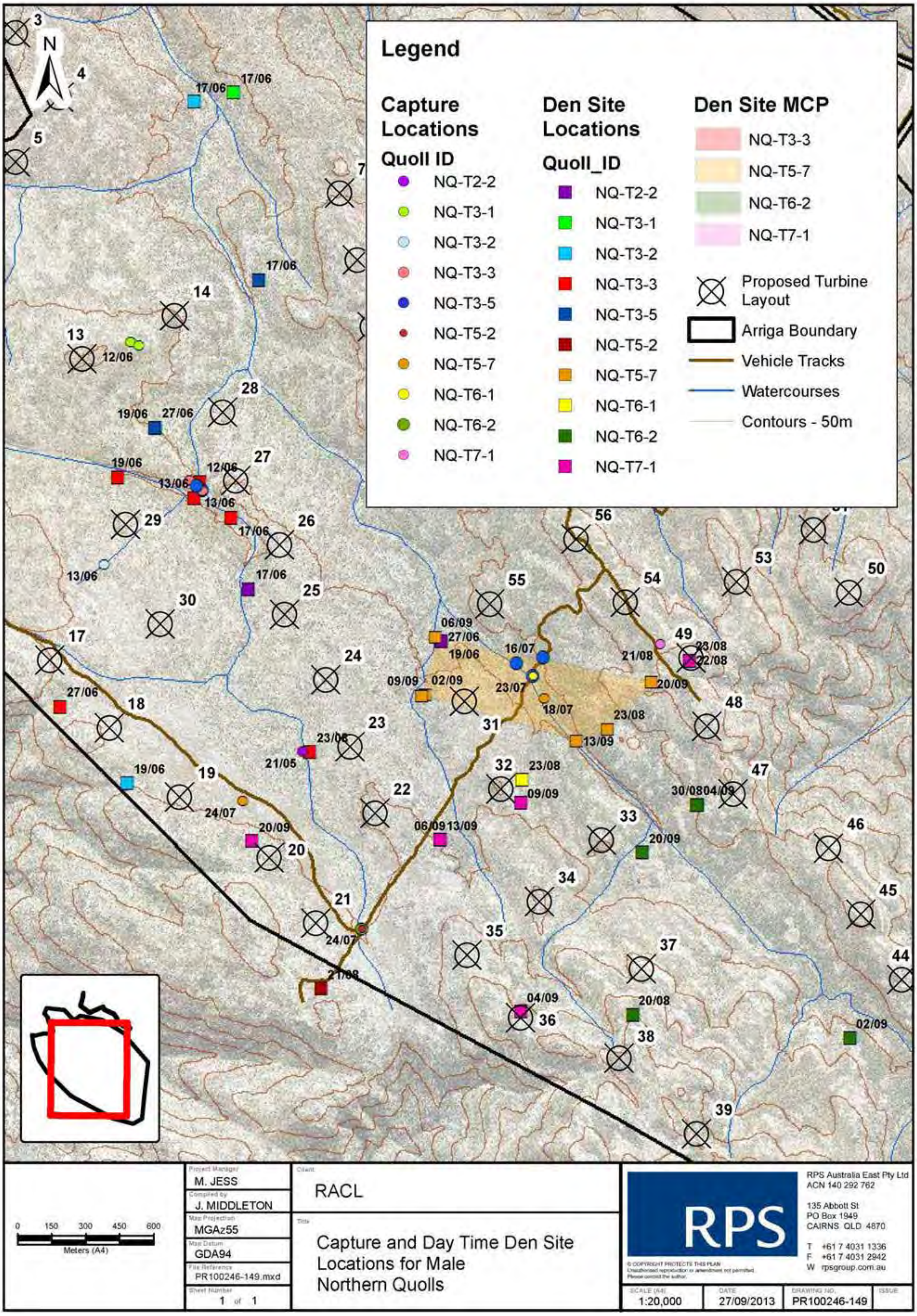

Figure 8 Capture and Day Time Den Sites for Male Northern Quolls. ***MCP = minimum convex polygons***

3.3 Movement Data Obtained with Automated Radio-Telemetry System

At the Southern ARTS site a subset of all of the fix locations obtained for animal NQ-T2-1 (150.950) were extracted from the raw ARTS data by Michael Ward (University of Illinois) for the period 24th April to the 28th May 2013 and are shown in **Figure 9**. The estimated locations are clearly not accurate as the fix locations are all well outside the likely detection area of the southern ARTS site towers i.e. > 2 km (**Figure** 9). Further ARU data for the period 17th July to the 8th August 2013 from the southern ARTS site was provided to Michael Ward for analysis. A test transmitter beacon (150.2700 Hz) was operating during this entire sampling period. The estimated location fixes provided by Michael Ward for the test beacon together with the actual location as recorded with a hand-held GPS are shown in **Figure 10**. It is evident that there is a significant spatial error in the estimated locations of the beacon (mean difference of the distance between the estimated and the actual location = 231.79 m, range = 14 m to 1005.9 m) (**Figure 10**).

No useful data was able to be collected at the northern ARTS site at all during the period of deployment due to hardware failure and too many programming errors by the manufacturer (**Table 2**). At the time of the deployment of the ARU units, non functioning software complete with an instruction manual was provided by the manufacturer to extract the location bearings from the signal strength data.

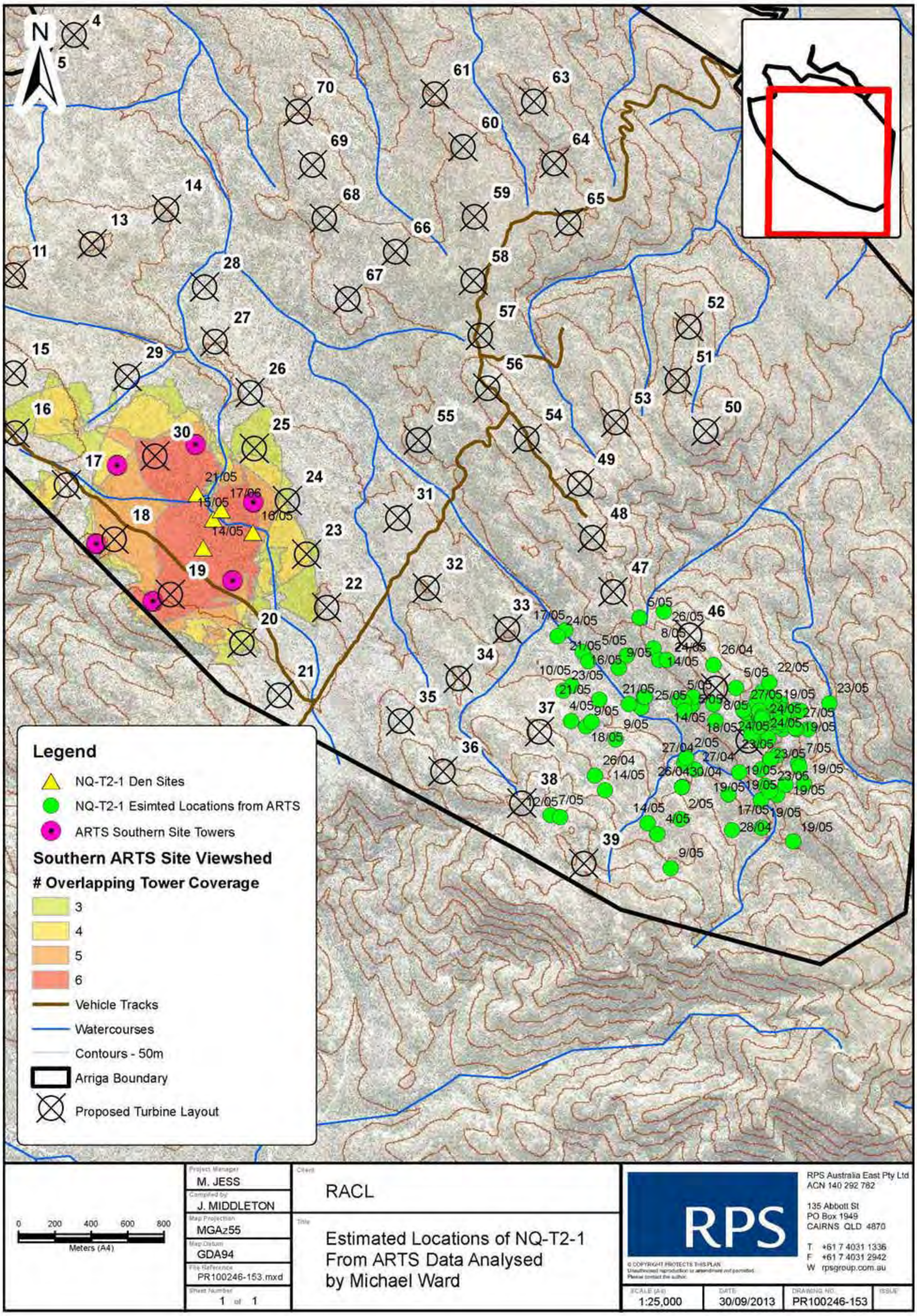

Figure 9 Estimated Locations of NQ-T2-1 derived from the Automated Radio-telemetry System (ARTS)

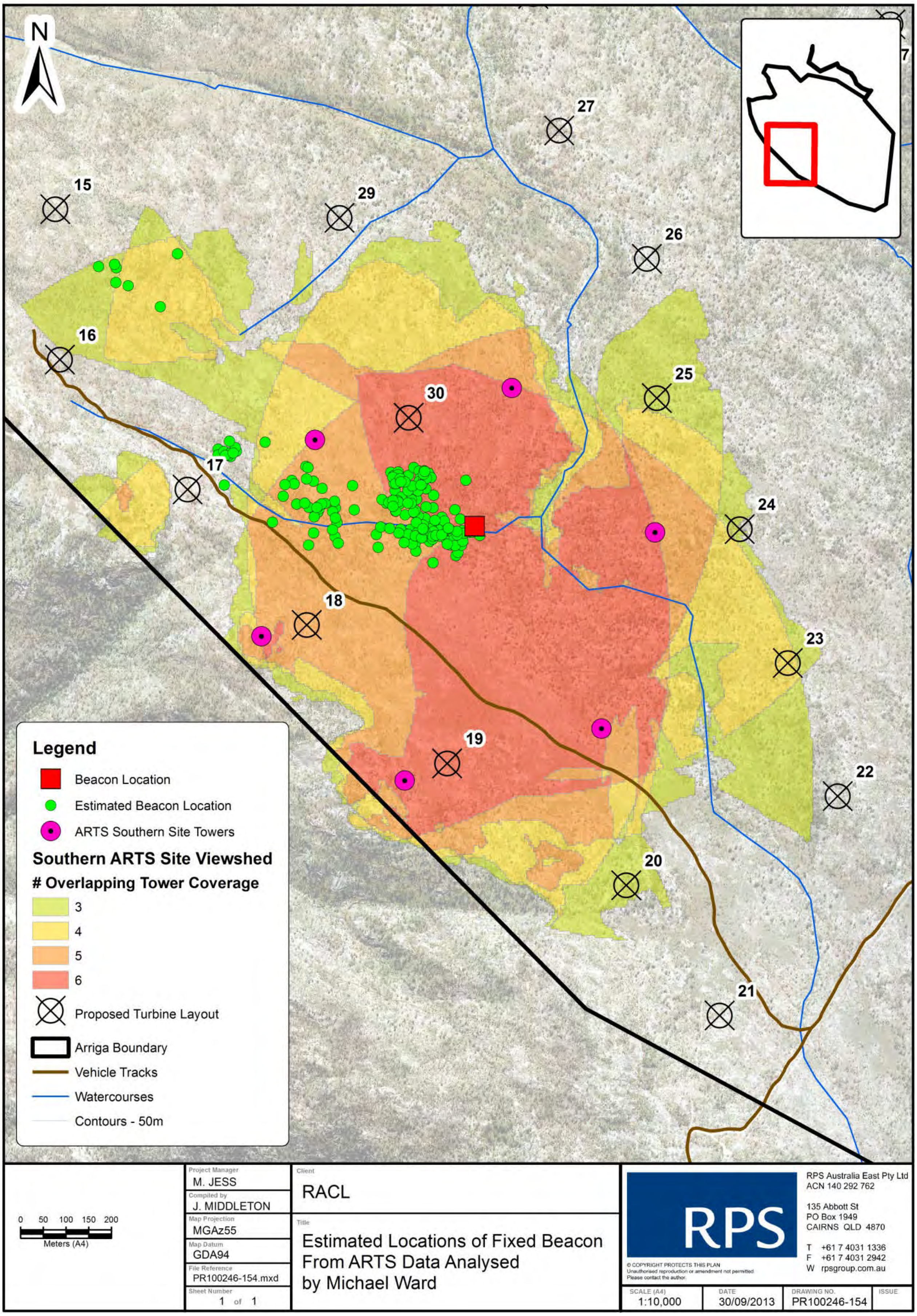

Figure 10 Fixed Beacon Estimated Locations derived from the Automated Radio-telemetry System (ARTS)

3.4 Collar Deployment /Animal Welfare Issues

Holohill collars attached with fine elastic thread proved to be an unacceptably risk to the well-being of the collared juvenile Northern Quolls due to a design flaw that resulted in the thread progressively ratcheting tighter through the attachment tube.

The following alterations where made to the collars to ensure that they could not tighten:

- the bore of the attachment tube was enlarged; and
- the entire elastic thread was circling the animals neck was covered in heat shrink so that even if the thread was pulled tight, the diameter of the collar could not shrink.

However, even with the changes to the Holohill collars, some individuals managed to insert an arm underneath the collar which resulted in severe abrasion injuries in the arm pit and opposing side of the upper neck.

Following the recapture of a juvenile male with a severe neck abrasion in February 2013, every effort was made to recapture all of the collared animals by targeted trapping in the immediate vicinity of the day time den sites determined by manual radio-tracking. All collared animals except for a single male (NQ-T1-4) were recaptured within 10 days of their first capture and the collars removed. All wounds were treated by application of copious antiseptic iodine. NQ-T1-4 was recaptured on the 21st May 2013 approximately 766 m from its first capture location and the Holohill collar was removed and the wound treated. Upon its recapture the following night, the wound was found to have healed well having formed a scab and was no longer weeping. The Holohill collar on this animal appears to have malfunctioned as no signal was able to be detected within the estimated battery life period of 49 days despite intensive searching for a signal on foot in the vicinity of the capture location, from surrounding high vantage points and from the air in a helicopter.

Only one individual (adult male NQ-T3-5) that was fitted with a Sirtrack suede collar exhibited any injuries that appeared to be related to poorly fitting collars. This individual was first collared on the 12th June and was recaptured on the 12th July and again on the 17th July 2013, when a weeping abrasion on the neck under the collar directly beneath the nylon securing nut was detected. The collar was removed and the injury treated with aqueous iodine. The animal was recaptured again on the 18th July 2013 and the abrasion injury was dry and had formed a scab. Following this incident, the nylon nut and bolt that secured the suede collar was completely covered with heat shrink on all subsequent deployments.

A total of three Sirtrack suede radio-collars were found detached from the animals within den sites or on the ground surface (**Figure 11**). It was not known whether the animals managed to squeeze out of the collars due to expansion of the suede when moistened by rain or heavy dew, or whether the animals were predated upon and the collars remained after the animals were consumed. No signs of teeth marks or puncture marks were observed on the detached collars.

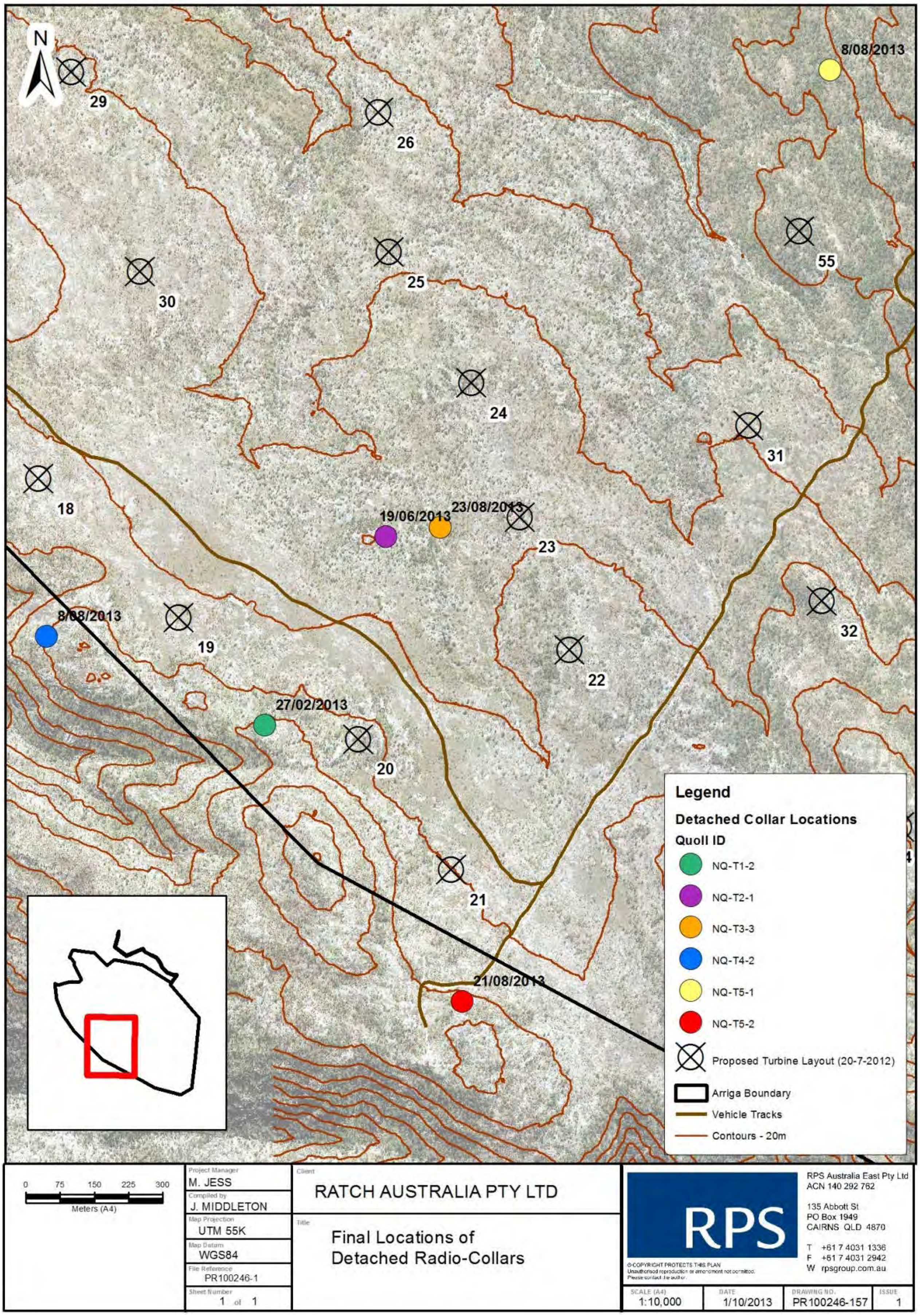

Figure 11 Final Locations of Detached Radio-Collars

3.5 *D. hallucatus* Mortality

At least one individual female D. hallucatus (NQ-T2-1) was confirmed to have died whilst fitted with a collar. The animal’s head with collar still attached, scattered hair and the remains of the stomach were located on the 19/6/13 at c. 327248E 8100024N (refer **Figure 11**). It is likely the animal was predated shortly prior to the discovery as the eye surface was still bright

A collar that was fitted to a male, NQ-T5-2 on the 16/7/13 was located in a large stick nest (belonging to either raptor or a corvid) located on uppermost section of a high voltage transmission line at c. 327416E 8099000N (**Figure 11**) which indicates that the animal was most likely predated or scavenged after death, or that the detached collar was picked up and incorporated as nesting material by the bird that made the nest.

4.0 Discussion

The objective of this study was to examine the spatial and temporal fine-scale habitat utilisation of *D. hallucatus* on the project site to assist with assessing the likely impact of the project on the local population.

Obtaining frequent, accurate radio-telemetry locations for *D. hallucatus* on the proposed Mt Emerald Wind Farm site presented many challenges. *D. hallucatus* have a large home range relative to other predatory mammals of the same body size (*pers com* Dr Scott Burnett) and were capable of moving large distances overnight. The steep terrain, loose rocky substrate and dense grass layer that characterised much of the site made it difficult and time consuming to located den site of animals on foot. It was often not possible to detect signals from many of the collared animals, particularly males, possibly due to the signals being attenuated or reflected when animals were denning within burrows or deep within rock piles, especially in steep gullies, or simply that the animals may have moved out of detection range (~1-2 km line of sight). Oakwood (1997) found that male *D. hallucatus* frequently moved out of range and were hence unable to be located at each daily attempt.

4.1 Den Site Use

Relatively little information on the seasonal variation in den site utilisation was able to be obtained for any for any age and sex classes of *D. hallucatus* on the project site. Most of the den sites of the collared animals were located in within rocky outcrops suggesting that this is an important microhabitat on the site. Very little information was able to be gathered on maternal den site preferences by females due to the small number of females able to be collared for a long-period. As of September 2013, only a single adult female with pouch young was fitted with a radio-collar and only a total of nine dens were located within a period of 27 days. Although it would not be valid to make any general inferences about overall female maternal habitat usage on the such limited data, all of the den site locations for this female were located along a ridge line in close proximity to proposed turbine locations.

Oakwood (1997) tracked thirty-two *D. hallucatus* (13 females and 19 males) to 302 dens on 658 occasions within an 8km^2 area in tropical savanna of Kakadu National Park, Northern Territory over a 365 day period (345 days in the dry season and 11 days in the wet season). Each female was found to use between 20-55 dens each (mean = 35).(Oakwood (1997). Both male and females showed a preference for denning in different microhabitat with 98 dens located in hollows in live trees, 84 in rock crevices, 64 in logs, 25 in termite mounds, 21 in dead trees and 10 in burrows. During March-July, males and females differed significantly in their frequency of use of different den types. Although both sexes used live tree hollows most frequently, females used rock crevices more often than males, while males used logs more often than females (Oakwood, 1997). Oakwood (19977) found that female *D. hallucatus* showed a preference for denning in the rocky hills more often than in the gently sloping open forest and woodland habitats present on her study site.

Both males and females on the project site typically used different dens on consecutive days. Oakwood (1997) found that during the period when adult male *D. hallucatus* were present, both sexes tended to shift dens every night. A possible explanation for such frequent den shifting by *D. hallucatus* is to avoid ambush predators such as pythons (Oakwood, 1997).

4.2 Movements

Despite the investment of considerable time and resources into live-trapping, collaring and radio-tracking (manual and automated), of both juvenile and adult *D. hallucatus* over a period of approximately eight months, the objective of the study to examine seasonal variation in the fine-scale habitat utilisation of *D. hallucatus* on the project site using automated radio-telemetry was not able to be achieved successfully.

It is apparent that further work is required in order to obtain accurate location fixes using ARTS. The estimated location fixes provided to date for those individuals that were present within the range of the southern ARTS site antenna arrays are highly likely to be characterised by a large degree of spatial error as indicated by the large variation between the estimated and actual locations of the fixed test beacon. Wind-induced positional changes in the orientation of the whip aerial of the fixed test beacon are likely to have contributed the large spatial position errors for the estimated position of the test beacon. Ward *et al.* (2013) found that postural changes (e.g. coiled or uncoiling) by snakes fitted with radio-transmitters relative to the ARTS antennas resulted in changes in signal strength without any changes in location. Field testing that involved altering the position and posture of both live and model snakes fitted with transmitters was required in order to be able to determine thresholds in signal strength and bearing that indicated actual changes in location (Ward *et al.* 2013). RPS Group was not informed by Sparrow Systems of the need to ensure that the test beacon whip aerial was fixed in either a horizontal or vertical position until after the final sampling period (17^{th} July to the 8^{th} August 2013). Given that *D. hallucatus* are scansorial (adapted for climbing), the orientation of radio-collars will vary substantially (e.g. vertical when traversing flat ground, horizontal when climbing up vertical surfaces such as trees and rock faces) and therefore, it would be necessary to conduct field testing similar to that described by Ward *et al.* (2013) to account for this source of spatial error in estimated locations.

The areas on the site that were suitable for the establishment of an Automated Radio-telemetry System comprising six 4m tall towers were relatively small relative to the entire site due to severe constraints from topography and by the distribution and abundance of Northern Quolls (as determined by camera trapping in 2012). It was not feasible to establish the ARTS sites in topographically complex areas, which typically had highest quoll abundance, due to the limited detection view shed and resulting limited size of the area where triangulated fixes are possible to be obtained. In addition, the view shed calculations were computationally complex and time-intensive which limited the number of potential sites that could be assessed. The two ARTS sites that were selected were located within a relatively flat section of the proposed MEWF project site. Although the view shed of both sites contained examples of ridge and creek habitats, they are not representative of much of the southern, eastern and western sections of the site. However, this limitation was unavoidable at the time as no other alternative technological solution to obtain fine-scale habitat utilisation data was available.The only *D. hallucatus* movement information obtained in the study was that inferred from the consecutive day time den site locations. Unfortunately It was not possible to collect sufficient den site locations for any collared individual to be able to provide an estimate of the denning ‘home range’ as per Oakwood (1997). Oakwood (1997) found that the maximum distance recorded between successive dens was 2.1km for a male and 1.2 km for a female, which is comparible with the our results.

4.3 Recommended Further Research

4.3.1 Combined GPS-VHF Radio-Telemetry Studies

Recent advances in GPS collar technologies have made it feasible to deploy on Northern Quolls. WildSuppply (Helensvale, QLD) have provided RPS Group with a test model of a light-weight GPS collar (27 g) that is capable of capturing 21 GPS fixes per day for a period of seven days. The test unit is combined with a VHF transmitter than is scheduled to operate continuously for a period of ~ 30 days to assist with the recapture of the animal and the recovery of the collar and the stored location data. In addition, WildSupply are in the process of testing units incorporating Robin Systems ultra low weight GPS tags (3 g) (Cellguide, 2012) and have indicated that they will be available for testing by Nov-Dec 2013 (Geoff Carey, pers. com). The Robin System GPS tags allow a range of battery and weight configurations, can provide up to eight months of operation (1 hourly fixes for 225 days at 6.2 g weight) and are capable of capturing GPS fixes in <70 msec.

When compared with traditional manual radio-tracking and automated radio-telemetry systems GPS collars have the following advantages including:

- Capable of capturing fixes in all types of terrain (as long as the view to the sky not too obscured);
- Not restricted to a limited area within which radio-signals can be detected;
- Have fewer biases; and
- Capable ofobtaining positions frequently during day or night regardless of weather and terrain.

GPS collars have some disadvantages compared with VHF radio-tracking including:

- Collared animals must be recaptured in order to download the data. Retrieving the GPS collars could potentially be a time-consuming and expensive undertaking given the rugged terrain that characterises much of the project site. This is likely to be especially the case when animals are located in some of the deeply dissected valleys or areas away from vehicle access. It is likely that aerial radio-tracking will be required in order to initially locate the animal and then to transport staff and equipment required to recapture the animals once they are located;
- GPS collars are relatively expensive compared to VHF collars (~$1000 and ~$300, respectively); and
- Currently available light-weight GPS collars are still limited to animals >600 g body weight which limits the proportion of animals that it can be deployed upon.

Despite these constraints, the GPS collars that are currently available for use on Northern Quolls are likely to offer the most cost effective method to obtain information on the fine-scale habitat utilisation of Northern Quolls on the site.

It is recommended that WildSupply GPS collar is trialled on adult Northern Quolls on the MEWF site as soon as possible, as it is likely that the majority of the females will be dead by the end of the 2013 dry season (Nov-Dec), and further opportunities to collar adults with a body size of >600 g will be limited until approximately May-June 2014 when this year's young have grown sufficiently. In the event that Robin Systems light-weight GPS collars are made available in the near future, it is highly recommended that additional live-trapping and collaring of animals with these units is conducted on the site in order to gather fine-scale habitat utilisation data.

5.0 Conclusion

Obtaining fine-scale habitat utilisation information for *D. hallucatus* on the proposed Mt Emerald Wind Farm site was extremely challenging and ultimately, largely unsuccessful. In order to be able to develop effective mitigation strategies to avoid impacts to the local population of *D. hallucatus* on the project site from the proposed development, it is essential to continue to attempt to understand patterns of fine-scale habitat utilisation prior to construction beginning. Given the recent availablility of light-weight combined GPS-VHF collars, it is probably not worth continuing with the use of the ARTS given the need to invest considerabley more time and money to obtain accurate fixes, and the limited detection range of the system compared with GPS telemetry (i.e. no detection area limitations).

It is particularly important to determine if the rocky ridge habitats, which will be disproportionally impacted by clearing and ongoing disturbance such as noise, vibration and dust, compared with other habitat types including creek lines, level country or mid-slopes, are used preferentially for denning by females with dependent young. If this is found to be the case, then the potential impacts on the local *D. hallucatus* population could be much greater than would otherwise by indicated by the relatively small total area of proposed clearing (~51 ha or ~2% of the total area of the project site).

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Appendix 20

Fauna, Vegetation & Flora Assessment – Proposed Mt Emerald Wind Farm

Prepared by RPS

Fauna, Vegetation & Flora Assessment - Proposed Mt Emerald Wind Farm

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Document Status

Version	Purpose of Document	Orig	Review	Review Date	QA Review	RPS Release Approval	Issue Date
1	Prelim Assessment	SG & JM	DF	09/08/11	09/08/11	09/08/11	09/08/11

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EXECUTIVE SUMMARY

The Mt Emerald wind farm at completion is proposed to include up to 75 turbines on land described as Lot 7 on Plan SP235244 located approximately 5 km west of the township of Walkamin at the northernmost extension of the Herberton Range, which forms part of the Great Dividing Range. The proposed wind farm will connect directly into the existing Chalumbin to Woree 275 kV transmission line which traverses the site.

The surveys described in this report were conducted on the site as an early-dry season fauna and flora survey in May 2010; a late-wet season flora and fauna survey in March-April 2011; and a targeted camera trap survey for the endangered Northern Quoll and additional microchiropteran bat surveys in the mid-dry season June-July 2011. Additional vegetation surveys were undertaken in June 2011.

Of the 5 plants and 46 fauna species of conservation significance predicted to occur on the site on the basis of previous records or the confirmed presence of suitable habitat on the site, the presence of a total of 3 plant and 12 fauna species were confirmed during the field surveys.

Regional ecosystem mapping for the site indicates the presence of an “of concern” vegetation community located predominately within the ridge top areas where wind turbines are proposed to be sited. However, extensive field surveys covering the proposed turbine locations did not confirm the presence of the tree *Syncarpia glomulifera*: the dominant canopy species characterising this ecosystem. The results of numerous vegetation sampling sites indicate a more correctly defined regional ecosystem for the particular ridge environment that is “least concern”, comprising a mosaic of two units: RE 7.12.30b/7.12.65k.

The construction of access tracks (37.2km: 37.2ha footprint), turbine pads (75 of 30 m x 40 m: 9.0 ha footprint) and electricity substation (1ha footprint) will result in the clearing of approximately 47.2ha of remnant vegetation, of which 20ha will rehabilitated post-construction. This represents approximately 1.9% of the total area of the site. The majority of the clearing is concentrated along rocky ridge-top and mid slope habitats which may be utilised preferentially by some fauna species as foraging, nesting or roosting habitats.

Fauna species of conservation significance were recorded or are predicted to occur on the site, including birds and bats belonging to groups identified as of being at particular risk of mortality from impacts with turbine rotors or from barotraumas. In addition ground-dwelling and hollow-roosting/nesting fauna, in particular Northern Quolls could be potentially impacted by habitat clearing and associated impacts (weed invasion, change in fire regime, increased predation rates etc).

Many of the potential impacts on conservation significant fauna resulting from the construction and operation of the proposed wind farm may be reduced to acceptable levels through the implementation of appropriate management strategies which may include the relocation of turbines away from sensitive areas, weed control, appropriate fire regimes and predator control, site construction timing and rehabilitation measures

The project is likely to result in limited short term impacts to a range of local common species, however these impacts may potentially be minimised through the implementation of appropriate construction phase controls and operational phase management. In the longer term, operational impacts on these species are not considered likely to be significant provided the recommended monitoring and management programs are implemented.

A Statement of Commitments has been prepared which provides the basis for future plans, strategies and direct actions the Proponent proposes to undertake prior to, during and post construction to ensure that all potential environmental impacts are considered.

1.0 Introduction

Mt Emerald Wind Farm Pty Ltd (of which Transfield Services are an equity partner with Port Bajool) are seeking planning approval for the establishment of a wind farm on land at Arriga, located on the Atherton Tablelands, approximately 60 km east of Cairns (**Figure 1**).

The Mt Emerald Wind Farm, at completion, will consist of 75 wind turbines, each with a nominal capacity of between 2-3 MW. While the actual turbine make and model is yet to be confirmed, the typical physical characteristics of the turbines include a tapering steel tower supporting a three blade rotor, which includes blade length up to 50m and a hub height of between 80-90 m. Of the turbines currently being considered the largest has an overall tip height of 131 m (hub height of 80 m and a blade length of 51 m).

Adequate setbacks will be established for each turbine to ensure that no part of the turbine overhangs adjacent properties (not part of the application) or gazetted roads. Each turbine will be connected, via a transformer located adjacent to each tower, to the proposed substation via a network of both underground and overhead cables. The substation will ultimately be connected via overhead transmission lines to the existing Chalumbin to Woree 275 kV transmission corridor which traverses the site.

RPS Group was engaged to undertake a fauna assessment of the area proposed for the wind farm to determine if there are any significant fauna issues associated with the development of this project and to suggest appropriate strategies to mitigate these impacts where possible given the available knowledge.

1.1 Site Description

The wind farm project site, hereafter referred to as the "site" or "project area" is a single rural property, formerly describd as Lot 7 on Plan SP235244, and covering an area of approximately 2422 ha (**Figure 1**).

The site is situated at the northern most end of the Herberton Range, which forms part of the Great Dividing Range. The site varies in altitude from 540 m a.s.l at the northern-most point along Kippen Drive to 1089 m a.s.l in the south-eastern most section closest to Mt Emerald. The north-western section of the site is dominated by Walsh's Bluff (907 m a.s.l) (**Figure 1**).

The site is dominated by a series of three, approximately parallel high rhyolite ridges running in a south-east to north-west direction (**Figure 1**). There is a large area (~500 ha) of relatively flat country located in the western section (**Figure 1**). The site is dissected by a series of steep rocky ephemeral drainage lines and gorges, including the headwaters of a tributary of Granite Creek (**Figure 1**).

The site is intersected by a 5-10 m wide, 6.7 km long access track for Powerlink's Chalumbin to Woree 275 kV transmission line that roughly traverses the property (**Figure 1**). Two other vehicle tracks, 750 m and 2.95 km in length respectively, connect the two test wind towers with the main power line access track (**Figure 1**).

The site is not currently grazed by domestic stock and aside from the cleared areas of access tracks and test wind monitoring tower pads, consists entirely of remnant vegetation (see Part 2 – Vegetation & Flora section).

The site is located on the boundary of the Einasleigh Uplands and the Wet Tropics Bioregions, both of which are characterized by high levels of bioregional endemic flora and fauna species.

The climate of the local area as indicated by the long-term weather records obtained for the nearby township of Walkamin is monsoonal, with alternating wet and dry seasons that typically last for 4 and 8 months respectively (Weatherzone, 2011), although this can vary considerably depending on the severity of the El Nino/Southern Oscillation.

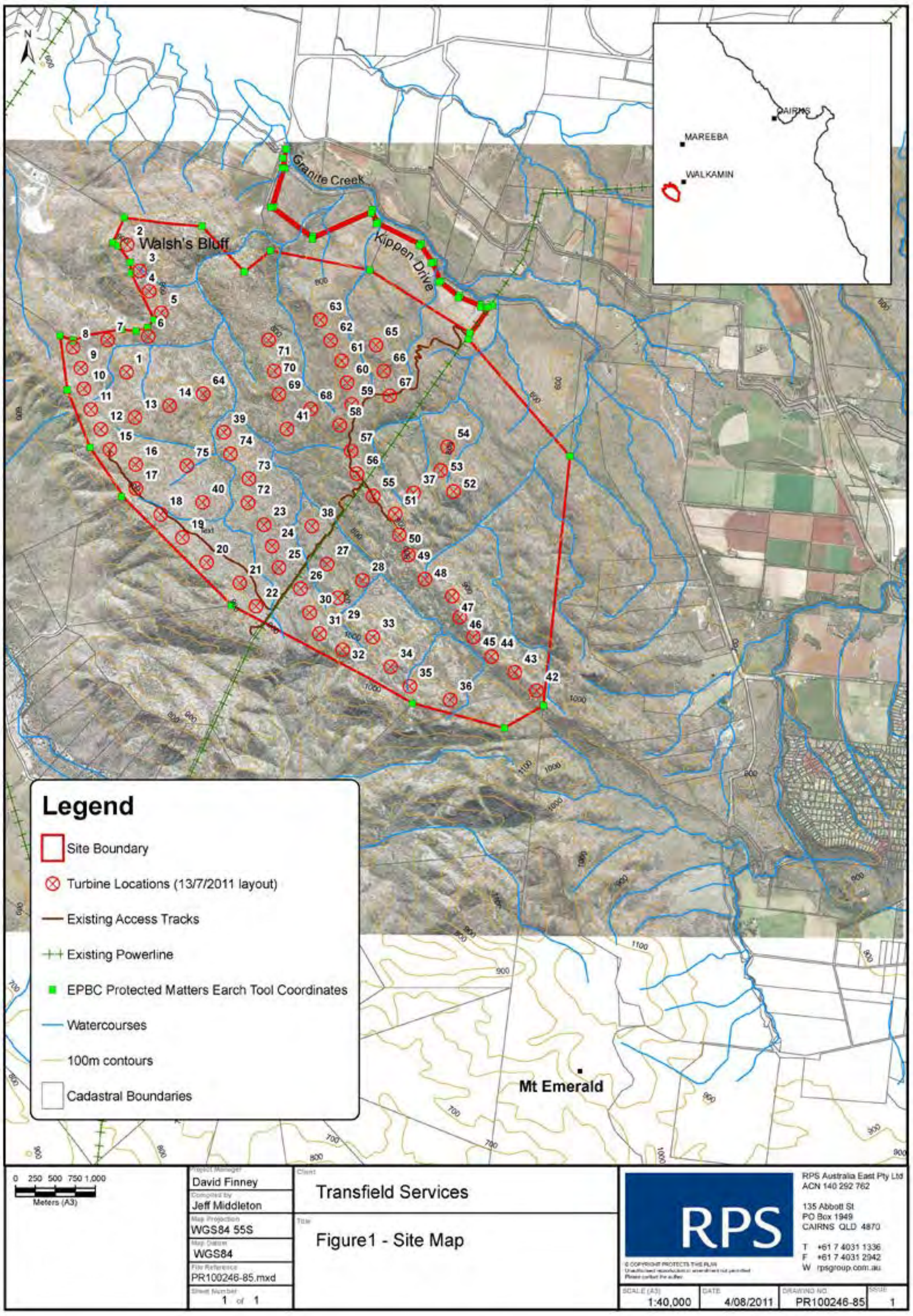

Figure 1. Site Location

PART 1 – FAUNA ASSESSMENT

2.0 Sources of Information – Fauna Assessment

This section of the report identifies the sources of information and methodology used to assess fauna on the project site and its surrounds. Only terrestrial vertebrate fauna (birds, bats, reptiles, mammals and frogs) were considered during this assessment.

2.1 Existing Information

This investigation is based on the information sources described below.

An *Environmental Protection and Biodiversity Conservation Act 1999* Protected Matters Report was generated using the on-line search function on the federal Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) website (SEWPAC, 2011). This was used to identify matters of national environmental significance that are known from, or have the potential to occur in, the region within 10 km of the cadastral boundaries of the site as defined by the following series of points and shown in **Figure 1**:

-17.15419,145.35489,	-17.15471,145.35634,	-17.15351,145.3618,	-17.15241,145.36547
-17.14409,145.36138,	-17.14093,145.36211,	-17.14191,145.37088,	-17.14705,145.37561,
-17.14465,145.37858,	-17.14683,145.38974,	-17.15376,145.40073,	-17.16774,145.41225,
-17.19577,145.40927,	-17.19832,145.40485,	-17.19551,145.39454,	-17.18454,145.37422,
-17.1727,145.3623,	-17.16678,145.35825 &	-17.16032,145.35571.	

Fauna recorded or known to occur within a 10 km buffer of the centroid of the site (-17.166736, 145.386955), were obtained from the Queensland Department of Environment and Resource Management's (DERM) Wildlife Online Database (DERM, 2011). The information used to produce the wildlife lists is based on collated species lists and wildlife records acquired by the department through a range of sources including specimen collections, research and monitoring programs, inventory programs including extension activities, literature records, wildlife permit returns and community wildlife recording programs. As the department is still in the process of collating and vetting wildlife data, it is possible the information given is not complete. The absence of a species from the list does not mean that it does not occur there, but only that records are not held within the department wildlife database.

Data on bird occurrence in the one degree square containing the centroid of the project site (-17.166736, 145.386955) were reviewed from Birds Australia's (BA) Birddata website (BA, 2011).

Additional information used to derive predictive lists of fauna species likely to occur within the site was obtained from the following sources:

- Mammals - Van Dyck and Strahan (2008); Menkhorst and Knight (2004);
- Bats - Churchill (2009);
- Reptiles – Wilson (2005); Cogger (2000);
- Frogs – Barker *et al*. (1995); Frogs Australia Network (2011); and
- Birds – Pizzey and Knight (2007); Nielsen (1996); Simpson and Day (2010).

3.0 Field Methodology

3.1 Survey Timing

A total of three separate fauna surveys were conducted at the site:

- An early dry season survey conducted between the 10th and 14th May 2010;
- A late wet season survey conducted between the 28th March and 1st April 2011; and
- A targeted Northern Quoll *(Dasyurus hallucatus)* camera trap survey conducted during the breeding season between the 1st June and the 2nd July 2011.

3.2 Survey Methodology

A variety of survey techniques were used to provide a comprehensive assessment of fauna species occurring on the site. The trapping and fauna detection methods used were based on the standard biological survey methodology developed by the NSW Department of Primary Industries and Animal Research Review Panel, and approved by the Queensland Department of Environment and Resource Management (DERM) and the Queensland Department of Employment, Economic Development and Innovation (DEEDI) Animal Ethics Committee. Specifically the survey methodology was developed and undertaken in accordance with the following guidelines:

- Wildlife Survey Guidelines, NSW Department of Agriculture and NSW National Parks and Wildlife Service (recognised and recommended wildlife survey guidelines for Queensland use) including:
- Guideline 3 – General ethical considerations and wildlife surveys;
- Guideline 4 – Surveys of terrestrial and arboreal mammals;
- Guideline 5 - Surveys of bats;
- Guideline 7 – Surveys of birds;
- Guideline 8 – Surveys of reptiles and amphibians;
- ANZCCART Guidelines for the Euthanasia of Animals Used for Scientific Purposes; and
- Hygiene protocol for the control of disease in frogs (NSW National Parks and Wildlife Service).

Standardised early dry season fauna searches were conducted at a total 23 sites through the range of habitat types occurring in the study area, targeting signs of fauna species including visual observations, tracks, scats, nest sites, diggings, fur, feathers and remains (**Figure 2**). At six of the 23 sites, terrestrial fauna species were surveyed using the following methods: pitfall traps, Elliott traps and hair tubes (during the dry season only) (**Figure 3; Appendix A1**). Standardised late wet season fauna searches (timed, area searches for birds and reptiles) were conducted at an additional 29 sites (**Figure 2; Appendix A1**). A detailed description of the survey methods used is as follows:

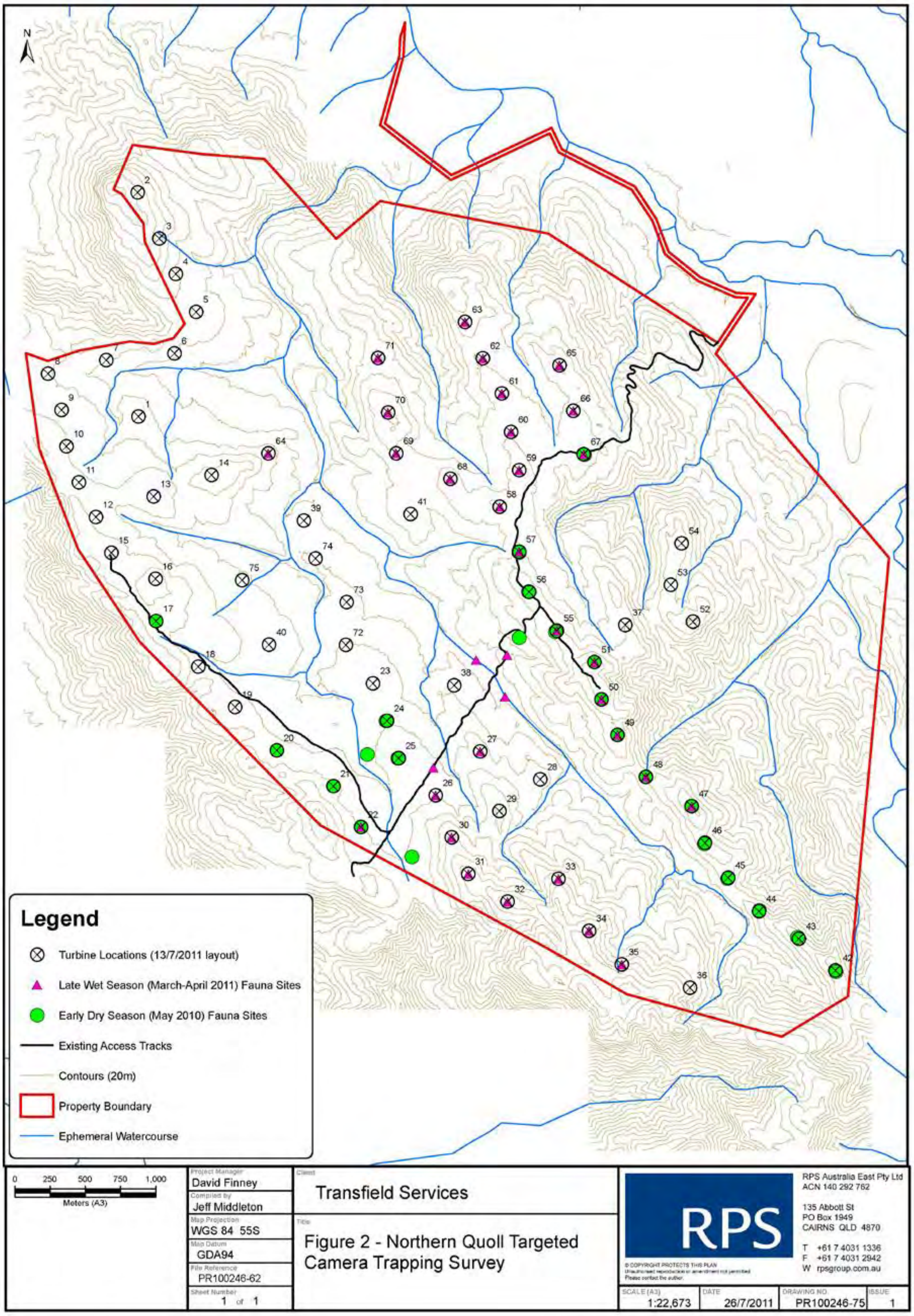

Figure 2. Fauna Survey Site Locations

3.2.1 Pitfall Trapping (May 2010 only)

Pitfall traps were established predominantly to sample for reptiles, amphibians and small mammals. Each pitfall trap line comprised one PVC bucket (200 mm diameter, 400 mm depth) set into the ground with the lip flush with the ground surface, and a 10 m long and 400 mm high drift fencing, also dug into the ground.

Two pitfall traps were established at three sites, set approximately 20 m apart, depending on the habitat, terrain and conditions at each site, with drift fencing positioned at right angles to each other. A total of six pitfall traps were established across three sites in the study area. Traps were checked twice daily in the early morning and late afternoon.

All pitfall traps were opened for four consecutive days and three consecutive nights.

3.2.2 Elliott Trapping (May 2010 only)

Elliott box traps (size A and B) were deployed at six survey sites. Trap-lines consisted of five traps, with the exception of the Granite Creek site which comprised 10 Elliott traps, spaced at approximately 10 m apart. These lines were installed approximately 20 m from and parallel to the pitfall traps. A small bait of peanut butter, rolled oats and honey was placed in Elliott traps as bait at some of the sites targeting small mammals, such as rodents. Pilchards were used to bait the remaining Elliott traps, targeting carnivorous mammals such as dasyurids.

All Elliott traps were left open during the day and night, and checked twice per day. All Elliott traps were opened for three consecutive days/nights, with the exception of Site 67, which were open for two consecutive nights only.

3.2.3 Funnel Trapping (May 2010 only)

One line comprising eight funnel traps was established along a small, first order drainage line close to the centre of the site. Funnel traps were used to target larger reptiles, specifically snakes. These traps were set along potential movement pathways, such as alongside fallen timber and piles of debris and through obvious animal runs in stream bank vegetation.

3.2.4 Harp Trapping (May 2010 only)

One harp trap was deployed for four consecutive nights across a potential flyway over the creek at the Granite Creek site. The trap was strategically placed to trap bats foraging over the water body or to capture bats coming down to drink along the creek. The harp trap was checked at approximately 1900 hours and 2230 hours each night, and 0545 hours each morning.

3.2.5 Microchiropteran Bat Call Detection (May 2010, March-April 2011, June-July 2011)

Microbat calls were sampled using Anabat SD1 (Titley Electronics, Ballina, NSW) and SM2BAT (Wildlife Acoustics, Concord, Massachusetts, US) electronic bat detectors.

During the early dry season surveys, passive monitoring was undertaken for four consecutive nights in the vicinity of the Granite Creek site, and an additional four consecutive nights of passive monitoring was undertaken on the ridge tops at both the southern and northern extents of the site, where some significant rock fissures could be observed during helicopter reconnaissance flights.

During the late wet season surveys (April 2011), passive monitoring using Anabat SD1 detectors was conducted for a single night at the following locations: turbine # 30, #26, #60, #56, #55 (April 2011 layout). At each site, monitoring commenced at dusk (approximately 1830 hours) and continued until dawn (approximately 0545 hours). Anabat units were attached to tree trunks and set ~2m above the ground. Active monitoring was conducted with an Anabat SD1 unit from a slow-moving vehicle travelling along the power line access track from the vicinity of turbine #67 to the south-eastern section of the property in the vicinity of turbine #22 and back again. The vehicle transect was surveyed on the 29th and 31st March.

Additional bat call monitoring was conducted between 1st June and 2nd July 2011 using SM2BAT detectors (Wildlife Acoustics, 2011). A stereo channel unit utilising two ultrasonic omnidirectional microphones was established at both of the existing test wind towers. The locations and microphone set-up used at each tower site was as follows:

- The 80 m tower located in the vicinity of turbine #50 with one microphone set at ~70 m and the other at 30 m above the ground.
- The 50 m tower located in the vicinity of turbine #15 with one microphone located at the top of the tower and the other at ~10 m above the ground).

The main aim of these additional wind tower bat surveys were to attempt to survey the bat species flying above the canopy and within the potential rotor strike zone, in particular the Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus nudicluniatus*). The remaining three single-channel SM2BAT units were attached to tree trunks set at ~2 m above the ground at established in the vicinity of turbine #18, #38 and #56. All SM2BAT units were set to record continuously from sunset to sunrise for a period until either the battery or memory cards were used up. Analysis of microchiropteran bat calls was conducted by Greg Ford from Balance-Environmental, Toowoomba. Copies of the bat analysis reports are provided in **Appendix E1**.

3.2.6 Diurnal Bird Surveys (May 2010 & March-April 2011)

During the early dry season, diurnal audio-visual bird surveys were conducted at 20 of the 75 proposed turbine sites. While it is preferable that bird surveys be conducted within 2-3 hours after dawn to coincide with the period of highest bird vocalisations, site accessibility, the relatively large size of the property and logistical considerations meant that some surveys were conducted outside of this period. Surveys were undertaken by one observer walking slowly through an area of approximately 1 ha in the vicinity of the proposed turbine locations each accessible turbine site recording all bird species seen or heard. No attempt was made to determine estimates of individual species abundance.

During the late wet season, diurnal audio-visual birds surveys were conducted in the vicinity of 12 turbine locations. Bird surveys were conducted up to 2 ½ hours after dawn and consisted of a single observer waking randomly through an area of approximately 1 ha for 15 minutes recording all birds seen or heard.

3.2.7 Spotlighting (May 2010 & March-April 2011)

Spotlighting both on foot (using head torches and variable intensity spotlights) and by slow-moving vehicle (0-5 km/hr), was undertaken targeting reptiles, amphibians, bats, terrestrial and arboreal mammals and nocturnal birds.

During the early dry season, spotlighting surveys on foot were conducted along transects moving through accessible proposed turbine sites, and along the creek at the Granite Creek site, which represented the only accessible, semi-permanent source of fresh water within the study area. Several hundred metres were surveyed in a set time frame. Each foot survey was conducted in the first two hours after sunset, while spotlighting from a slow-moving vehicle generally occurred between 2000 hours and 2200 hours. One experienced observer conducted each survey. All sightings were recorded. During the late wet season, vehicle based spotlighting for nocturnal fauna was conducted on the 29/3/2011 along the power line access track between turbine #22 and #67

3.2.8 Owl Call Playback (March-April 2011)

Call playback of the following species (Barking Owl, Pacific Barn Owl, Masked Owl, Southern Boobook Owl and Grass Owl) using a Toa 15 W megaphone was undertaken at various sites along the power line access tracks during the active bat monitoring and spotlighting surveys. Each call was played for several minutes followed by a period of listening for responses and spotlighting in the immediate vicinity.

3.2.9 Active Searches

3.2.9.1 Dry Season

Active searches were undertaken at 18 sites (**Appendix A1**) and targeting reptiles and amphibians within the study area. This involved hand searches of suitable microhabitats, such as under bark, under and in fallen logs and timber, under rocks, in leaf litter, in and around termite mounds and in rock fissures and crevices. A minimum of 45 people-minutes of habitat searches were conducted at each site. It is noted that weather conditions for herpetofauna surveys was not optimal given the extended period of dry weather and cooler conditions preceding the survey.

3.2.9.2 Late Wet Season

Active searches were undertaken at a total of 12 sites (refer to **Appendix A1**). The methodology was similar to the dry season searches, except that two people searched for a period of 15 minutes (=30 people-minutes). Surveys were conducted during the warmer part of the day between 1000 and 1500 hours. Weather conditions were optimal for surveying reptiles, being largely warm and sunny.

3.2.10 Raptor Searches (March-April 2011)

During the March-April 2011 survey, searches for raptors were undertaken at four sites located on high ridges that afforded good unobstructed views of the surrounding area (**Appendix A1**). Raptor searches were conducted at each site for a minimum of 60 minutes and involved one or two observers scanning the surrounding area for soaring raptors.

3.2.11 Opportunistic Observations

Non-systematic sampling was conducted across all sites and throughout the remainder of the accessible survey area. The presence of all vertebrate species was recorded wherever and whenever possible. Opportunistic sampling included the following:

- Incidental sightings
- Secondary evidence **-** the presence of evidence or activity, including tracks, scats, pellets, scratches, diggings, burrows, dens and nests were recorded wherever and whenever possible.

3.2.12 Camera Trapping (Targeted Northern Quoll Survey)

A targeted survey for the endangered Northern Quoll (*Dasyurus hallucatus*) was conducted between 1st June and 2nd July 2011 in accordance with the requirements set out in the draft Northern Quoll EPBC Act 1999 referral guidelines (SEWPAC, 2011b).

Trap sites were selected largely on the basis of the latest proposed turbine layout provided by Transfield Services at the time of the survey. The impact sites were located within the immediate vicinity of the proposed turbine locations, which are located predominately along ridges (**Figure 3**).

The 59 'non-impact' sites were predominately located along ephemeral creek lines and were selected so as to cover as much of the site as possible (**Figure 3**).

Only one turbine location (c. UTM 55K 326533 8101046), that was added in the proposed turbine layout was not surveyed; however, a "non-target" camera trap was located only 137 m away in a nearby ephemeral creek line (**Figure 3**).

Camera traps were mounted to tree trunks at a distance of ~1.2 m above the ground and facing downwards at a raw chicken carcass firmly wired to a large rock or log or base of a tree.

Camera traps were set to be triggered for a period of 7 continuous nights. Images were downloaded and all fauna captured were identified to species where possible (all species except for smaller murid rodents). Identification of all individual Northern Quolls from comparison of spot patterns on captured images for the purposes of determining relative abundances was begun but it became apparent that this task would be very time consuming given the relatively high numbers of individuals captured at many of the camera trap locations examined. After consultation with SEWPAC, it was that agreed that spatial occupancy data alone would be adequate.

4.0 Results

4.1 Habitat Assessment

The following faunal habitats were identified on the site:

- Dry sclerophyll woodland to open woodland with dominant species including *Eucalyptus cloeziana*, *E. portuensis*, *E. reducta*, *E. drepanophylla* (sens. lat.), *E. shirleyi*, *E. granitica*, *Corymbia leichhardtii*, *C. abergiana*, *C. lockyeri* subsp. *exuta*, *C. pachycalyx*, *C. clarksoniana*, *C. intermedia*, *C. citriodora*, *Allocasuarina littoralis* and *Callitris intratropica* with a grassy understory dominated by *Themeda triandra*. Occurs on ridges and flats throughout the site.
- Low shrub-land/heath land dominated by *Acacia calyculata* and *Jacksonia thesioides*. Occurs on ridges and flats throughout the site.
- Riparian zone vegetation with dominant species including *Lophostemon grandiflorus*, *Bursaria incana*, *Eucalyptus tereticornis*, *Diospyros* sp. A narrow, disjunct band occurs along ephemeral watercourses throughout the site.
- Riparian zone vegetation occurring along the lower reaches of Granite Creek adjacent to Kippen Drive with dominant species including Euc*alyptus tereticornis, E. grandiflorus* and *E. platyphylla.*

Faunal microhabitats identified as occurring throughout the site include:

- Dense grassy understory;
- Leaf litter;
- Exfoliating rock slabs, rock pavements, boulder piles and rock fissures;
- Standing living and dead tree hollows;
- Exfoliating bark;
- Termite mounds;
- Fallen dead timber; and
- Ephemeral pools (from <1 m diameter to >10 m diameter)

The site has a high overall degree of ecological integrity with few exotic plant species and minimal habitat modification or clearing associated with the power line easement and associated access tracks.

4.2 Fauna Species Occurrence

Based on the field assessment of habitat availability on the site and a review of existing sources of information on species distributions, a total of 379 species, comprising 27 amphibians (1 introduced), 189 birds, 92 mammals (8 introduced) and 81 reptiles were recorded within the site during the course of the field surveys or are predicted to occur on the basis of their known distributions and the confirmed presence of suitable habitat (**Appendix B1**).

Of the 46 fauna species of conservation significance predicted to occur on the site on the basis of known distributions and the confirmed presence of suitable habitat on the site, a total of 12 fauna species (including 10 birds and 2 mammals) were recorded during the field surveys (**Table 1**).

The EPBC Protected Matters Report and the DERM Wildlife Online searches for the region within a 10 km buffer of the site produced 38 fauna species (2 critically endangered, 12 endangered, 9 vulnerable and 16 migratory) listed under the EPBC Act 1999, and 33 species (10 endangered, 9 vulnerable and 13 near-threatened) listed under the Queensland *Nature Conservation Act 1992* (**Appendix C1** & **D1**). However the search area for the EPBC Protected Matters Report and the DERM Wildlife Online searches comprising a 10 km buffer around the site boundaries and around the centroid of the site, includes several fauna habitats not occurring on the site including large, artificial, permanent water bodies, such as Nardello's Lagoon and Lake Tinaroo, as well as areas of upland notophyll vine forest and wet sclerophyll forest occurring south of the site near Mt Emerald.

A total of 21 fauna species, comprising mostly obligate rainforest species and water birds, returned by the EPBC Protected Matters Report and the QLD DERM Wildlife Online search are not considered as being likely to utilize the site for foraging, nesting or roosting due to a lack of suitable habitats, that is, rainforest and permanent wetlands with aquatic macrophytes. Areas of mapped wetland occur along the Granite Creek directly adjacent to site along the Kippen Drive access and along Oaky Creek to the west, which may provide a small amount of potential habitat for water birds. Water birds may potentially fly over the site while moving between areas of suitable habitat and therefore could be impacted by the proposed wind farm. Further research is required to quantify the frequency of any such fly-over movements and to determine any potential impacts on waterbirds.

Table 1. List of fauna species of conservation significance recorded or predicted to occur on the site

Family	Common Name	Scientific Name	Status EPBC	Status NCA	Likelihood of Occurrence
BIRDS					
Accipitridae	Collared Sparrowhawk	*Accipiter cirrocephalus*	M		Recorded
Accipitridae	Brown Goshawk	*Accipiter fasciatus*	M		Recorded
Accipitridae	Grey Goshawk	*Accipiter novaehollandiae*	M	NT	Possible
Accipitridae	Wedge-tailed Eagle	*Aquila audax*	M		Recorded
Accipitridae	Pacific Baza	*Aviceda subcristata*	M		Possible
Accipitridae	Swamp Harrier	*Circus approximans*	M		Possible
Accipitridae	Spotted Harrier	*Circus assimilis*	M		Possible
Accipitridae	Black-shouldered Kite	*Elanus axillaris*	M		Possible
Accipitridae	Letter-winged Kite	*Elanus scriptus*	M		Possible
Accipitridae	White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M		Recorded
Accipitridae	Brahminy Kite	*Haliastur indus*	M		Possible
Accipitridae	Whistling Kite	*Haliastur sphenurus*	M		Recorded
Accipitridae	Black-breasted Buzzard	*Hamirostra melanosternon*	M		Possible
Accipitridae	Little Eagle	*Hieraaetus morphnoides*	M		Recorded
Accipitridae	Square-tailed Kite	*Lophoictinia isura*	M	NT	Possible
Accipitridae	Black Kite	*Milvus migrans*	M		Possible
Apodidae	Fork-tailed Swift	*Apus pacificus*	M		Possible
Apodidae	White-throated Needletail	*Hirundapus caudacutus*	M		Possible

Family	Common Name	Scientific Name	Status		Likelihood of Occurrence
			EPBC	NCA	
Ardeidae	Great Egret	*Ardea alba*	M		Possible
Ardeidae	Cattle Egret	*Ardea ibis*	M		Possible
Dicruridae	Satin Flycatcher	*Myiagra cyanoleuca*	M		Possible
Dicruridae	Rufous Fantail	*Rhipidura rufifrons*	M		Recorded
Falconidae	Brown Falcon	*Falco berigora*	M		Recorded
Falconidae	Nankeen Kestrel	*Falco cenchroides*	M		Recorded
Falconidae	Grey Falcon	*Falco hypoleucos*	M	NT	Possible
Falconidae	Australian Hobby	*Falco longipennis*	M		Possible
Falconidae	Peregrine Falcon	*Falco peregrinus*	M		Possible
Falconidae	Black Falcon	*Falco subniger*	M		Possible
Fringillidae	Gouldian Finch	*Erythrura gouldiae*	E, M	E	Possible
Fringillidae	Star Finch (eastern)	*Neochima ruficauda ruficauda*	E	E	Possible
Hirundinidae	Barn Swallow	*Hirundo rustica*	M		Possible
Meropidae	Rainbow Bee-eater	*Merops ornatus*	M		Recorded
Turnicidae	Buff-breasted Button-quail	*Turnix olivii*	E	V	Possible
Zosteropidae	Silvereye	*Zosterops lateralis*	M		Possible
MAMMALS					
Dasyuridae	Northern Quoll	*Dasyurus hallucatus*	E	E	Recorded
Emballonuridae	Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	CE	E	Possible
Emballonuridae	Troughton's Sheathtail Bat	*Taphozous troughtoni*		E	Possible
Hipposideridae	Diadem Leafnosed Bat	*Hipposideros diadema reginae*		NT	Recorded
Hipposideridae	Semon's Leafnosed Bat	*Hipposideros semoni*	E		Possible
Megadermatidae	Ghost Bat	*Macroderma gigas*		V	Possible
Pteropidae	Spectacled Flying-fox	*Pteropus conspicillatus*	V	V	Possible
Rhinolophidae	Large-eared Horseshoe Bat	*Rhinolophus philippinensis maros*	E	E	Possible
REPTILES					
Elapidae	Common death adder	*Acanthophis antarcticus*		NT	Possible
Elapidae	Yellow-naped snake	*Furina barnardi*		NT	Possible
Scincidae	Yakka skink	*Egernia rugosa*	V	V	Possible
Typhlopidae	Faint-striped blind snake	*Ramphotyphlops broomi*		NT	Possible

E-Endangered, V-Vulnerable, NT-Near Threatened, M-Migratory

4.2.1 Mammals

A total of 26 species of mammals were recorded on the site during the field surveys and an additional 48 species are predicted to occur on the site on the basis of their known distributions and the confirmed presence of suitable habitat and microhabitats (**Appendix A1**).

4.2.1.1 Mammals of Conservation Significance

Two mammal species of conservation significance were recorded during the field survey and an additional six mammal species are predicted as being likely to occur on the site (**Table 1**).

Northern Quolls *(Dasyurus hallucatus)* are listed as endangered under both the EPBC Act 1999 and the QLD NCA 1992. The results of extensive targeted camera trapping survey indicate that *D. hallucatus* is abundant and widespread across the site, with images captured at 88 of the 131 camera trap sites (43 impact sites and 45 non-impact creek line sites) (**Figure 3; Plate 1**).

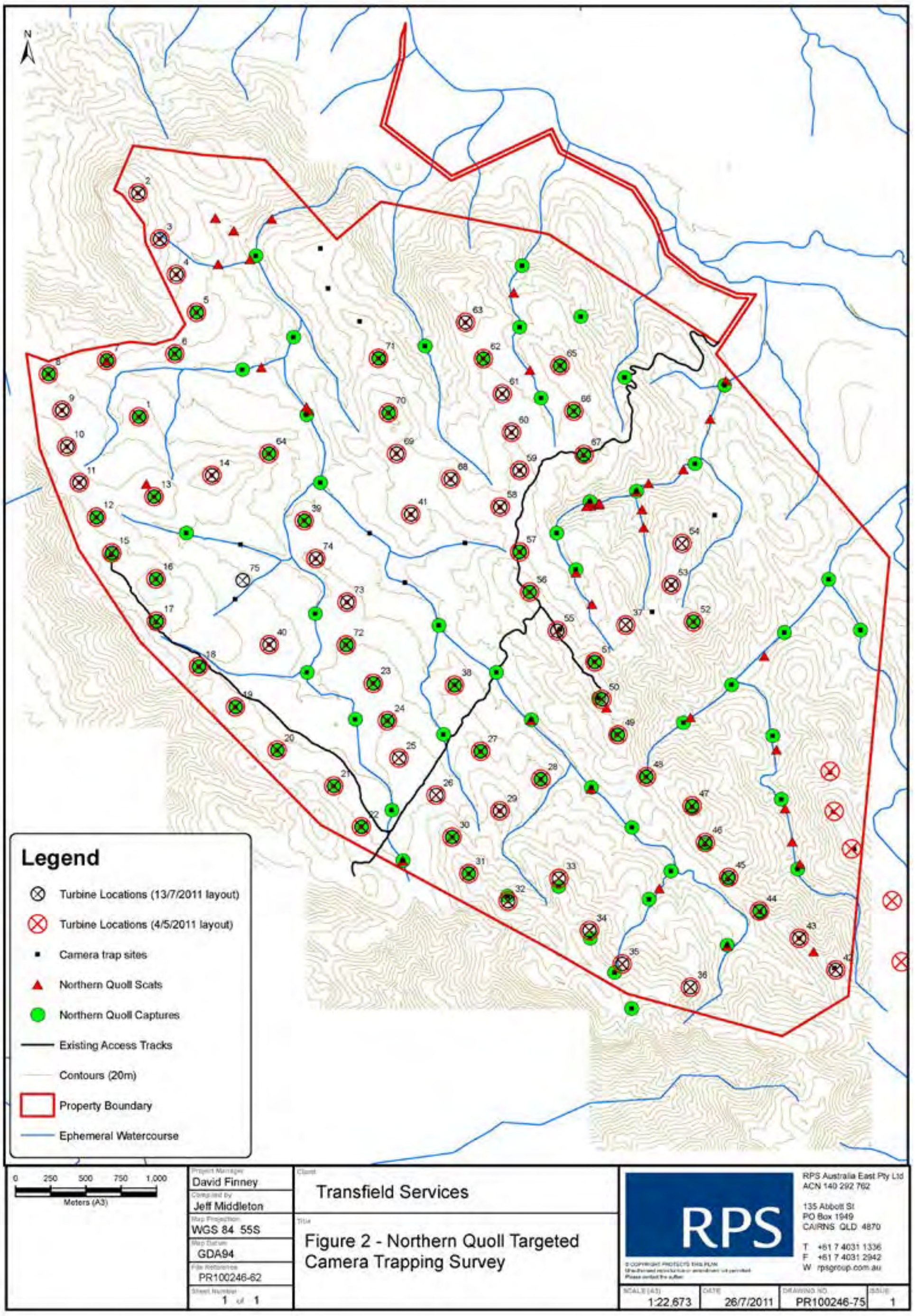

Figure 3. Targeted Northern Quoll Camera Trap Survey Sites

Plate 1. One of the many Northern Quolls (*Dasyurus hallucatus*) captured on an infrared camera trap during the targeted surveys.

The Diadem Horseshoe Bat (*Hipposideros diadema reginae*), listed as near-threatened under the NCA 1992 was positively confirmed to occur on the site from single call recorded during the May 2010 field surveys.

Two calls (out of a total of 1091 detected calls; 0.002% of total) were detected that may have belonged to the Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus nudicluniatu*s) were recorded in the vicinity of turbine #30 and turbine #38. This high flying species is listed as critically endangered under the EPBC Act and endangered under the NCA. However, it was not possible to differentiate these calls from that of two other high flying species: the Yellow-bellied Sheathtail Bat *(S. flaviventris)* and Troughton's Sheathtail Bat *(Taphozous troughtoni)*, which is listed as endangered under the NCA.

The Spectacled Flying-fox (*Pteropus conspicillatus*), which is listed as vulnerable under both the EPBC and NCA was not recorded, however is considered to potentially forage on the site during mass flowerings of myrtaceous plant species.

No Ghost Bats *(Macroderma gigas), listed as vulnerable under the NCA, were recorded during the surveys nor were any* potentially suitable roosting sites (caves, mines, boulder piles) were observed on the site. However, potential roost areas may occur within or immediately adjacent to the site (e.g. large granite boulder piles located ~ 2 km to the north) and the site provide foraging habitat for this species. There are sporadic records of *M. gigas* known from the surrounding Atherton Tablelands region (e.g. Black Mountain, Mt Carbine, and Mt Molloy) (J. Middleton, pers. obs)

The Large-eared Horseshoe Bat *(Rhinolophus philippinensis maros*), listed as endangered under both the EPBC and NCA, is known to roost in caves and disused mines and may also roost in dense vegetation and tree hollows (Churchill, 2009). Although no Large-eared Horseshow Bats were recorded during the survey, suitable roosting and foraging habitat (open woodland and rainforest) are present on or adjacent to the site so it is considered possible that this species may be present on the site. Similarly, although Semon's Leaf-nosed Bat *(Hipposideros semoni),* which is listed as endangered under the EPBC, was not recorded during the surveys, it is known to occur in open savannah woodland and roost in tree hollows and caves (Churchill, 2009) and could therefore potentially occur within the site.

4.2.2 Birds

A total of 56 species of birds were recorded on the site during the field surveys and an additional 140 species are predicted as being likely to occur within the site on the basis of their known distribution and the confirmed presence of suitable habitats and microhabitats on the site (Appendix B1). The most commonly encountered species included Pied Currawongs, Helmeted Friarbirds, Pied Butcherbird, Grey Butcherbird, Weebill, Noisy Miner, Australian Magpie, Brown Treecreeper, Rainbow Bee-eater, Wedge-tailed Eagle, Brown Falcon, Australian Kestrel, Rainbow Lorikeet and Pale-headed Rosella. A total of 99 species, consisting mostly of water birds, are not considered likely to utilize the site for roosting, nesting or foraging habitats due to the lack of large areas of suitable wetland or rainforest, habitats, however, the potential exists for them to fly over the site while moving between surrounding suitable habitats (**Appendix B1**).

4.2.2.1 Birds of Conservation Significance

A total of 10 bird species of conservation significance were recorded on the site during the field surveys and an additional 24 species are predicted to occur on the site on the basis of their known distribution and the confirmed presence of suitable habitats and microhabitats on the site (**Table 1**). The majority of the conservation significant species that were recorded or are likely to occur on the site are listed as migratory species under the EPBC, including all 20 of the raptor species (**Table 1**).

4.2.3 Reptiles

A total of 20 species of reptiles were recorded on the site during the three field survey periods and a further 66 species are predicted as being likely to occur within the site on the basis of their known distribution and the confirmed presence of suitable habitats and microhabitats on the site (**Appendix B1**). The most commonly encountered reptiles including *Carlia jarnoldae, Oedura coggeri*, *Gehyra dubia* and *Diporiphora australis.*

4.2.3.1 Reptiles of Conservation Significance

No reptile species of conservation significance were recorded on the site during the field surveys. Four species are predicted to occur on the site on the basis of their known distribution and the confirmed presence of suitable habitats and microhabitats on the site (**Table 1**).

4.2.4 Amphibians

A total of six frog species and the introduced Cane Toad (*Rhinella marinus*) were recorded during the field surveys and a further 20 species are considered likely to occur on the site on the basis of their known distribution and the confirmed presence of suitable habitats and microhabitats on the site

(**Appendix B1**). The most commonly encountered amphibians were the introduced Cane Toad *(Rhinella marinus)* and *Litoria rubella*.

4.2.4.1 Amphibians of Conservation Significance

No frog species of conservation significance are predicted as being likely to occur on the site.

4.3 Potential Faunal Movement through the Landscape

To date, there has been little research documenting the large-scale migratory movements of birds along the east coast of Australia or the local-scale or regional movements of birds within the Atherton Tablelands. The site forms part of the Great Dividing Range which may potentially lie along of the flight path of some EPBC listed migratory bird species.

The site is surrounded to the west, north and east by irrigated agricultural lands with scattered large artificial water bodies, such as Nardello's Lagoon and Lake Tinaroo and QLD DERM mapped important wetland areas along Granite Creek and Oaky Creek. Given the location of the site with respect to these known habitats, the site could potentially lie within the flight path of several species of conservation dependant water birds as they move across the landscape between suitable foraging or roosting habitats. However, there is no local data on the flight paths of water birds.

The Atherton Tablelands is an important over-wintering site for the significant populations of two species of Australian Cranes, the Brolga and the Sarus Crane. Sarus Cranes, which are globally and nationally vulnerable are known to fly down from the southern Gulf of Carpentaria region to the Atherton Tablelands and may fly over the site due to it's proximity to suitable irrigated agricultural and wetlands, numerous Sarus Cranes feeding and roosting sites have been recorded within short flight distances of the site (Elinor Scrambler, Oz Cranes, pers. com.).

Further investigations would be required to clarify the movement patterns (height, frequency, number of individuals etc) of conservation significant bird species that may potentially fly over the site

5.0 Potential Faunal Impacts

The proposed wind farm project may have the following impacts on fauna:

- rotor strike and barotrauma (microchiropteran bats only) (operation phase),
- habitat alienation caused by fauna species avoidance of the turbines due to visual or noise impacts (operation phase),
- habitat modification resulting from clearing for infrastructure, changes in fire regime and weed invasion (construction and operation phase),
- concentration of predation by feral predators along new access tracks (construction and operation phase), and
- changes in fire regime associated with potential weed invasion or increased risk of anthropogenically ignited fires.

Notwithstanding the above, a range of mitigation measures and further pre-construction studies are proposed to offset or minimise potential impacts.

5.1 Turbine Collisions and Barotrauma

5.1.1 Bird & Bat Collisions

Research both in Australia and overseas indicates those groups of birds at most risk of collisions with turbine blades, towers and nacelles are:

- Wetland birds that form large flocks (e.g. ducks, ibis, Magpie-geese etc);
- Migratory birds that follow defined flight paths;
- Night-flying birds (e.g. owls, nightjars, frogmouths);
- Raptors; and
- Species that flock and fly above the tree canopy (e.g. lorikeets, wood-swallows, swifts etc.) (SEWPAC, 2009).

Relatively little published research has been conducted on assessing the risk of bird and bat collisions with wind turbines in Australia. Statistical modelling of collision risk modelling for a range of Australian bird species to date indicates that mortalities are typically low (Smales, 2005; Smales and Muir 2005; Smales, 2006). Overseas research has established that even collision-prone bird species avoid collisions with wind turbines on most occasions, with measured avoidance rates for a variety of bird species ranging from 100% (Percival, 1998) to 98% (Winkelman, 1992; Still *et al.*, 1995). Australian studies conducted at the Codrington Wind Farm have so far demonstrated a 95-100% avoidance rate (Meredith *et al*., 2002). Data over the longer-term is likely to be consistent with that from overseas with avoidance rates for some species being less than 100%, but still very high, possibly 98% (Meredith *et al.*, 2002). Mortality rates documented for Australian wind farms sited predominately in cleared agricultural settings typically average collision rates between <1 to 4 birds per turbine per year (BLA, 2005).

Resident birds may learn to show a degree of habituation and ability to avoid turbines, which does not however, eliminate the risk of turbine collision entirely. Vacancies in free territories caused by death of residents may be filled by turbine naïve adult “floaters’ and dispersing juveniles, both of which are likely to be at a higher risk of mortality than turbine habituated residents, thereby creating a potential population 'sink effect'. This sink effect may be especially relevant for large, territorial raptors such as Wedge-tailed Eagles, and could potentially lead to long-term declines in the local populations.

A number of bird species were recorded or are predicted to occur on the site that belong to those groups identified as being at risk of collisions. Previous Australian wind farm assessments, suggest that it is unlikely that the proposed wind farm will result in a significant impact to any of the bird species at a regional or national scale, although some species may potentially experience a reduction in their local populations as a result of turbine strike.

Flying-foxes have the potential to be at risk from turbine collisions because they regularly fly within the proposed wind turbine rotor strike zone and often fly in large aggregations. Flying fox populations have a "low capacity for increase and depend on low levels of natural mortality and high survival rates of adults to maintain stable population levels" (TSSC, 2007). Little information is available on the risks posed by wind farms to flying foxes in Australia as most wind farms have been located away from flying-fox roosts or foraging areas. Although no flying foxes were recorded during the survey, it is highly likely that three species, including the Spectacle Flying-fox (*Pteropus conspicillatus*), listed as vulnerable under the EPBC will forage seasonally within the site (David Westcott, CSIRO, pers. com.). The nearest confirmed *P. conspicillatus* roost sites are located at Tolga Scrub, only approximately 9 km to the SW, and in Mareeba, approximately 20 km to the north. Spectacled Flying-foxes are known to travel at least 20 km from their roost sites to feed in dry sclerophyll woodlands and forests on blossoms and nectar of *Eucalyptus*, *Corymbia* and *Melaleuca* species (Parsons, *et al*., 2007). Myrtaceous species typically undergo mass flowering and are likely to represent an easily locatable, densely distributed and super-abundant food resource for *P. conspicillatus* (Parsons, *et al*., 2007), in addition to *P. scapularis* and *P. alecto.*

Additional utilisation surveys conducted during periods of mass flowering of the various Mytraceous species (typically August-September but likely to be substantial variation amongst dominant species (S. Gleed, pers. com.), would be required in order to quantify the potential risk of turbine strike on flying-foxes.

5.1.2 Barotrauma

Recent overseas research indicates that inappropriately sited wind farms have caused significant microchiropteran bat mortality, mostly amongst high-flying or migratory species (Arnett *et al*., 2011). The major cause of bat deaths has been shown to be due to *barotrauma*, that is, damage to the lungs caused by changes in air pressure near the moving blades, rather than direct turbine collisions (Kunz *et al.*, 2007). There is a significant lack of information on the population dynamics of most Australian microchiropteran bat species, therefore the context and influence of any wind-turbine related fatalities remains uncertain. Some bat deaths have been reported from wind farms in Australia for example, occasional deaths of the White-striped Freetail Bat have been reported at Codrington Wind Farm in Victoria (BIOSIS, 2005b). Wind farms could potentially have cumulative effects on bat populations, partly because bats are typically relatively long-lived for their size, have low reproductive rates compared to other mammals (Findley, 1993) and tend to make slow recoveries after declines (Arnett *et al*., 2011). Previous wind farm assessments in Victoria indicate that the rate of bat collisions is between 1 and 4 bats per wind farm per year (BLA, 2008).

Most of the microchiropteran bat species recorded during the surveys or predicted to occur on the site are known to forage predominately below the canopy with the exception of *Chaerephon jobiensis*, *Saccolaimus flaviventris, Taphozous troughtoni* and *Saccolaimus saccolaimus nudicluniatus,* which are all high flying species that forage predominately above the canopy (Churchill, 2009). However, the surveys using ultrasonic bat detectors set up the test wind towers within the rotor strike/barotrauma zone (one microphones set at 70 m for 4 nights, one at 30 m for 3 nights and one at 30 m for 4 nights) confirmed the presence of at least three common bat species, including *Chaerephon jobiensis, Austronomus australis* and *Miniopterus orianae*.

In addition, a total of 67 unidentified bat calls were detected within the potential rotor strike/barotrauma zone. These unidentified calls could potentially have belonged to any of the bats recorded during the surveys (refer **Appendix E1**). It should be noted that there is a degree of uncertainty as to the detection range of the ultrasonic microphones and thus, the approximate height that the bats were flying at, as this depends upon a range of factors including the frequency of the particular species call, the humidity and the presence of mist. However, it is reasonable to assume that at least some of the detected bat calls, including from some of the species recorded from detectors set at 2 m above the ground were from bats flying within the potential rotor strike/barotraumas zone.

Further utilisation studies involving active call detection and visual estimation of flying heights would be required to quantify the potential barotrauma mortality risk of the proposed wind farm on the bat species recorded or predicted as possibly occurring within the site, in particular the five threatened species (Table 1).

5.2 Habitat Alienation due to Turbine Avoidance

Certain overseas research indicates that one of the most commonly reported impacts of wind farms on fauna is the displacement of birds away from the vicinity of turbines, due to noise and/or visual disturbances (Sharp, 2010). Studies have reported displacement effects ranging from 75 m to as far as 800 m away from turbines (Strickland, 2004). Avoidance behaviour is likely to reduce the risk of bird mortality due to rotor strike, but may affect populations where the alienated habitats are important to the survival of the affected species. There has been little published research investigating avoidance behaviour of fauna groups other than birds.

The degree of disturbance to bird communities, and potentially other fauna groups, due to avoidance behaviour is likely to be influenced by the following factors (Sharp, 2010):

- The number, spatial arrangement and type of turbines
- The species composition of the bird community
- The seasonal pattern of habitat use by species
- The availability of alternative habitat

Displacement of a fauna species from an area around wind turbines may effectively result in a degree of habitat loss and a reduction in carrying capacity of the site for sensitive species. Avoidance behaviour may also lead to a linear barrier effect where turbines are located in linear arrays, such as along ridges as is proposed for Mt Emerald, where the spatial proximity of turbines exceeds the zone of disturbance for a particular species. Alienation of important habitat such as updraft areas above ridge lines may have important impacts on soaring raptors.

It is not clear to what extent the fauna species on the project site, particularly those species of conservation significance, may be affected by the avoidance of turbines as there have been no comprehensive peer-reviewed investigations of avoidance behaviour and distances for any fauna species made at any wind farm in Australia (Smales, 2006). It is possible that species that rely upon hearing to detect prey or predators (e.g. quolls and owls) may avoid the area immediately beneath the turbines due to the elevated noise levels or be subject to higher levels of predation. .

5.3 Habitat Modification

The construction of access tracks (37.2 km: 37.2 ha footprint), turbine pads (75 of 30 m x 40 m: 9.0 ha footprint) and electricity substation (1 ha footprint) will result in the disturbance of approximately 20 ha (temporary) and 27.6 ha (permanent) of remnant vegetation, although this figure is indicative only and is likely to be subject to alteration depending upon the final layout of the proposed turbines. Although the proposed total clearing footprint only represents approximately 1.9% of the total area of the site, the majority of the clearing is concentrated along rocky ridgetop and mid slope habitats which may be utilised preferentially by some fauna species as foraging, nesting or roosting habitats. It should be noted that turbine pad clearings will be rehabilitated post construction and 50% of the intialy cleared area of access tracks will be rehabilitated.

Some individuals belonging to ground-dwelling and tree hollow-dwelling species are likely to be directly killed as result of the clearing of habitat during the construction phase. Conservation significant fauna recorded or predicted to occur within the site that could potentially be directly impacted by habitat clearing includes the Northern Quoll, Yakka Skink *(Egernia rugosa),* a blind snake (*Ramphotyphlops broomi),* the Yellow-naped Snake *(Furina barnardi),* Gouldian Finch and Bare-rumped Sheathtail Bat *(Saccolaimus saccolaimus nudicluniatus)*.

It is not certain what the long-term impacts of clearing ridge-top habitats would be to the local populations of the threatened species recorded or predicted as possibly occurring within the site. If the ridge-top habitat provides essential nesting/roosting/denning/foraging habitat for some species, e.g. complex rocky fissures and boulder piles for Northern Quolls, it is possible that the loss of some of this habitat may result in a permanent reduction in the carrying capacity of the site for those species. The importance of these areas is currently not clear. For species that are listed as endangered or critically endangered, the loss of small amounts of critical habitats may have a disproportionate impact on their local populations. The indirect impacts of habitat clearing on some fauna species, in particular the loss of foraging habitat, may decline over time with rehabilitation for cleared areas, but this is unlikely to be the case for the destruction of complex rocky fissures or boulder piles and of large tree hollows, which may take decades to form. Direct and indirect impacts of habitat clearing on fauna could potentially be ameliorated to some extent through the implementation of appropriate mitigation strategies (see section 6.0).

Connectivity is the “linkages of habitats, communities and ecological processes at multiple spatial and temporal scales” (Noss, 1991 in Lindenmayer & Burgman, 2005). Landscapes which retain more connections between remnant habitats are assumed to be more likely to maintain populations of species (Lindenmayer & Burgman, 2005). Connectivity is species-specific because it depends on a number of life history factors of the species (including dispersal behaviour and mode of movement) and their interaction with landscape patterns (Lindenmayer & Burgman, 2005). Clearing can often result in the habitat fragmentation through creation of barriers to the movement of individuals between faunal populations (i.e. disruption to habitat connectivity). The dry sclerophyll fauna recorded or predicted to occur on the site is either highly mobile, or well adapted to the presence of open ground, therefore, the relatively small amount of proposed habitat clearing is unlikely to cause any significant changes to connectivity to habitats on the site and thus to the movement of fauna species within the site.

During the construction phase, the creation of dust, noise, vibration and activity associated with the construction of access tracks, turbine pads, underground cable lines and the electricity substation may temporally disturb susceptible fauna species which could potentially result in their displacement from the immediate vicinity of the works for the duration of the disturbance. However, this is unlikely to have a significant long-term impact on any species.

In the absence of a comprehensive weed management programme, there exists the potential for invasive grasses including Gamba Grass (*Andropogon gayanus)*, Thatch Grass *(Hyparrhenia rufa), Guinea Grass (Megathyrsus maximus* var*. maximu*s) and Grader Grass *(Themeda quadrivalvis)* to be carried onto the site on construction machinery and other vehicles and spread along access tracks and in the vicinity of turbine clearings, particularly during the construction phase of the project. These exotic grasses can readily invade undisturbed dry sclerophyll woodland habitat away from road verges and clearings and can significantly increase the frequency, intensity and extent of fires due to their elevated fuel loads compared to existing native grasses. Effective control of these grasses would be difficult if they spread away from access tracks and clearings due to the rugged terrain. Changes in fire regime, particularly an increase in the frequency and intensity of late dry season fires, has been identified as a potentially threatening process under the EPBC Act for several conservation significant fauna species that occur or are predicted to occur on the site including the Gouldian Finch, Black-throated Finch, Yakka Skink and Northern Quoll. The risk of weed invasion is currently present on the site due to unregulated public access and the regular maintenance of the power transmission access tracks by Powerlink. Effective construction and post construction phase weed monitoring, control and management will therefore be critical to the maintenance of fauna biodiversity on the site.

5.4 Increased Predation Risk Adjacent to Access Tracks

Access tracks are known to be used preferentially for hunting by introduced predators including feral cats and dingo's or wild dogs. Although feral predators are known to currently occur throughout the site, the construction of an additional 37.2 km of access tracks may potentially result in elevated levels of predation of susceptible fauna, including Northern Quolls, ground-dwelling reptiles and ground-nesting birds, by foxes, cats and wild dogs along ridge habitats where the proposed access tracks and turbine clearings will be concentrated, unless appropriately managed

5.5 Potential Impacts on the Endangered Northern Quoll

The targeted camera trapping survey indicates that Northern Quolls are widely distributed across the majority of the site and appear to be in relatively high numbers. Given the precipitate decline of Northern Quolls through most of their former range following invasion by Cane Toads (e.g. Cape York and Northern Territory), the potentially large population of Northern Quoll within the site is likely to be an "important population" as defined under the EPBC Act 1999, that is, a "population that is necessary for the species' long-term survival and recovery" and a "key source population for either breeding or dispersal". Rocky areas, such as those occurring on the site predominantly along the ridge lines, throughout the Northern Quoll distribution are known to be important refugial areas for the species (SEWPAC, 2011a). In particular, Northern Quolls are known to frequently den in rocky boulder piles, often at the highest points of hills or outliers (Oakwood, 1997).

Northern Quolls are sedentary with a moderately large home range with female home ranges known to average 35 ha and male home ranges covering 100ha or more during the breeding season (SEWPAC, 2011a). Northern Quolls reproduce once per year and have on average seven young; however they have a short lifespan with most males and females usually only surviving approximately one year (SEWPAC, 2011a). In rocky habitats, both sexes can have longer life spans (2-3 years) (Oakwood, 1997).

This species exhibits highly synchronous mating which begins between in the mid-dry season (May-July) (Oakwood, 1997). Young start to eat insects at four months old, (Oakwood, 1997) and leave the den to forage at five months old, whilst still suckling from their mother. Juveniles are weaned at 6 months old, in November to early December (Oakwood, 1997). Females wean two to three young which become reproductively mature at 11 months (Oakwood, 1997). Young are left in the den when they are eight to nine weeks old, in late August or September (Braithwaite & Begg, 1995), whilst the mother forages at night (Oakwood, 1997). Females have been shown to utilize between 20-55 different dens and move their dependant young between dens frequently (Oakwood, 1997). Mortality of young is highest during the denning stage; although it seems likely that the main cause is predation by feral cats, pythons and owls, it is unclear whether this mainly occurs in the den or during transit between dens (Oakwood, 1997).

The intense physical effort of male quolls (roving during the breeding season) appears to cause the physiological decline of most males and their subsequent die off, which is unique in a mammal of this size (SEWPAC, 2011a). These unusual life history traits can exacerbate the effects of population decline and habitat loss, and make recovery of population very slow (SEWPAC, 2011a). Management of the potential direct and indirect impacts of habitat clearing, disturbance due to noise, dust and vibration, increased predation rates and changes in fire regime will be essential to ensure that this important population is not adversely impacted by the proposed development.

6.0 Potential Mitigation Options and Further Work

6.1 Rotor Strike/Barotrauma

The most effective potential strategy to reduce the potential impact of rotor strike and/or barotrauma on susceptible bird and bats species would be to relocate turbines away from areas of high bird/bat utilization (e.g. ridges in the case of soaring raptors) to areas of lower utilization. As previously mentioned, the potential risk of rotor strike and/or barotrauma for susceptible bird and bat species identified could not be assessed at the site with a high degree of certainty based on the preliminary studies conducted to date.

An accurate quantitative assessment of the risk posed by the proposed wind farm to birds and bats would require well designed, spatially and temporally replicated utilisation studies to be conducted prior to construction. Bird and bat utilisation studies would require sufficient temporal replication to take into account seasonal differences in utilisation rates.

Additional bat utilisation surveys involving a combination of active ultrasonic call detection surveys together with either spotlighting or thermal imaging video to determine the numbers and species of bats flying within the potential barotrauma zone should be conducted within the vicinity of all of the proposed turbine locations. This would enable a more informed assessment of the risks associated with rotor strike or barotrauma than would be possible through the use of passive ultrasonic call detection alone.

A post-construction monitoring programme of bird and bat mortality due to collisions/barotrauma would allow the determination of the impacts of the wind farm on bird and bat species that utilise the site and to help develop appropriate adaptive mitigation measures such as turning specific turbines off during periods of high mortality.

One potentially highly effective strategy to reduce the impact of barotrauma on microchiropteran bats that has been identified to date is to raise the wind-turbine cut-in speed, defined as the lowest wind speed at which turbines generate power to the utility system. Recent research from a single wind farm in the US, suggests that reducing turbine operation during periods of low wind speed resulted in nightly reductions in bat mortality, from between 44% to 93%, with minor annual losses of ≤1% of total output (Arnett *et al*., 2011). Bat activity at a proposed wind farm site in Leonard's Hill in Victoria showed a 50% reduction when wind increased from 3-3.9 $m.s^{-1}$ to 5-5.9 $m.s^{-1}$ (Richards, 2011) which indicates that a reduction in cut-in-speed could also be an effective mitigation strategy for Australian bat species.

Further long-term surveys using ultrasonic call detection and thermal imaging set up the two existing test wind towers within the potential rotor strike/barotrauma zone to examine the relationship between wind speed and bat activity to be examined would enable the effectiveness of increasing turbine cut-in speeds to reduce bat mortality to be assessed.

6.2 Habitat Modification

The following general recommendations are proposed for areas to be cleared to reduce the impacts on susceptible fauna:

- survey of vegetation including locating, recording and marking specific habitat features (e.g. hollows, hollow bearing trees, hollow-bearing limbs, complex rock fissures and boulder piles);

- inspection of habitat features to identify resident fauna species for relocation;
- development of appropriate capture and release methods (depending on observed fauna);
- identification of appropriate release areas for the relocation of fauna species prior to clearing; and installation of temporary artificial nest/retreat sites such as nest boxes and hollows adjacent to the area proposed to be cleared before clearance.
- cleared vegetation to be stockpiled (not burned);
- All stockpiled vegetation(including any hollow tree trunks) to be respread over cleared area after turbine construction; and
- Re-creation of boulder piles in cleared turbine sites and along track verges where possible

As a preference, (i.e. where access to trees by an excavator is safe and practical), clearing of hollow bearing trees is recommended to be performed in a two stage process where surrounding vegetation is cleared one day before the removal of habitat trees to allow fauna an opportunity to move. Where the removal of hollow bearing trees cannot be avoided, it is preferable that the clearing operation is performed by careful felling and leaving felled trees in situ for a suitable period to allow fauna an opportunity to escape. A minimum of 24 hours would be ideal, especially in the case of nocturnally active animals. The loss of critical tree-hollows and complex rocky outcrops and fissures could potentially be partially offset by the provision of artificial roosting/nesting/denning habitat adjacent to the cleared footprint.

It is recommended that prior to construction, targeted surveys of the proposed clearing footprint be undertaken for the following ground-dwelling species of conservation significance that are predicted as possibly occurring on the site on the basis of their known distribution and the confirmed presence of suitable habitat: Yakka Skink *(Egernia rugosa),* Common Death Adder *(Acanthophis antarcticus),* Yellow-naped Snake *(Furina barnardi)* and the blind snake *(Ramphotyphlops broomi).*

The specific impacts of habitat clearing on Northern quolls are discussed in detail below given their wide distribution and likely high density within the site. It is considered that further research could provide valuable information in order to design mitigation strategies to reduce or avoid the impacts of actions that have a high risk of significant impact (as defined by SEWPAC (2011b)) on the Northern Quoll population on the site. An understanding of the species habitat utilisation, in particular the importance of the rocky ridge lines as foraging habitat, maternal den habitat and as a fire refuge is essential in order to develop appropriate and effective mitigation strategies and ensure the survival of this important Northern Quoll population. Adult female Northern Quoll have been shown to live longer and therefore experience greater lifetime reproductive success when their home ranges include a greater proportion of rocky areas (Oakwood, 1997). Such crucial habitat utilization information could be gathered through systematic surveys of Northern Quolls using detection dogs to locate active dens in both target and not-target areas and an intensive radio-tracking study of individual animals live-trapped in the vicinity of the proposed infrastructure footprint for the duration of an entire breeding season (May to November) to determine habitat usage and to locate day-time den sites, especially maternal dens.

It should be recognised that the live-trapping, particular of females with dependant young in dens, may itself pose a mortality risk and procedures would need to be followed to ensure that animals are retained for as short a time as possible, especially during the period when the highly altricial young are largely unfurred and poikilothermic (Oakwood, 1997). Suggested mitigation strategies to avoid significant direct impacts on the local population of Northern Quolls would be to avoid construction during the breeding season (May-November) (SEWPAC, 2011b) or to relocate infrastructure such as tracks or even turbine sites to avoid clearing maternal den sites or critical foraging areas.

As previously mentioned, it is important to understand the importance of ridge habitats containing complex rocky outcrops and fissures to the long-term maintenance of a viable quoll population, given that they are known to frequently den in rocky areas particularly at the highest point of hills (Oakwood, 1997). It may be possible that non impacted areas (e.g. creek lines) are also important which would lessen the overall potential impact on the population, however this is currently unknown.

All hollow bearing trees that lie within the proposed clearing footprint should be thoroughly investigated with a fibre optic scope to search for roosting sites of critically endangered Bare-rumped Sheathtail bats (*Saccolaimus saccolaimus nudicluniatus*) and other hollow-roosting/nesting conservation significant species that may potentially occur on the site.

Threatened species management plans for each of the conservation significant species confirmed or predicted to occur on the site are recommended to manage all potential impacts of the project on these species.

The development and implementation of a rigorous invasive weed management programme is strongly recommended to ensure that exotic weeds with the potential to increase the intensity and frequency of late dry season fires do not become established on the site. Furthermore, a fire management plan for the site should be designed and implemented to ensure that the incidence, severity and extent of hot, late dry season fires is reduced. The successful complete eradication of invasive grasses would be difficult to achieve once they spread away from clearing edges into the rugged terrain, highlighting the need for a rigorous Weed Management Plan to be implemented (see section 13.2 below).

The development and implementation of an ecological Fire Management Plan is recommended to reduce the frequency, intensity and extent of hot, late dry season fires which are known to be a significant threat to Northern Quolls and several other species of conservation significant fauna predicted to occur on the site.

6.3 Increased Predation Pressure

The development and implementation of a comprehensive feral predator monitoring and control programme is strongly recommended, in particular for cats and foxes. Although the control of dingo, which is currently classified as a Class 2 pest is required under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002,* recent research indicates that stable packs of dingos can effectively control populations of feral cats and foxes to the benefit of many native species (Johnson, 2007).

7.0 Conclusion

The project may potentially result in limited short term impacts to a range of local common species, however impacts can be minimised through the implementation of appropriate construction phase controls and operational phase management. In the longer term, operational impacts on these species are not considered likely to be significant provided the recommended monitoring and management programs are implemented.

Fauna species of conservation significance were recorded or are predicted to occur on the site, including birds and bats belonging to groups identified as of being at particular risk of mortality from impacts with turbine rotors or from barotraumas. In addition ground-dwelling and hollow-roosting/nesting fauna, in particular Northern Quolls could potentially be impacted by habitat clearing and associated impacts (weed invasion, change in fire regime, increased predation rates etc).

These impacts may be manageable with the implementation of appropriate wind farm construction and operational measures. Measures may include the relocation of turbines away from sensitive areas, weed control, appropriate fire regimes, predator control, and site construction timing and rehabilitation measures.

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PART 2 – VEGETATION & FLORA ASSESSMENT

8.0 Methods – Vegetation & Flora Assessment

The methods adopted for completing the vegetation and flora studies are detailed below and consist of two primary aspects: a desktop review of published environmental information; and a physical ground investigation of the environmental characteristics of the study area. The primary objective was to gain a sound understanding of the vegetation and floristic qualities of the land intersected or likely to be impacted by the proposed wind farm.

8.1 Desktop Review

A review of databases and information relating primarily to rare and threatened species of flora and fauna was undertaken as a preliminary exercise to determine the probability of particular species occurring at or in the vicinity of the study sites. The results of these searches and reviews of information assisted with planning targeted field surveys for conservation significant species, as well as gaining a better understanding of the ecology of certain species. Concurrent with this review was an examination of vegetation mapping for the region.

The following databases and sources of information were reviewed:

- *Regional Ecosystem mapping.* The most recent version of the Department of Environment and Resource Management's (DERM) regional ecosystem (RE) vegetation mapping (version 6.0, November 2009) was used to provide an indication of the status and position of remnant vegetation in relation to landforms of the project site. This mapping was overlaid on a digital colour aerial photograph base sourced from Google Earth™;
- *Regional Ecosystem Description Database* (REDD). Detailed descriptions of remnant vegetation communities (regional ecosystems) in Queensland. Version 6.0b, January 2011.
- *Essential Habitat mapping*. In association with the RE mapping for the study area, essential habitat mapping has been prepared by DERM for conservation significant species. A review of this mapping in relation to the vegetation types and respective habitats was made to establish its relevance;
- *Wildlife Online* database of flora and fauna. This database holds records of plants and animals that have either been sighted or collected within a given radius of the site (a search parameter was prescribed limiting the search area to a 10 km radius around an approximate central point of the study area). The records held in this database are jointly maintained by Queensland's Environmental Protection Agency and the Queensland Parks and Wildlife Service - now incorporated into DERM;
- *Protected Matters* database of Matters of National Environmental Significance (NES). This database applies a range of bio-models to predict the presence of species of flora and fauna and other matters of NES within a given radius of the site (a search parameter was prescribed limiting the search area to a 10 km radius around an approximate central point of the study area), as cited under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *HERBRECS* database of plant records. This database provides confirmed records of plant collections made within a specified area, of which voucher specimens are held by the Environmental Protection Agency's (EPA) Queensland Herbarium. Data from this source provides useful information on the location of rare and threatened species and expedites targeted surveys for such plants in the field;

- *Queensland Museum Biodiversity database.* This database provides confirmed records of fauna species recorded within a specified area. Data from this source provides additional information on the known location of rare and threatened fauna species;
- *Regional Vegetation Management Code – Coastal & Western Bioregions*. The 'Performance Requirements' of these codes (as issued under the *Vegetation Management Act 1999*) were addressed and interpreted for their relevance to the project; and
- Literature review. A range of scientific papers and other literature were reviewed for a number of related matters.

8.1.1 Flora and Vegetation Survey Methods

Representative sites were selected across the project area in order to sample the broadest vegetation types likely to be impacted by the establishment of the wind farm, and to understand the diversity of vegetation types and probable locations of particular flora species restricted to certain habitats or limited by environmental conditions. The location of the vegetation survey sites is shown in **Appendix A2**).

Methods adopted for the survey are in keeping with protocols outlined and issued by DERM (Wannan, 2009). We note however, that it was unnecessary to determine whether a particular vegetation type is considered remnant or non-remnant as defined under the *Vegetation Management Act 1999*, as all the turbines are considered to occur in areas mapped as remnant vegetation. The remnant status of these sites has been accepted and thus detailed transects to determine percentage foliage intercept were not undertaken. Structural formations were ascribed according to Specht, *et al.*, (1974).

A minimum 500 m^2 plot area was surveyed at each vegetation survey site. Plots were orientated so that the longest side was parallel to the prevailing land contour. Within each survey plot the structural layers of the vegetation were characterised according to five strata: the dominant tree layer (tallest layer), the sub canopy or secondary tree layer, the dominant shrub layer, a secondary shrub layer (if present), and the ground layer. Emergent trees above the dominant tree canopy layer were noted, but not recorded as a layer.

Only vascular plant species were recorded including trees, shrubs, grasses, forbs and graminoids. An inventory of species was compiled. For species that could not be identified in the field, a voucher specimen was collected and used for later identification. A number of specimens are currently being prepared for lodgement with the Queensland Herbarium (BRI) for formal identification. Ground searches were made for plants of conservation interest. In many cases, these searches extended beyond the bounds of the vegetation survey plot, and typically included sections of land between turbines. This land is mostly associated with ridge topography.

Access constraints and the limited time of the ground survey precluded the opportunity to survey all 75 proposed wind turbine sites. This is relevant particularly for the southern end of the project area, where plant diversity is expected to be highest, given the juncture of the Einasleigh Uplands and Wet Tropics bioregions. Also, Mount Emerald, an area regarded for its concentration of plants with narrow or limited distribution occurs in this location, and its geographical influence is considered important.

The habitat qualities of these sites in respect to supporting rare and threatened plants was also assessed based on a range of characteristics such as the maturity of the vegetation, the complexity of structural layers and an interpretation of plant functional groups and how they relate to ecological processes. A broad assessment was also made of landscape and vegetation connectivity, refugial areas, and fireproof niches.

9.0 Results of Desktop Review - Vegetation

A review of published literature, as well as a range of databases provided a historical and scientific basis from which ecological considerations could be made in relation to flora and vegetation in the project area and the regional perspective; particularly for rare and threatened species, and the landscape importance of environmental features. The findings of this exercise are discussed in the following section.

9.1 Regional Ecosystem Mapping

Remnant vegetation communities in Queensland are classified as Regional Ecosystems (REs) for the purposes and administration of the *Vegetation Management Act* 1999 (VMA). Vegetation mapping of these communities in the wet tropics bioregion was revised and updated in September 2009 and released as version 6.0. The scale of this mapping is 1:50,000. DERM (2009) describe regional ecosystems as:

> *"Regional ecosystems are communities of vegetation that are consistently associated with a particular combination of geology, land form and soil in a bioregion. Each regional ecosystem has been assigned a conservation status which is based on its current remnant extent (how much of it remains) in a bioregion"*.

The Regional Ecosystem (RE) mapping for the study area encompasses two bioregions: the Wet Tropics (1:50,000) and the Einasleigh Uplands (1:100,000). The map production scale for each bioregion renders the resolution of the mapping significantly different. For example, heterogeneous polygons are applied for many areas in the Einasleigh Uplands due to the scale of the mapping and the possible presence of small patches of vegetation associations that cannot be differentiated at a scale of 1:100,000; whereas, the percentage of heterogeneous polygons shown in the Wet Tropics bioregion is much lower due to the finer resolution of the mapping at 1:50,000.

Regional ecosystem mapping shows the remnant vegetation communities found within the broader study area occur primarily on a single land zone type - 12, described as: Mesozoic to Proterozoic igneous rocks, forming ranges, hills and lowlands. Predominantly granitic rocks and intermediate to acid volcanics such as granites, granodiorites, andesites and rhyolites, as well as minor areas of associated interbedded sediments and basic intrusive rock types such as gabbros and dolerites. Excludes serpentinites (land zone 11) and younger igneous rocks (land zone 8). Soils are mainly Tenosols and Rudosols on steeper slopes with Chromosols and Sodosols on lower slopes and gently undulating areas. Soils are typically of low to moderate fertility. The principal geology across the site is rhyolite.

Descriptions of these REs are given in **Table 1** with their respective conservation status as listed under the VMA. Effectively this interpretation reflects what types of remnant vegetation will be potentially affected by clearing and disturbance during the construction phase.

Current mapping showing the landscape position of remnant communities (REs) in relation to the study area and each turbine site is given in **Appendix B2**. Descriptions of remnant vegetation are reproduced from the information and data held in the latest version of REDD updated in January 2011 (version 6.0b). Complete descriptions of REs are given in **Appendix C2** (some information from the REDD description of less ecological relevance has been omitted for brevity).

Table 1. Description of regional ecosystems mapped in the project area.

RE	Description	Status[1]
7.12.34	*Eucalyptus portuensis* (white mahogany) and/or *E. drepanophylla* (ironbark), +/- *C. intermedia* (pink bloodwood) +/- *C. citriodora* (lemon-scented gum), +/- *E. granitica* (granite ironbark) open-woodland to open-forest. Uplands on granite, of the dry rainfall zone.	LC
7.12.57	Shrubland and low woodland mosaic with *Syncarpia glomulifera* (turpentine), *Corymbia abergiana* (range bloodwood), *Eucalyptus portuensis* (white mahogany), *Allocasuarina littoralis* (black sheoak) and *Xanthorrhoea johnsonii* (grasstree). Uplands and highlands on granite and rhyolite, of the moist and dry rainfall zones.	OC
9.12.2	Mixed open forest to occasionally low open woodland including combinations of the species *Eucalyptus portuensis* (white mahogany), *Corymbia citriodora* (lemon-scented gum), *E. granitica* (granite ironbark) or *E. drepanophylla* (narrow-leaved ironbark), *C. intermedia* (pink bloodwood) or *C. clarksoniana* (Clarkson's bloodwood) +/- *E. cloeziana* (Gympie messmate) +/- *Corymbia* spp. There is often an open to mid-dense sub-canopy containing canopy species +/- *Melaleuca viridiflora* (broad-leaved paperbark) +/- *Lophostemon suaveolens* (swamp mahogany) +/- *C. leichhardtii* (yellowjacket) . The shrub layer varies from scattered shrubs to mid-dense and includes juvenile canopy species, *Acacia flavescens* (yellow wattle), *Callitris intratropica* (cypress pine), *L. suaveolens*, *Xanthorrhoea johnsonii* (grasstree) and *Petalostigma pubescens* (quinine). The dense grassy ground layer is generally dominated by *Themeda triandra* (kangaroo grass) +/- *Heteropogon triticeus* (giant speargrass) +/- *Mnesithea rottboellioides* (northern canegrass). In some areas, patches dominated by *E. moluccana* (gum-topped box) or *E. cloeziana* may occur. Occurs on rises, hill and ranges.	LC
9.12.4c	Low woodland to low open woodland of *Callitris intratropica* (cypress pine) and *Eucalyptus shirleyi* (silver-leaved ironbark) and/or *E. melanophloia* (silver-leaved ironbark) +/- *Corymbia leichhardtii* (yellowjacket). The sparse mid layer can include juvenile canopy species, *Melaleuca monantha* (teatree), *Dolichandrone heterophylla* (lemonwood), *Alphitonia obtusifolia*, *Petalostigma pubescens* (quinine), *Acacia bidwillii* (corkwood wattle) and *Grevillea* spp. The dominants in the grassy ground can include *Schizachyrium fragile* (firegrass), *Heteropogon contortus* (black speargrass) or *Themeda triandra* (kangaroo grass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills.	LC
9.12.20	Woodland to low woodland of *Eucalyptus pachycalyx* (pumpkin gum) +/- *E. cloeziana* (Gympie messmate) +/- *Corymbia leichhardtii* (yellowjacket) +/- *Callitris intratropica* (cypress pine) +/- *E. portuensis* (white mahogany) +/- *E. cullenii* (Cullen's ironbark) or *E. atrata*. The mid-dense shrub layer includes juvenile canopy species, *Grevillea glauca* (bushman's clothepeg), *Persoonia falcata* and *Xanthorrhoea johnsonii* (grass-tree). The medium to dense grassy ground layer is mostly dominated by *Themeda triandra* (kangaroo grass). Occurs on steep rugged hills on acid volcanics.	LC
9.12.30a	Woodland to open forest of *Corymbia leichhardtii* (yellowjacket) and *Eucalyptus cloeziana* (Gympie messmate) +/- *E. portuensis* (white mahogany) +/- *C. citriodora* (lemon-scented gum) +/- *E. cullenii* (Cullen's ironbark) +/- *Callitris intratropica* (cypress pine). Some canopy species can occur as emergents. The sparse to mid-dense shrub layer is dominated by juvenile canopy species, *Persoonia falcata*, *Grevillea glauca* (bushman's clothepeg) and *Allocasuarina inophloia* (stringybark sheoak) and a lower shrub with *Jacksonia thesioides* and *Xanthorrhoea johnsonii* (grass-tree) can occur. The sparse to mid-dense ground layer is dominated by *Themeda triandra* (kangaroo grass). Rocky rhyolite hills to steep hills.	LC

[1] Conservation status as listed under the *Vegetation Management Act 1999*: LC – Least Concern, OC – Of Concern.

9.1.1 Amendment to Regional Ecosystem Mapping

It is noted that RE 7.12.57 (Of Concern) was not found to occur in the ridge areas shown on the mapping. This is evidenced by the absence of the constituent canopy tree for this RE – *Syncarpia glomulifera*. Ridge vegetation was found to more closely correspond with the descriptions for RE 7.12.30, with frequent occurrences of rock pavements and sparsely vegetated zones of skeletal soil, which are consistent with the description for RE 7.12.65k (listed as Least Concern under the *Vegetation Management Act 1999*).

Due to the small area that RE 7.12.65k occupies along ridges, it is proposed to amend the mapping to show a heterogeneous polygon that reflects this vegetation condition. Proportionately, the proposed heterogeneous unit will include 80 percent of RE 7.12.30b and 20 percent of RE 7.12.65k. These REs are described in **Table 2** and shown on the mapping in **Appendix D2**.

Table 2. Descriptions of RE 7.12.30 and 7.12.65 from the Regional Ecosystem Description Database (Queensland Herbarium, 20011b).

Descriptions of REs in proposed heterogeneous polygon to replace RE 7.12.57	
7.12.30 *Corymbia citriodora* (lemon-scented gum) +/- *Eucalyptus portuensis* (white mahogany) woodland to open-forest. Granite and rhyolite (often coarse-grained red earths and lithosols with much surface rock). (BVG1M: 10b). Listed as Least Concern under the *Vegetation Management Act 1999*.	
Major vegetation communities of 7.12.30:	
7.12.30a	*Corymbia citriodora*, *Eucalyptus portuensis*, *C. intermedia*, *Syncarpia glomulifera* woodland to low woodland to open-forest with *Callitris intratropica*, *Acacia calyculata* and *Xanthorrhoea johnsonii*. Uplands and highlands, of the moist and dry rainfall zones. (BVG1M: 10b)
7.12.30b	*Corymbia citriodora* and *Eucalyptus granitica*, +/- *E. reducta*, +/- *C. abergiana* woodland to low open-woodland often with *Acacia calyculata* and *Jacksonia* sp., and with *Themeda triandra* in the ground stratum. Rocky granite footslopes and mid-slopes. (BVG1M: 10b)
7.12.30c	*Eucalyptus portuensis*, *Corymbia citriodora*, *Syncarpia glomulifera* woodland and shrubland with a shrubby understorey of *Lophostemon confertus* and *S. glomulifera*, and a ground stratum of *Xanthorrhoea johnsonii*. Rocky slopes on rhyolite and granite. (BVG1M: 10b)
7.12.65 Rock pavements or areas of skeletal soil, on granite and rhyolite, mostly of dry western or southern areas, often with shrublands to closed forests of *Acacia* spp. (wattles) and/or *Lophostemon suaveolens* (swamp mahogany) and/or *Allocasuarina littoralis* (black sheoak) and/or *Eucalyptus lockyeri* subsp. *exuta*. (BVG1M: 28e). Listed as Least Concern under the *Vegetation Management Act 1999*.	
Major vegetation communities of 7.12.65:	
7.12.65a	Rock pavement communities of the dry rainfall zone with *Acacia leptostachya*, *Eucalyptus lockyeri* subsp. *exuta*, *Lophostemon confertus*, *L. suaveolens*, *Persoonia falcata*, *Ficus rubiginosa* and *Allocasuarina inophloia*. (BVG1M: 28e)
7.12.65b	Rock pavement communities of the dry rainfall zone with *Acacia leptostachya*, *Eucalyptus lockyeri* subsp. *exuta*, *Lophostemon confertus*, *L. suaveolens*, *Persoonia falcata*, *Ficus rubiginosa* and *Allocasuarina inophloia*. Far northern areas including Adeline Creek. (BVG1M: 28e)
7.12.65c	Low woodland and shrubland complex with *Lophostemon suaveolens*, *Corymbia citriodora*, *Eucalyptus lockyeri* subsp. *exuta*, *E. granitica*, *E. drepanophylla* and *E. portuensis*. Shrubs often occur in clumps or groves either as an understorey or scattered shrubland communities within the type and include *Lophostemon suaveolens*, *L. confertus*, *Acacia leptostachya*, *Allocasuarina inophloia* and *Melaleuca viridiflora*. Dry rainfall zone areas of abundant surface rock and shallow or

Descriptions of REs in proposed heterogeneous polygon to replace RE 7.12.57	
	skeletal soils. (BVG1M: 9d)
7.12.65d	*Eucalyptus cloeziana*, *Corymbia abergiana*, *C. citriodora*, *E. portuensis*, *E. shirleyi*, *E. lockyeri* subsp. *lockyeri* woodland with a shrubby understorey dominated by *Petalostigma pubescens*, *Bursaria spinosa*, *Grevillea sessilis*, *Grevillea glauca*, *Allocasuarina inophloia*, and *Xanthorrhoea johnsonii*. Rocky slopes on granite. (BVG1M: 28e)
7.12.65e	Complex of open to closed shrublands, low to medium woodlands and forests and grasslands of mountain granite and rhyolite rock pavements. Main component: scrub (*Allocasuarina littoralis*, *Syncarpia glomulifera*, *Lophostemon confertus*), shrubland (*Banksia aquilonia*, *Leptospermum* sp.) and heath (*Xanthorrhoea johnsonii*, *Gahnia* spp., *Dicranopteris linearis*). Granite and rhyolite rock pavements. (BVG1M: 28e)
7.12.65f	Rock pavement communities on granite, of the dry rainfall zone with *Acacia leptostachya*, *Eucalyptus lockyeri* subsp. *exuta*, *Lophostemon confertus*, *L. suaveolens*, *Persoonia falcata*, *Ficus rubiginosa* and *Allocasuarina inophloia*. All areas except Adeline Creek and other northern areas. Rock pavement communities on granite. (BVG1M: 28e)
7.12.65g	Open to closed-scrub and low forest with *Leptospermum neglectum*, *Banksia aquilonia*, *Allocasuarina littoralis*, *A. torulosa* (in valleys), *Acacia celsa* (in valleys), *Syncarpia glomulifera*, and *Rhodomyrtus trineura*. Low forest is confined to the lower sections of deep valleys. Escarpments and rocky knolls and adjacent deep valleys. (BVG1M: 28e)
7.12.65h	*Acacia* spp. low closed shrubland and forest. Areas of skeletal soils. (BVG1M: 28e)
7.12.65i	*Lophostemon suaveolens* low closed shrubland. Steep rocky slopes on the drier margins of Herbert Gorge. (BVG1M: 28e)
7.12.65j	Bombax ceiba or *Cochlospermum gillivraei* deciduous low woodland to open woodland. Granite. (BVG1M: 7b)
7.12.65k	Bare granite and rhyolite rock, of dry western areas, associated with shrublands to closed forests of *Acacia* spp. (wattles) and/or *Lophostemon suaveolens* (swamp mahogany) and/or *Allocasuarina littoralis* (black sheoak) and/or *Eucalyptus lockyeri* subsp. *exuta*. Dry western areas. Granite and rhyolite. (BVG1M: 28e)

9.2 Essential Habitat

A review of regional ecosystem and the associated essential habitat mapping was made to determine what areas of vegetation constitute this important type of habitat for conservation significant species of flora and fauna. A circular area associated with the south-western corner of the study area is shown to be essential habitat for the species listed in **Table 3**. Proposed turbines 26 and 28-35 occur within the mapped essential habitat zone. Turbines 22 and 27 are shown to be just outside of this area.

Table 3 - Plant species shown to have essential habitat in the study area.

Scientific Name	Common Name	NCA[1]	EPBC[2]
Acacia purpureopetala	A wattle (prostrate)	V	V
Grevillea glossadenia	A shrub	V	V
Homoranthus porteri	A shrub	V	V
Plectranthus amoenus	A herb	V	-

[1] Conservation status as listed under the *Nature Conservation Act 1992*:
E – Endangered, V – Vulnerable, LC – Least Concern

[2] Conservation status as listed under the *Environment Protection and Biodiversity Conservation Act 1999*:
E – Endangered, V - Vulnerable

Grevillea glossadenia is widespread across the project area south of the power line, and is in fact growing *en masse* in disturbed ground around the cleared wind monitoring tower near turbine 50, as well as at numerous other sites.

Homoranthus porteri was found in precisely the area shown on the essential habitat mapping, and in a number of other locations. This species clearly favours the edges of rock pavements and forms almost mono-specific thickets. It is entirely restricted to exposed ridge topography.

Plectranthus amoenus was found at a number of sites on rock pavements in small colonies. It is entirely restricted to the depauperate growing environment of rock pavements and sites with little if any soil.

Despite concerted ground searches, the prostrate wattle *Acacia purpureopetala* was not found in this area. However, this does not discount its presence in similar habitat at this location, and the steeply dissected country of the south-western corner of the study area is likely to harbour this inconspicuous species. It is recommended that detailed ground searches are undertaken at precise locations of the turbines in this area, at a time when more focussed investigation can be undertaken.

The REs which correspond with the essential habitat mapping and associated species are listed in **Table 4**.

Table 4 - Regional ecosystems corresponding with essential habitat (not all REs shown here are present in the study area).

Species	RE (Habitat)
Acacia purpureopetala	None listed, but mapping shows: 7.12.34, 7.12.57, 9.12.4c/9.12.2, 7.12.65k.
Grevillea glossadenia	None listed, but mapping shows: 7.12.34, 7.12.57, 9.12.4c/9.12.2, 7.12.65k.
Homoranthus porteri	None listed, but mapping shows: 7.12.34, 7.12.57, 9.12.4c/9.12.2, 7.12.65k.
Plectranthus amoenus	7.12.7; 7.12.27; 7.12.30; 7.12.34; 7.12.52; 7.12.57; 7.12.65; 9.12.4; 9.12.17; 9.12.20

9.3 Wildlife Online Database Search - Flora

A total of 95 records of flora were returned in a search of the Wildlife Online database. This search was based on a four kilometre search radius established around the approximate centre of the study area (centred on coordinates latitude 17.1676° and longitude 145.3814°). Given the wind farms relatively isolated position in the landscape – separated from different landforms by steeply dissected rocky terrain, this search area was considered sufficient to capture representative data from the range of vegetation and habitat types likely to be found.

Of these records, seven species are listed as conservation significant and are shown in **Table 5**. It is noted that these records from the Wildlife Online database are either confirmed through visual sightings or by voucher specimens held in the Queensland Herbarium (cf. HERBRECS data). Field surveys confirmed the presence of three conservation significant plant species: *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus*. The complete Wildlife Online search results are given in **Appendix E2**.

Table 5 - Conservation significant flora as listed in the Wildlife Online database (search centred on coordinates: latitude 17.1676°, longitude 145.3814° within a four kilometre radius search around the site).

Scientific Name	Common Name	NCA[1]	EPBC[2]
Acacia purpureopetala	A prostrate wattle	V	V
Goodenia stirlingii	A woody subshrub	V	-
Grevillea glossadenia	A shrub	V	V
Homoranthus porteri	A shrub	V	V
Melaleuca uxorum	A shrub	E	-
Peripleura scabra	A forb	NT	-
Plectranthus amoenus	A succulent	V	-

[1] Conservation status as listed under the *Nature Conservation Act 1992*:
E – Endangered, V – Vulnerable, NT – Near Threatened

[2] Conservation status as listed under the *Environment Protection and Biodiversity Conservation Act 1999*:
E – Endangered, V - Vulnerable

9.4 Protected Matters Database Search - Flora

A polygon search was made of the EPBC Act's Protected Matters database for 'matters of national environmental significance' that could occur within the study area. This database returns records of conservation significant species as listed under the EPBC Act, and are based on a range of parameters and predictions using a range of bio-models and data. The search resulted in eight records of flora that could possibly occur within the study area in suitable habitats. Records for plants of conservation interest are shown in **Table 6**. The complete Protected Matters report including an account of the conservation significant flora) is given in **Appendix DI** (as per fauna section).

The landscape context of the wind farm proposal is important to consider when predicting whether a certain species is likely to occur; for example, epiphytic ferns such as *Huperzia marsupiiformis* are most unlikely to occur on ridge topography where turbines are proposed to be constructed, due simply to a complete absence of suitable, closed forest habitat. It is noted that the search of the Protected Matters database did not return results for plants of conservation interest (and listed under the EPBC Act) that obviously occur within the search area, and have been validated by voucher specimens held in the Queensland Herbarium. Two species that are relevant in this context are *Grevillea glossadenia* and *Homoranthus porteri* – both of which were found during the current survey in the south-west portion of the study area.

Table 6 - Conservation significant flora as listed in the EPBC Act's Protected Matters database.

Scientific Name	Common Name	Status[1]	Presence in Study Area
Acacia guymeri	A wattle	V	**Low possibility** although no specimens collected or shown in HERBRECS data.
Acacia ramiflora	A wattle	V	**Low possibility** although no specimens collected or shown in HERBRECS data.
Chamaesyce carissoides	A forb	V	**Unlikely** - no specimens collected or shown in HERBRECS data.
Dendrobium superbiens	Curly Pinks	V	**Unlikely** – sub-optimal habitat.
Huperzia marsupiiformis	Water Tassel-fern	V	**Unlikely** due to absence of well-developed vine forest habitat.
Phalaenopsis rosenstromii	An orchid	E	**Unlikely** due to altitude above sea level. Generally occurs at lower elevation in well-developed rainforest.

Scientific Name	Common Name	Status[1]	Presence in Study Area
Taeniophyllum muelleri	Minute Orchid, Ribbon-root Orchid	V	**Unlikely** due to sub-optimal habitat.
Tropilis callitrophilis	Thin Feather Orchid	V	**Low possibility** although no specimens collected or shown in HERBRECS data.
[1] Conservation status as listed under the *Environment Protection and Biodiversity Conservation Act 1999*: CE – Critically Endangered, E – Endangered, V – Vulnerable, X – Extinct.			

9.5 HERBRECS – Queensland Herbarium Records

HERBRECS is the Queensland Herbarium's specimen records database and lists voucher specimen label data for plants that have been collected from a given region. A request was made to the Herbarium to supply the records data for the project area.

From the HERBRECS data, 1048 species of plants have been recorded from a grid that encompasses the project area. This grid incorporates a wide zone extending well beyond the project's footprint, and consequently takes in a range of habitats that are not present in the study area. To retrieve a more representative account of the flora presence in the study area, the HERBRECS data was reviewed and redundant taxa excluded. For example, rainforest-obligate species collected from east of the Kennedy Highway were pruned from the dataset.

The pruned dataset identifies that 12 specimens comprising nine species of conservation significant plants have been collected within or adjacent to the project area. A summary of significant species extracted from the HERBRECS data is given in **Table 7**. The location of these species in relation to the study area is shown in **Appendix F2**.

Several taxa shown in the HERBRECS data may not be encountered within the project area. It is noted also, that the conservation status under the NCA has recently been revised, and some species such as *Tephrosia savannicola* are no longer conservation significant. Given the proximity of the project area to Mt Emerald and the Stannary Hills region, where several species of conservation interest have been collected, there is reasonable probability that a number of taxa shown in the table could occur in the project area.

Table 7 - Summary of HERBRECS data for conservation significant flora.

Name	NCA[1]	EPBC[1]	No. Collections	Comments
Acacia longipedunculata	NT	-	3	Outside project area. Stannary Hills.
Acacia purpureopetala	V	V	2	Specimens collected from south of turbine 31. Also from Stannary Hills.
Agathis microstachya	NT	-	4	Significantly outside project area. Associated with poor rainforest.
Alloxylon flammeum	V	V	1	Outside project area. Rocky Creek.
Archidendropsis xanthoxylon	NT	-	1	Outside project area. Atherton district.
Brasenia schreberi	NT	-	1	Outside project area. Nardello's lagoon.
Cajanus mareebensis	E	E	2	Outside project area. Near Dimbulah, and Gorge Creek west of Mareeba.
Chamaesyce carissoides	V	V	1	Outside project area. Stannary Hills.
Elaeocarpus coorangooloo	NT	-	2	Outside project area. Atherton district and

Name	NCA[1]	EPBC[1]	No. Collections	Comments
				Tolga.
Glossocardia orthochaeta	E	-	1	Outside project area. Stannary Hills.
Grevillea glossadenia	V	V	3	Specimens collected from south of turbine 31 and just SW of 51. Confirmed sightings during this survey 500 m SE of turbine 22.
Homoranthus porteri	V	V	3	Specimens collected from south of turbine 31. Confirmed sightings during this survey 500 m SE of turbine 22.
Lysiana filifolia	NT	-	1	Significantly outside project area. Stannary Hills.
Melaleuca uxorum	E	-	2	Specimen collected from rocky country just south of turbine 36.
Peripleura scabra	NT	-	2	Outside project area. Stannary Hills.
Peripleura sericea	NT	-	2	Outside project area. Stannary Hills.
Plectranthus amoenus	V	-	5	Specimens collected from near turbine 66. Other specimens collected outside of study area south of turbine 31.
Prostanthera sp. (Dinden P.I.Forster+ PIF17342)	E	-	1	South of project area near Oaky Creek.
Rhamphicarpa australiensis	NT	-	1	Outside project area. Nardello's Lagoon.
Tephrosia savannicola	R	-	1	Outside project area. Stannary Hills. Note, this species is no longer listed under the NCA.
Thaleropia queenslandica	NT	-	3	Significantly outside project area. In rainforest.
Zieria obovata	V	V	1	Outside project area. Stannary Hills.

[1] The conservation status codes under the *Nature Conservation Act 1992* and the *Environment Protection and Biodiversity Conservation Act 1999* as follows: E – Endangered, V – Vulnerable, R – Rare (former status), NT – Near Threatened.

9.6 Regional Vegetation Management Codes

A review was made of the Regional Vegetation Management Codes as issued under the *Vegetation Management Act 1999*. Two codes are relevant, as the project area encompasses two bioregions: the Einasleigh Uplands (Western Bioregions Code), and the Wet Tropics (Coastal Bioregions code). Both code versions were released in November 2009.

A provisional address to the performance requirements of the codes is given in **Appendix G2**.

9.7 Watercourses

Watercourses occurring in the study area were mapped using the Department of Environment and Resource Management's (DERM) Regrowth Watercourses data (version 2.0, 2010). These features are shown on the mapping given in **Appendix H2**. The mapping shows that a number of lower order watercourses will be crossed (mostly first order stream features). All these features flow intermittently during the wet season, and their integrity is expected to remain in near natural condition with expected limited levels of disturbance. It is noted that where these features are intersected, the proposed track will use existing stream crossings currently used as maintenance access for the powerline infrastructure.

A comprehensive survey of watercourses was not undertaken in the field, although detailed floristic investigations were undertaken of a reach of Granite Creek approximately situated in the centre of the study area. This section of watercourse is in sound ecological condition. Vegetation lining this feature is limited to a narrow band of *Lophostemon grandiflorus* trees, which form the only differentiation between stream bank dependent vegetation and the surrounding woodland. This limited floristic diversity is an indicator of seasonal flows and relatively dry bank conditions.

9.8 Wetlands

Granite Creek at the base of the wind farm project area is mapped as a Wetland by DERM. A reach of this watercourse adjacent to the main entry point and lower access road into the site has a 100 m buffer shown as a Wetland Management Area trigger zone. Approximately, 1 km of the lower access road passes through this trigger area due to the proximity of the existing track to Granite Creek.

It is noted however, that no wetlands or wetland trigger areas are present in the project footprint where wind turbines are proposed at higher elevation.

10.0 Field Investigation – Vegetation & Flora

A five-day field survey of the study area was undertaken in early May 2010 to investigate the vegetation, floristic composition, and range of habitats present in the study area. Several field surveys were also undertaken in 2011 during February, March, April and June. A total of 120 vegetation surveys were completed across the project area.

An opportunity was also taken during the field investigation to make an assessment of the probable level of impact that the proposed project might have on the immediate environmental character of the study area, with reference to vegetation communities and flora of conservation interest.

The survey aimed at investigating a number of sites where wind turbines are proposed to be located. These sites were determined through consultation with representatives of the project's proponent, and through interpretation of aerial photography of the study area showing the remnant vegetation overlay and the provisional position of each wind turbine. A degree of lateral investigation was allowed for in order to accommodate for site-specific changes if required (e.g. in the event that a provisional position of a turbine occurred in an environmentally sensitive area). Several turbine location amendments were made during the course of the investigations.

Quaternary level vegetation surveys focussed on determining the accuracy of RE mapping and making assessments of the conspicuous floristic composition of mapped vegetation communities. This level of survey is consistent with the methods outlined by Neldner *et al* (2005) and records the landform characteristics, and the floristic composition of all structural layers (canopy, subcanopy, shrub and ground layers). Wherever possible, flora surveys were inclusive of an area approximating the expected cleared footprint for a turbine, plus a buffer distance around the proposed site.

A small number of turbine locations could not be investigated due to their remoteness and the difficulty in reaching these sites within the timeframe allocated for the investigation. Nevertheless, a number of sites were adopted as surrogates for those that could not be reached and investigated. Detailed floristic accounts for these surrogate sites, particularly for the ground flora could not be compiled.

The findings of the field investigations of vegetation and flora, as well as an overview of fauna and habitats are presented in the following sections.

10.1 Flora and Vegetation Assessment

10.1.1 Vegetation Overview and Condition

The project area has high levels of ecological integrity and intactness, which is evidenced by low levels of disturbance and the contiguous nature of remnant vegetation. Consequently, vegetation condition is high, with areas of physical disturbance restricted to the existing powerline easement and access roads that link the tower infrastructure for this power line. Small populations of grader grass (*Themeda quadrivalvis*) are a weed of significance observed in the project area that detracts from the landscape condition.

Other notable exotic grasses found in the project area include molasses grass (*Melinis minutiflora*); pigeon grass (*Setaria pumila*) and thatch grass (*Hyparrhenia rufa*). These species are found adjacent to existing access tracks and the powerline easement. *M. minutiflora* is found outside of this typical disturbance footprint in remnant woodland on sheltered slopes on the eastern side of the project area. Molasses grass and grader grass are known to exacerbate wildfires and will outcompete native grasses, such as Kangaroo grass - *Themeda triandra* (Humphries & Stanton, 1992). Where these exotic grasses occur, floristic integrity in the groundlayer is compromised.

The current RE mapping and respective descriptions of each vegetation community (version 6.0 data) is provided in **Appendix B2** and **C2** respectively.

Outside of the disturbance footprint of the powerline infrastructure, vegetation integrity is at its highest, with no signs of physical modification, and only marginal incursions of weeds, of which Praxelis (*Praxelis clematidea*) and *M. repens* are noteworthy species. Praxelis is invariably found as widely dispersed individuals in intact woodland communities, and its presence is a consequence of its wind dispersed seeds, or possibly carried in the fur of mammals. There appears to be no particular preference for Praxelis to inhabit a certain niche (unlike grader grass for example, which has the propensity to occupy the verges of roads). Molasses grass is found in a number of locations in woodland communities, and generally has a preference for the eastern half of the project - particularly on eastern facing slopes with higher levels of moisture retention and capacity to capture prevailing wind-borne moisture.

Several remnant vegetation communities are present in the project area. Many of these have limited patterns of distribution and occupy relatively small niches associated with the rocky and dissected terrain. The commonest and most widespread community is the woodland association comprising *Callitris intratropica*, *Corymbia leichhardtii* and *Eucalyptus shirleyi* on flatter land in the centre of the project area. This landform is characterised by less surface rocks; whereas a majority of the other communities are found on ridges or in the limited growing environment afforded by accumulated organic material amongst outcropping rhyolite rock formations and rock pavements with skeletal soils.

A woodland community typified by *Eucalyptus cloeziana* occurs as patches mostly across western facing slopes. This woodland merges with other woodland types and may include other co-dominant trees such as *Corymbia citriodora* and *Eucalyptus portuensis*.

Ridges are characterised by the ironbark *Eucalyptus granitica* (primarily along northern ridges), *Eucalyptus lockyeri* subsp. *exuta*, *Eucalyptus portuensis* and *Corymbia abergiana* (mostly along southern ridges). The tree diversity in this situation is relatively simple, where greater plant diversity is found in the ground and lower shrub layers.

Stream dependent vegetation is confined to a very narrow band of a single, interrupted line of trees along Granite Creek that flows through the valley and exits the survey area through the ravine just east of Walsh's Bluff. Detailed surveys of vegetation in this ravine were not undertaken as this area is considered to be outside of the proposed zone of impact. The common species of this watercourse and other seasonal drainage lines is *Lophostemon grandiflorus*, which is entirely restricted to the immediate bank environment. A number of deeply incised ravines and gorges are likely to support similar vegetation types, or may afford habitats for unusual types in inaccessible areas.

The project area, particularly south of the existing powerline infrastructure and in the vicinity of Mt Emerald, has important habitat values for rare and threatened plants (conservation significant fauna are discussed separately). These plants include species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and Queensland's *Nature Conservation Act 1992*. Commonly occurring conservation significant species in this respect are *Eucalyptus lockyeri* subsp. *exuta*, *Grevillea glossadenia* and *Homoranthus porteri*. Less common, but encountered on rock pavements, is *Plectranthus amoenus*.

Although not encountered in field surveys, the conservation significant prostrate wattle *A. purpureopetala* is likely to occur in the south-west of the project area and possibly elsewhere. Similarly, although not encountered, the highly restricted and endangered *Melaleuca uxorum* is also known to occur around the south-west portion of the project area.

10.1.2 Effects of Fire

Fire mapping based on interpretation of satellite imagery obtained from the Northern Australia Fire Information (NAFI, 2011) indicates that the entire site was burnt most recently in 2009. No other fires were mapped on the site back until at least 2004. It should be noted that the pixel size of the MODIS satellite imagery is approximately 300 m^2 so the mapping is unable to provide a realistic indication of the degree of the spatial heterogeneity of fires.

From visual assessments of the extent of scorching on trees, the fires are presumed to have been relatively hot and ferocious – extending completely into the crowns of trees in the canopy of vegetation to 10 m high. Emergence of epicormic shoots and young branchlet formation provide evidence that the fires severely affected sections of ridgeline vegetation (particularly smaller trees such as *Corymbia abergiana*). Dense, monospecific stands of low wattle regrowth (believed to be *Acacia calyculata*) have developed as the dominant shrub layer in areas where fire appears to have had the severest impact. Little other ground layer vegetation is present in these situations except for clumps of tussock grasses (an *Aristida* sp.).

The 2009 fires do not appear to have affected the whole project area. For example, the flat-bottomed valley in the interior and the western ridgeline has remained relatively unburnt and show fewer signs of severe fire events. In this sense, it is believed that fire passes through the project area on a periodic basis – enough to limit the development of excessive fuel loads. For example, sections of woodland or open forest where the pronounced effect of recent fires was not evident, did not support a conspicuously 'heavy' fuel load in the ground layer, and in fact, were relatively easy to traverse. In these circumstances, grasses such as *Themeda triandra* and *Heteropogon triticeus* are invariably present and favour the under-canopy environment afforded by the structural formation of woodland to open forest, rather than sparser open woodland. Generally, it was found that ironbarks (*Eucalyptus drepanophylla* and *E. granitica*) are sparsely represented in these vegetation communities.

10.1.3 Flowering and Fruiting Phenology

No trees were observed to be flowering or fruiting at the time of the surveys. The vestiges of capsules of *Corymbia abergiana* (rarely), *C. leichhardtii*, *Eucalyptus cloeziana*, *E. lockyeri* subsp. *exuta* and *E. shirleyi* aided their identification in the early stages of the survey. Scorched flower buds of *E. reducta* were also observed.

Shrubs, notably *Homoranthus porteri* and *Grevillea glossadenia* were flowering along with a range of subshrubs and woody legumes. Wattles (*Acacia* spp.) do not feature prominently as floristic elements other than the relatively common presence of *Acacia umbellata* on flat surfaces and *A. calyculata* along fire-affected ridges and on rock pavements. The latter species is the most widespread and is the commonest wattle across the study area and clearly favours open woodland communities and landforms that are sparsely populated by trees. A number of shrubs were observed to be sterile, rendering their identification difficult. Most of these shrubs occurred on rocky substrates with a particular preference to exposed rocky knolls and outcropping rhyolite.

The ground layer was observed to be relatively productive in terms of flowering and fruiting. Herbaceous legumes are relatively uncommon across the study area, and only two taxa were encountered in sterile form. All species of grass were seen in fertile form, as were non-leguminous forbs and subshrubs. Two species of *Lomandra* were found to be sterile. Two ferns: a hirsute *Cheilanthes* species and an indeterminate species were sterile.

10.1.4 Regional Ecosystem Mapping Amendment

Regional ecosystem mapping was found to have varying levels of accuracy, particularly in regard to the floristic composition when compared to the RE descriptions. Polygon boundary accuracy is difficult to detect on the ground, but such accuracy is assumed to be greater in the wet tropics bioregion portion of the project site, where mapping has been prepared at a scale of 1:50,000.

Mapping accuracy is markedly different for the remainder of the study area (mostly the northern section) where this area is included in the Einasleigh Uplands bioregion. Mapping for this region was prepared at a scale of 1:100,000 and the application of heterogeneous polygons are more frequent.

An important observation was made of a significant mapping error in the Wet Tropics bioregion section of the project area south of the powerline. Here, the RE 7.12.57 (Of Concern) is erroneously mapped along ridges and higher ground. This unit, characterised by trees of *Syncarpia glomulifera* is clearly absent. *S. glomulifera* is a distinctive species and easily identified by its pseudo-whorled leaves and very pale abaxial leaf surface. The species was not found as a constituent canopy tree at any of the 120 vegetation survey sites along ridges or in the project area.

Woodland communities mapped adjacent to the RE 7.12.57 unit are shown to be RE 7.12.34 (Least Concern). Surveys confirmed that the 7.12.34 unit is correct. It was found to extend to ridgeline topography, where it is typically intersected by rock pavements and areas of skeletal soils. These smaller areas of rock pavement and rocky soils were determined to be RE 7.12.65 or subunit derivatives thereof (e.g. 7.12.65k). The RE mapping for the project area in the Wet Tropics bioregion is therefore amended to reflect the presence of these rock pavements and sparsely vegetated zones. The proposed new heterogeneous polygon is 7.12.30b / 7.12.65k – this descriptor replaces occurrences of RE 7.12.57 within the project area. Amended RE mapping is shown in **Appendix D2**.

The REDD description (Queensland Herbarium, 2011b) for RE 7.12.30b and 7.12.65k is as follows:

> **7.13.30b** – *Corymbia citriodora* and *Eucalyptus granitica*, +/- *E. reducta*, +/- *C. abergiana* woodland to low open-woodland often with *Acacia calyculata* and *Jacksonia* sp., and with *Themeda triandra* in the ground stratum. Rocky granite footslopes and mid-slopes. (BVG1M: 10b).
>
> **7.12.65k** – Bare granite and rhyolite rock, of dry western areas, associated with shrublands to closed forests of *Acacia* spp. (wattles) and/or *Lophostemon suaveolens* (swamp mahogany) and/or *Allocasuarina littoralis* (black sheoak) and/or *Eucalyptus lockyeri* subsp. *exuta*. Dry western areas. Granite and rhyolite. (BVG1M: 28e).

The amended RE mapping does not apply to any vegetation communities represented outside of the project area boundary. It is also noted that more detailed vegetation information could be required for the extreme south-eastern section of the project area; although no turbines are proposed in this area.

10.2 Description of Vegetation Survey Sites

Several ground surveys were undertaken to sample as widely as possible, a range of vegetation communities over an 18 month period. Field investigations aimed at sampling representative communities in which turbines are proposed to be established. Given the scale of the project (75 wind turbines) it was not possible to sample the entire project area, and consequently the complete areas of vegetation likely to be impacted. For example, vegetation between a number of turbines where the construction of roads is proposed was not possible given the provisional nature of the layout, and the need to refine track routes. In this respect, it is recommended that further vegetation studies are undertaken closer to the final layout of the project, with reference to ground searches for plants of conservation interest and important or novel vegetation units.

Emphasis was placed on surveying sites for flora where a wind turbine is proposed to be located. Surveys were undertaken by establishing sample plots with a minimum area of 50 x 50 m or greater if the location allowed for such. Note that some ridge lines are less than 50 m wide, and therefore, the vegetation sampling area was reconfigured accordingly. Plots were systematically surveyed for all vascular plants in all structural layers. To gauge floristic variation and discrete vegetation patterns, random meander surveys were also performed outside of the plot and through vegetation that links one turbine to the next where a string of turbines are proposed to be situated on ridges.

The survey recorded native species (deemed to occur naturally in the region), and naturalised species (i.e. not native to Australia and often expressed as weeds). A checklist list of the flora species identified during this survey is provided in **Appendix I2**. It is noted that at the time of the first ground survey in 2010, the ridges along the eastern boundary of the survey area had been affected by severe fires during 2009, and many plants in the shrub and ground layers had not fully recuperated, rendering their identification difficult or impossible. Similarly, given the relatively low structure of the vegetation on these ridges, many of the principal canopy tree species had responded to the fires by developing dense epicormic growth with atypical leaf forms.

Many plants in the ground layer along ridges are expected to be ephemeral or annual species, and are quite likely to regenerate once suitable conditions prevail. The survey for flora must therefore be viewed as provisional, being more indicative of the woody, perennial component rather than the ephemeral or annual component, which is expected to comprise grasses, legumes and a number of forbs and sub-shrubs.

Typical descriptions of the vegetation survey points are given in the following sub-sections. The location of these sites is shown in **Appendix A2** and structural descriptions for the 120 sites surveyed are given in **Appendix J2**. The vegetation integrity ratings were derived from Wannan (2009) and shown in the box below.

Vegetation Integrity Ratings (after Wannan, 2009)					
Rating	**Structure & Floristics**	**Weed Invasion**	**Woody Vegetation**	**Herbaceous Vegetation**	**Physical Disturbance**
1	Intact or almost so	Minimal or absent	Intact	90-100% native cover	Minimal or nil
2	Substantially intact	Low levels	Intact	70-90% native cover	Low
3	Partially intact	Moderate levels	Intact	>50% native cover	Moderate
4	< 50% cover of native spp. & much reduced richness	>50% cover of weeds	Upper strata moderate-high cover	With <50% native cover	High
5	Grossly modified	Very high cover	Scattered dominants of upper strata persisting	Understorey and groundcover >90% exotic	High to very high

Vegetation Integrity Ratings (after Wannan, 2009)					
Rating	**Structure & Floristics**	**Weed Invasion**	**Woody Vegetation**	**Herbaceous Vegetation**	**Physical Disturbance**
6	Plantations of exotic or "native' vegetation				

The level of survey was equivalent to the secondary site detail outlined in Neldner *et al*. (2005) except where stated. The minimum area surveyed was 500 m^2. Generally, additional survey was undertaken outside a plot or detailed investigation area to detect species outliers and occurrences of indiscrete plant communities.

Terminology used in the following descriptions is as follows: **T1** – tallest tree layer (equivalent to the ecologically dominant layer); **T2** – secondary tree layer; **T3** - third tree layer (if discernible); **S1** – tallest shrub layer; **S2** – secondary shrub layer (if present and discernible); **G** – ground layer. **E** indicates an emergent (generally scattered) tree above the tallest stratum. Height was estimated in the field. Cover is equivalent to the projected foliage cover of each structural layer. Underlined taxa indicate that a species is dominant. A taxon in parenthesis indicates a rare occurrence in the 500 m^2 plot, or was recorded outside of the plot area. An asterisk (*) preceding a species name indicates that the plant is naturalised. Nomenclature follows Bostock & Holland (2010). Numbered survey sites are shown previously on the mapping in **Appendix A2**.

10.2.1 Vegetation Survey Site 1 (Land surrounding Granite Creek)

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Open woodland to woodland 8-15 m of *Callitris intratropica* and *Corymbia leichhardtii* interspersed with ± bare rock pavements.

T1 (8-10 m): <u>*Callitris intratropica*</u>, <u>*Corymbia leichhardtii*</u>, (*Eucalyptus lockyeri* subsp. *exuta*), *Corymbia citriodora*, (*E. drepanophylla*).

T2 (4-6 m): *Callitris intratropica*, *Corymbia leichhardtii*, *E. shirleyi*, (*Melaleuca nervosa*), *M. viridiflora*, (*E. drepanophylla*).

S1 (3 m): *Acacia umbellata*, *Breynia oblongifolia*, (*Grevillea glauca*, *G. parallela*), *C. leichhardtii*, *Persoonia falcata*, *Xanthorrhoea johnsonii*, (*Asparagus* sp.), (*Petalostigma pubescens*), (*Dendrobium canaliculatum*), *Erythroxylon ellipticum*, (*Dolichandrone heterophylla*), (*Clerodendrum floribundum*).

S2 (1.5 m): *Acacia umbellata* in small patches, otherwise S2 is absent.

G (1 m): *Xanthorrhoea johnsonii*, *Eragrostis schultzii*, (*Aristida* sp.), <u>*Pseudopogonatherum contortum*</u>, <u>*Arundinella setosa*,</u> *Glossocardia bidens*, *Aeschynomene* sp., *Rhynchospora* sp., (**Praxelis clematidea*), *Melinis repens*, *Tacca leontopetaloides*, *Panicum effusum*, *Panicum seminudum* var. *cairnsianum*, *Vernonia cinerea*, *Lomandra* sp., (*Haemodorum coccineum*), *Cheilanthes tenuifolia*, (*Themeda triandra*), (*Persoonia falcata*), *Hibbertia stirlingii*, *Acacia humifusa*, *Cymbopogon bombycinus*, *Eriachne ciliata*, *Eriachne* sp. (short grass to 10 cm), *Polycarpaea spirostylis*, *Setaria surgens*, *Schizachyrium pseudeulalia*, *Cartonema spicatum*, *Crotalaria brevis*, *Scleria brownii.*, *Eragrostis* sp., (*Heteropogon triticeus*), (*Euphorbia mitchellii*).

Habitat Features: Exfoliating flakes on rock pavements (geckos). Limited, but longer term availability of water in rock pools in Granite Creek. Significant tree hollows not observed. Numerous dead standing trees - *Callitris intratropica* (stags).

Notes: A fairly uniform landscape with little topographical differentiation and relief. Includes the flatter parts of the project area, and excludes ridges, mid and upper slopes.

Ground becomes increasingly rockier as it gently ascends towards Walsh Bluff in the north. Country south of the existing power line is more dissected, where *Eucalyptus shirleyi* and *E. leichhardtii* become co-dominant and form a lower woodland community (~ 5-8 m). A vegetation integrity rating of 2 has been applied to this survey area, with the only disturbance limited to the infrequently used vehicle track that passes through the area. Weeds are virtually absent, and comprise widely dispersed individuals of herbaceous species (**P. clematidea* and **M. repens*).

10.2.2 Vegetation Survey Site 2

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland to open woodland 8-12 m of *Eucalyptus shirleyi* and *Callitris intratropica* with *E. cloeziana* on rolling hills.

T1 (8-12 m): <u>*Eucalyptus shirleyi*</u>, *Callitris intratropica*, *E. cloeziana* (tallest trees in disjunct groups).

T2 (5-7 m): *C. intratropica*, *E. shirleyi*, *E. drepanophylla*.

S1 (1.5 m): *C. intratropica*, (*Petalostigma pubescens*), *E. shirleyi*, (*Corymbia leichhardtii*), *Dolichandrone heterophylla*, *Breynia oblongifolia*, *Alphitonia excelsa*, *Alyxia spicata*, *Melaleuca* sp. (multi-stemmed, hirsute branchlets), *Grevillea dryandri*.

S2: Absent.

G (0.6 m): *Xanthorrhoea johnsonii*, *Cymbopogon bombycinus*, *Cheilanthes* sp., *Themeda triandra*, *Rhynchospora corymbosa*, *Grevillea dryandra*, *Asparagus racemosus*, *Haemodorum coccineum*, *Panicum effusum*, *Schizachyrium pseudeulalia*, (*Praxelis clematidea*), *Aristida utilis*, *Eriachne ciliata*, *Glossocardia bidens*, *Eragrostis* sp., *Arundinella setosa*.

Habitat Features: Limited features, although small rock pavement provides habitat for skinks. Possible development of good tree hollows in larger specimens of *E. cloeziana* trees. Canopy of nearby *E. cloeziana* trees provides cover for sheltering birds. Small zones of vegetated rock pavement provide habitat for skinks and geckos (fissures and cracks).

Notes: Site occurs on edge of roll over of hill where *E. cloeziana* trees are present. Top of roll-over characterised by more open and widespread vegetation dominated by *E. shirleyi*, with greater exposure and lower growing plant forms. Indeterminate *Melaleuca* sp. collected. No conservation significant species recorded. Weeds limited to isolated specimens of *Praxelis clematidea*. Vegetation integrity rating of 1: given absence of significant weeds, separation from tracks and power line easement.

10.2.3 Vegetation Survey Site 3

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Eucalyptus drepanophylla* and *Corymbia citriodora* to 10 – 12 m on relatively uniform surface.

T1 (10 -12 m): *Eucalyptus drepanophylla*, *Corymbia citriodora*.

T2 (6 – 8 m): *Callitris intratropica*, *E. drepanophylla*, *Corymbia citriodora*.

S1 (1.2 – 1.8 m): *Eucalyptus drepanophylla*, *Persoonia falcata*.

S2: Absent.

G (0.9): *Heteropogon triticeus*, *Themeda triandra*, *Pseudopogonatherum contortum*, *Xanthorrhoea johnsonii*, *Schizachyrium pseudeulalia*, *Arundinella setosa*.

Habitat Features: Relatively low given the patchy distribution of larger trees. Some small tree hollows in older specimens of *Corymbia citriodora*. The ground and shrub layers are floristically simple.

Notes: The vegetation integrity rating is 2 due to the proximity to an infrequently used vehicle track.

10.2.4 Vegetation Survey Site 4

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Low woodland to open woodland of *Eucalyptus shirleyi* to 4 – 5 m on stony rises.

T1 (4 – 5 m): <u>*Eucalyptus shirleyi*</u>.

T2 (3.5 m): *Melaleuca monantha.*

S1 (1.2 m): *Grewia retusifolia*, *Eucalyptus shirleyi*, *Persoonia falcata*.

S2: Absent.

G (0.5 m): *Heteropogon triticeus*, *Cymbopogon bombycinus*, *Themeda triandra*, *Breynia oblongifolia*, *Xanthorrhoea johnsonii*, *Melinis repens*, *Arundinella setosa*, *Hibbertia stirlingii*, *Schizachyrium pseudeulalia*, *Hibiscus meraukensis*.

Habitat Features: Limited to niche availability for reptiles (geckos and skinks) in outcropping rock jumbles.

Notes: This type is representative of what appears to be the most depauperate ground conditions in the study areas, and is also represented in other areas north and just south of the power line. The vegetation integrity rating is 2 due its proximity to an infrequently used vehicle track.

10.2.5 Vegetation Survey Site 5

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Eucalyptus drepanophylla* to 8 – 10 m on rocky surfaces of brow of hill.

T1 (8 – 10 m): <u>*Eucalyptus drepanophylla*</u>, *Corymbia citriodora*.

T2 (6 m): (*Melaleuca nervosa*), (*Corymbia leichhardtii*).

S1 (2 – 3 m): *Eucalyptus drepanophylla*.

S2: Absent.

G (0.6 m): *Xanthorrhoea johnsonii*, *Themeda triandra*, *Pseudopogonatherum contortum*, *Heteropogon triticeus*, Poaceae sp. (superficially similar to *Sarga plumosum*).

Habitat Features: Potential tree hollows in old specimens of *Corymbia citriodora*. A structurally simple vegetation type with limited floristic diversity.

Notes: The vegetation integrity rating is 2 due its proximity to an infrequently used vehicle track.

10.2.6 Vegetation Survey Site 6

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Eucalyptus cloeziana* and *Corymbia citriodora* to 8 – 10 m on uneven ground with rocky soils.

T1 (8 – 10 m): *Eucalyptus cloeziana*, *Corymbia citriodora*, (*Eucalyptus portuensis*).

T2 (5 – 7 m): *Corymbia citriodora*.

S1 (1.2 – 3 m): *Corymbia citriodora*, *Acacia calyculata*, *Grevillea parallela*, *Erythroxylon ellipticum*, *Jacksonia thesioides*, *Capparis canescens*, *Pogonolobus reticulatus*, *Persoonia falcata*, *Bursaria spinosa*.

S2: Absent.

G (0.3 – 0.9 m): *Grevillea dryandri*, *Indigofera pratensis*, **Vernonia cinerea*, *Heteropogon triticeus*, *Xanthorrhoea johnsonii*, *Tephrosia juncea*, *Schizachyrium pseudeulalia*, *Themeda triandra*, *Hibbertia stirlingii*, *Crotalaria brevis*, *Panicum effusum*, *Pseudopogonatherum contortum*, *Breynia oblongifolia*, *Lomandra* sp. (glaucous leaves), *Heteropogon triticeus*, *Grewia retusifolia*, *Aeschynomene micranthos*, *Arundinella setosa*.

Habitat Features: Not recorded.

Notes: The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement.

10.2.7 Vegetation Survey Site 7

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Low woodland of *Eucalyptus lockyeri* to 5 m on rocky, uneven surfaces.

T1 (4 – 5 m): *Eucalyptus lockyeri*.

T2 (3 m): (*Melaleuca viridiflora*).

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Sparsely vegetated with limited important habitat opportunities, except perhaps rocky ground surface (geckos and skinks).

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement.

10.2.8 Vegetation Survey Site 8

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Callitris intratropica* to 8 m on stony and rocky soils.

T1 (8 m): *Callitris intratropica*, (*Eucalyptus lockyeri* subsp. *exuta*).

T2 (4 – 5 m): *Corymbia leichhardtii*.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Limited due to absence of complexity is vegetated layers. Although not recorded, the ground and shrub layers are simple with limited floristic diversity.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement.

10.2.9 Vegetation Survey Site 9

Mapped RE: 7.12.34 (Least Concern under VMA)

Field Description: Woodland of *Corymbia leichhardtii* and *Eucalyptus lockyeri* subsp. *exuta* to 10 m on very rocky surfaces.

T1 (10 m): *Corymbia leichhardtii*, *Eucalyptus lockyeri* subsp. *exuta*, (*Eucalyptus cloeziana*).

T2 (6 – 8 m): *Corymbia leichhardtii*, *Eucalyptus lockyeri* subsp. *exuta*.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Limited due to absence of complexity is vegetated layers. Although not recorded, the ground and shrub layers are simple with limited floristic diversity.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.10 Vegetation Survey Site 10

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Eucalyptus shirleyi* to 5 m on rocky surfaces.

T1 (5 m): <u>*Eucalyptus shirleyi*</u>, (*Callitris intratropica* emergent to 8 m).

T2: Absent.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Tree hollows not observed. As with other areas where *Callitris intratropica* is present, this tree provides useful perching opportunities, but rarely exhibits hollows due to its resilience to decay. Minimal structural layering in vegetation, and limited diversity in ground and shrub layers.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.11 Vegetation Survey Site 11

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Woodland of *Eucalyptus drepanophylla* to 12 m on sloping ground.

T1 (12 m): *Eucalyptus drepanophylla*, (*Corymbia leichhardtii*).

T2: Not recorded.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Not recorded in detail; although tree hollows possibly present. Greater structural diversity and layering than sites to south-west (supporting *Eucalyptus shirleyi*). Potential edge zone of refugial areas leading into watercourse.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.12 Vegetation Survey Site 12

Mapped RE: 7.12.34 (Least Concern under VMA)

Field Description: Woodland of *Corymbia leichhardtii* and *Eucalyptus granitica* to 10 – 12 m on sloping ground with rocky surfaces.

T1 (10 – 12 m): *Corymbia leichhardtii*, *Eucalyptus granitica*, (*Corymbia citriodora*).

T2: Not recorded.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Not recorded in detail; although tree hollows possibly present. Has greater structural diversity and layering than sites to south-west (supporting *Eucalyptus shirleyi*). Has potential edge zone of refugial areas leading into watercourse.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.13 Vegetation Survey Site 13

Mapped RE: 7.12.34 (Least Concern under VMA)

Field Description: Woodland to open forest of *Eucalyptus cloeziana* and *Corymbia citriodora* to 15 m on side of rocky hill.

T1 (12 – 15 m): *Eucalyptus cloeziana*, *Corymbia citriodora*.

T2: Not recorded.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Not recorded in detail; although tree hollows possibly present in old *Corymbia citriodora* trees. Has greater structural diversity and layering than sites to south-west (supporting *Eucalyptus shirleyi*). Has potential edge zone of refugial areas leading into watercourse.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.14 Vegetation Survey Site 14

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Woodland of *Eucalyptus portuensis* to 8 m on rocky hill slope approaching ridge.

T1 (8 m): *Eucalyptus portuensis*.

T2 (5 -6 m): *Eucalyptus lockyeri* subsp. *exuta.*

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Reduction in structural layering and floristic diversity, which is likely to correspond with lesser habitat resources and fewer niche opportunities. Tree hollows not observed.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared track immediately below the power line; otherwise, vegetation is relatively intact.

10.2.15 Vegetation Survey Site 15

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Mixed woodland of *Corymbia abergiana*, *Eucalyptus lockyeri* subsp. *exuta*, *Corymbia citriodora* and *Eucalyptus shirleyi* on ridge with pale soils and scattered surface rocks (with small areas of rock pavement).

T1 (6 – 8 m): *Eucalyptus lockyeri* subsp. *exuta*, *Corymbia citriodora*, (*C. abergiana*).

T2 (4 – 5 m): *Eucalyptus shirleyi*.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: No tree hollows observed. Probable niche opportunities for reptiles (geckos and skinks) in fissures and flakes associated with scattered rock pavements. Vegetation structural layering is simple. Although recorded in detail, ground and shrub layer diversity is relatively low.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared vehicle track; otherwise, vegetation is relatively intact.

10.2.16 Vegetation Survey Site 16

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Woodland of *Eucalyptus cloeziana* and *E. portuensis* with *Callitris intratropica* to 8 m on ridge with pale, rocky soils.

T1 (8 m): *Eucalyptus cloeziana*, *E. portuensis*, *Callitris intratropica*, *Corymbia citriodora*.

T2: Not recorded.

S1: Not recorded.

S2: Not recorded.

G: Not recorded.

Habitat Features: Potential for tree hollows in older specimens of *Eucalyptus cloeziana* and *Corymbia citriodora trees*, but not observed. Structural layering and floristic diversity is expected to be higher than turbine site 56 (VP 15), as this trait has been observed at other sites where *E. cloeziana* occurs.

Notes: Observational survey from vehicle. The vegetation integrity rating is 2 due to close proximity of site to power line and cleared easement. Significant disturbance is restricted to the cleared vehicle track; otherwise, vegetation is relatively intact.

10.2.17 Vegetation Survey Site 17

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Low open woodland to woodland of *Eucalyptus portuensis* and *Allocasuarina littoralis* to 4 m.

T1 (4 m): *Eucalyptus portuensis*.

T2 (3 m): *Allocasuarina littoralis*.

S1 (1 – 1.5 m): *Xylomelum scottianum*, *Eucalyptus portuensis*, *Jacksonia thesioides*, *Persoonia falcata*.

S2: Absent.

G (0.5 m): *Aristida* sp. (*utilis*?), *Themeda triandra*, *Helichrysum newcastlianum*, *Tephrosia juncea*, *Grevillea dryandri*, *Evolvulus alsinoides*, Epacridaceae sp., *Jacksonia thesioides*, *Hibbertia stirlingii*, *Crotalaria brevis*, *Panicum effusum*, *Schizachyrium pseudeulalia*, *Tricoryne anceps*, **Vernonia cinerea*, *Xanthorrhoea johnsonii*, **Crassocephalum crepidioides*, **Praxelis clematidea*, *Breynia oblongifolia*, *Lindernia* sp.

Habitat Features: Potential habitat for skinks and geckos in angular rocks that characterise the ground surface.

Notes: Small area of perched rocks. The vegetation integrity rating is 1. This site was unaffected by the previous season's fires.

10.2.18 Vegetation Survey Site 18

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Low woodland of *Corymbia abergiana* and *Eucalyptus portuensis* to 5 – 6 m on broad ridge with pale, sandy soil.

T1 (5 – 6 m): *Corymbia abergiana*, *Eucalyptus portuensis*.

T2: Absent.

S1 (1.2 m): *Acacia calyculata*.

S2 (0.6 m): <u>*Acacia calyculata*</u> – formed by mass regrowth of basal coppice shoots after fire event.

G (0.6 m): *Arundinella setosa*, *Mnesithea formosa*, *Lomandra* sp., *Helichrysum newcastlianum*, *Grevillea dryandri*, *Phyllanthus* sp., **Crassocephalum crepidioides*, *Cheilanthes* sp., *Xanthorrhoea johnsonii*, *Jacksonia thesioides*, Epacridaceae sp., *Aeschynomene micranthos*.

Habitat Features: Limited due to development of thick *Acacia* thickets (i.e. absence of structural complexity). No tree hollows observed. Ground layer flora is simple.

Notes: Comparatively 'thicker' soil development than other sites on same ridge. Site affected severely by previous season's fires (~October 2009). The vegetation integrity rating is 1, given its separation from disturbance influences such as tracks and power lines.

10.2.19 Vegetation Survey Site 19

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Low woodland of *Corymbia abergiana* and *Eucalyptus portuensis* to 4 – 5 m on broad ridge.

T1 (4 – 5 m): <u>*Corymbia abergiana*</u>, *E. portuensis*, (*Callitris intratropica*).

T2: Absent.

S1 (~1.2 m): *Persoonia falcata*, (*Callitris intratropica*), *Acacia calyculata*, (*Eucalyptus shirleyi*), *Xanthorrhoea johnsonii*.

S2: Absent.

G (0.4 – 0.7 m): *Cymbopogon bombycinus*, *Grevillea dryandri*, *Aristida* sp., *Haemodorum coccineum*, *Vernonia cinerea*, *Helichrysum newcastlianum*, (*Eucalyptus shirleyi*), *Themeda triandra*, *Tricoryne anceps*, *Schizachyrium pseudeulalia*, *Jacksonia thesioides*, *Hibbertia stirlingii*.

Habitat Features: Relatively limited compared to other sites along the same ridge. The ridge topography is wider with greater development of the soil profile, but does not feature large class trees. The ground and shrub layers are structurally and floristically simple.

Notes: Affected severely by the previous season's fires (~October 2009), with scorch height extending through the canopies of trees. The vegetation integrity rating is 1, despite the site's unremarkable floristic composition. Northwards from this site, other sites along the ridge show similar traits of relatively simple floristic and structural composition.

10.2.20 Vegetation Survey Site 20

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Open forest of *Callitris intratropica* to 8 – 10 m on ridge.

T1 (8 – 10 m): <u>*Callitris intratropica*</u>, *Eucalyptus cloeziana* (emergent to 16 m).

T2 (8 m): *Corymbia citriodora*, *Callitris intratropica*.

S1 (1.5 – 2.0 m): *Corymbia abergiana*, *Acacia calyculata*, *Jacksonia thesioides*, *Larsenaikia ochreata*.

S2: Absent.

G (0.4 m): *Glossocardia bidens*, **Praxelis clematidea*, *Euphorbia mitchellii*, *Cymbopogon bombycinus*, *Cheilanthes* sp. (glabrous), *Cheilanthes* sp. (hirsute, grey), *Helichrysum newcastlianum*, *Xanthorrhoea johnsonii*, *Themeda triandra*, Poaceae sp. (5 cm, tufted, very narrow leaves), Apiaceae sp. (forb), *Rhynchospora* sp., *Haemodorum coccineum*, Epacridaceae sp., *Schizachyrium pseudeulalia*, *Buchnera* sp., *Hibbertia stirlingii*, *Phyllanthus* sp., *Crotalaria brevis*, *Aeschynomene micranthos*, *Panicum effusum*.

Habitat Features: Site characterised by its rocky substrate and revealed areas of rock pavement. This occurs on edge of steep drop-away, and above rock shelves. Has potential edge zone of refugial habitat for plants. Tree hollows not observed, but possible in larger specimens adjacent to site in surrounding woodland.

Notes: At the time of the inspection, this site was not windy – unlike other sites along the same ridge. The vegetation integrity rating is 1.

10.2.21 Vegetation Survey Site 21

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Woodland to open forest to 14 m of *Eucalyptus reducta* and *Corymbia citriodora* on flat top ridge.

T1 (14 m): *Eucalyptus reducta*, *Corymbia citriodora*.

T2 (7 – 9 m): *Corymbia abergiana*, *Eucalyptus portuensis*.

S1 (1.6 m): *Persoonia falcata*, *Jacksonia thesioides*, *Acacia aulacocarpa*.

S2 (0.6 m): Formed as a response to fire, with uniform development of *Acacia aulacocarpa*.

G (0.4 m): *Themeda triandra*, *Leucopogon* sp., *Hovea nana*, *Grevillea dryandri*, Epacridaceae sp., *Panicum trichoides*, *Hibbertia stirlingii*, *Vernonia cinerea*, *Lomandra* sp., *Schizachyrium* sp., *Thysanotus tuberosus*, *Tricoryne anceps*, *Xanthorrhoea johnsonii*.

Habitat Features: Site occurs on edge of eastern fall of steep ridge, where large rocks form crevices and broad cracks: potential for geckos and other dependent reptiles. Has potential habitat for rare and threatened plant species on rock ledges below site. No tree hollows observed, but possible in older specimens.

Notes: Small patches of rock pavement. Site exhibits no evidence of disturbance, and hence the vegetation integrity rating is 1.

10.2.22 Vegetation Survey Site 22

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Rock pavement at terminus of ridge with sparse vegetation cover limited to scattered trees of *Corymbia citriodora* and *Eucalyptus leptophleba* to 4 m.

T1: Absent (scattered stunted trees present: *C. citriodora* and *Eucalyptus* sp. to 4 m).

T2: Absent.

S1 (1.2 m): *Persoonia falcata*, *Acacia disparrima*.

S2: Absent.

G (0.6 m): *Xanthorrhoea johnsonii*, *Dianella* sp. (*nervosa?*), *Themeda triandra*, *Cheilanthes* sp., *Pseudopogonatherum contortum*, Poaceae sp. (5 cm, tufted, very fine leaves), *Grevillea dryandri*, *Phyllanthus* sp., **Praxelis clematidea*, *Hibbertia stirlingii*, *Thelymitra fragrans*, **Ageratum conyzoides*, *Evolvulus alsinoides*, *Schizachyrium* sp., *Breynia oblongifolia*, *Tricoryne anceps*, *Panicum* sp.

Habitat Features: Very limited: absence of exfoliating rocks and vegetated layering. Possible tree hollows in older trees of surrounding area.

Notes: Very simple vegetation structure, where plants persist on a thin veneer of soil in patches (i.e. many bare areas of exposed rock). The vegetation integrity rating is 1 – 2, and the natural erosive effects of wind stripping appear to be the conspicuous modifier.

10.2.23 Vegetation Survey Site 23

Mapped RE: 7.12.57 (Of Concern under VMA)

Field Description: Shrubland to low woodland 4-8 m of *Acacia leptostachya* (thickets), *Eucalyptus portuensis* and *E. cloeziana* on western edge of ridge.

T1 (4-8 m): <u>*Acacia leptostachya*</u>, *Eucalyptus portuensis*, *E. cloeziana*.

T2 (4 m): *Acacia leptostachya*, (*E. shirleyi*), (*Callitris intratropica*), *Alphitonia excelsa*, (*E. pachycalyx*), *E. lockyeri* subsp. *exuta.*

S1 (0.6-3 m): <u>*Acacia leptostachya*</u>, *Grevillea glossadenia*, *Homoranthus porteri* (common), *Xanthorrhoea johnsonii*, *Capparis canescens*, *Persoonia falcata*.

S2: Absent.

G (0.6 m): *Haemodorum coccineum*, *Phyllanthus* sp., *Dodonaea* sp., *Lomandra* sp., *Xanthorrhoea johnsonii*, *Grevillea glossadenia*, *Homoranthus porteri*, **Praxelis clematidea*, **Chloris virgata*, *Themeda triandra*, *Thysanotus tuberosus*, *Panicum trichoides*, **Vernonia cinerea*, *Pseudopogonatherum contortum*.

Habitat Features: Habitat for two species of rare and threatened plants: *Homoranthus porteri* and *Grevillea glossadenia*. Expected habitat for *Acacia purpureopetala*, but not sighted in ground survey. Numerous habitat opportunities for fauna making transition from ranges to land to the west in the vicinity of Oaky Creek. Tree hollows in older tree specimens (*Eucalyptus pachycalyx*).

Notes: Site is located to south-east of power line where land and ridges drop away dramatically to the west. Vegetation integrity rating is 2, with evidence of minor disturbance and presence of weeds in low abundance. *Acacia leptostachya* forms dense thickets on rocky substrates and is clearly associated with *Homoranthus porteri*, but less so for *G. glossadenia*, which grows amongst rhyolite rocks in fissures with poor soil development.

10.2.24 Vegetation Survey Site 24

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Open woodland to 8 m of *Eucalyptus portuensis* with *Allocasuarina inophloia* on colluvial slope.

T1: (8 m): *Eucalyptus portuensis*, <u>*Allocasuarina inophloia*</u>, (*E. cloeziana*), (*Corymbia leichhardtii*).

T2: (4-6 m): *Allocasuarina inophloia*.

S1 (1.2 – 2.0 m): *Allocasuarina inophloia*, *Melaleuca viridiflora*, *Melaleuca* sp. (multi-stemmed, hirsute branchlets), *Acacia leptostachya*, *Jacksonia thesioides*, (*Eucalyptus shirleyi*), *Persoonia falcata*.

S2: Absent.

G (0.6 m): *Breynia oblongifolia*, *Rhynchospora* sp., (**Crassocephalum crepidioides*), *Haemodorum coccineum*, *Schizachyrium pseudeulalia*, *Phyllanthus* sp., *Pseudopogonatherum contortum*, *Xanthorrhoea johnsonii*, *Eriachne* sp., *Themeda triandra*.

Habitat Features: Limited, simple ground and shrub layer flora. Surface rocks absent – soil is sandy. Tree hollows not observed, large class trees not present.

Notes: A relatively simple vegetation type with little structural development. The vegetation integrity rating is 2, and is affected by the proximity of the power line to the south of the survey site (presence of the Asteraceae weed *Crassocephalum crepidioides* is a part-indicator of nearby land disturbance). Fires had affected the ground and shrub layer significantly, many woody species regenerating from basal coppice shoots.

10.2.25 Vegetation Survey Site 25

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Small rock pavement surrounded by low woodland of *Eucalyptus portuensis* to 6 m.

T1 (6 m): Absent on rock pavement, but formed by *Eucalyptus portuensis* (6 m), *Corymbia citriodora* in surrounding woodland.

T2: Absent on rock pavement.

S1 (1.5 - 3 m): *E. portuensis*, *E. shirleyi*, *Clerodendrum floribundum*, *Dodonaea lanceolata*, *Callitris intratropica*, *Breynia oblongifolia*, *Grevillea parallela*, *Xanthorrhoea johnsonii*, *Tephrosia* sp., *Acacia humifusa*, *A. leptostachya*, *Persoonia falcata*, *Erythroxylon ellipticum*, *Capparis canescens*, *Jacksonia thesioides*, *Melaleuca* sp. (multi-stemmed, hirsute branchlets).

S2: Absent.

G (0.3 – 0.7 m): *Crotalaria brevis*, *Helichrysum newcastlianum*, *Heteropogon contortus*, **Praxelis clematidea*, *Commelina ensifolia*, *Themeda triandra*, *Panicum trichoides*, *Euphorbia mitchellii*, *Cymbopogon bombycinus*, *Vernonia cinerea*, *Polycarpaea spirostylis*, *Pterocaulon sphacelatum*, *Lomandra* sp. (grey short leaves, apex obtuse), *Eustrephus latifolia*, *Schizachyrium pseudeulalia*, indeterminate fern species.

Habitat Features: Niches for geckos, skinks amongst rocks, but site lacking exfoliating faces. Tree hollows possibly present in larger trees adjacent to survey area. Sheltered aspect to west of site, where land drops away steeply.

Notes: Narrow site will require significant levelling. Access tracks proposed along very narrow sections of ridge. The vegetation integrity rating is 1 given the absence of disturbance and very low abundance of introduced plant species (scattered individuals of *Praxelis clematidea*).

10.2.26 Vegetation Survey Site 26

Mapped RE: 9.12.4c/9.12.2 (both Least Concern under VMA)

Field Description: Rock pavement surrounded by shrubland of *Acacia leptostachya* to 4-5 m.

T1: Absent on rock pavement, but formed by *Eucalyptus portuensis* and *E. lockyeri* subsp. *exuta* in surrounding woodland.

T2: Absent on rock pavement, but *Callitris intratropica* in surrounding woodland.

S1: *Acacia leptostachya*, *Callitris intratropica* – peripheral zones of rock pavement. Otherwise: *Jacksonia thesioides*, *Dodonaea lanceolata*, *Eucalyptus shirleyi*, *Persoonia falcata*, *Alphitonia excelsa, Petalostigma pubescens*, *Larsenaikia ochreata*.

S2: Absent.

G: *Eriachne ciliata*, *Breynia oblongifolia*, *Borya septentrionalis*, *Lomandra filiformis*, *Drynaria rigidula*, *Xanthorrhoea johnsonii*, *Cheilanthes* sp., *Rhynchospora* sp., Apiaceae sp., *Aristida utilis*, *Waltheria indica*, Poaceae sp. (5 cm, very fine leaves), *Polycarpaea spirostylis*, *Schizachyrium pseudeulalia*, *Evolvulus alsinoides*, (**Praxelis clematidea*), *Helichrysum newcastlianum*.

Habitat Features: Long-term availability is limited to the cover given by large rock flakes (Cogger's Gecko). Short-term availability of water is surface scoops on pavement. No tree hollows observed.

Notes: The site of the turbine supports very little vegetation. Surrounding woodland has higher diversity with high levels of natural integrity with little if any weeds or evidence of disturbance.

10.3 Important Vegetation Communities and Habitats

Specialist habitats for plants were recognised in the project area across a range of landscape situations. The study area is broadly characterised by the perched basin located centrally and surrounded by undulated landforms which are terminated at the periphery by dissected, rocky ridge lines. These ridges are the preferred locations for a majority of the wind turbines.

The intermittently flowing Granite Creek passes more or less through the centre of the study area - flowing from south to north. This watercourse culminates in a series of pools and waterfalls before its outfall through the gorge at the northeast of the study area (just east of Walsh Bluff). Given the presence of this water in a mostly dry landscape, it is expected that small nodes of plant habitats could occur in the gorge in sheltered positions, although these will not be affected by the wind farm proposal. The gorge could be considered partially fireproof, and therefore constitutes an important refugial area for fauna as well as discrete vegetation types.

Despite Granite Creek not being directly affected by the wind farm proposal, this watercourse has important ecological values. Although not directly impacted by the need to clear vegetation for the establishment of turbines, access tracks that may have to cross this feature should take into consideration its ecological relevance in that it forms an important artery for ecological 'flows' through the project area. Watercourses can act as conduits for wildlife through the landscape, where even poorly treed features afford some cover and resources, and can link important habitats within a broad region.

The ridge country, particularly south of the existing power line, features niche habitats in highly restricted situations for a unique range of species not found elsewhere in the study area. Soil genesis at these sites is minimal and tends to be accumulated deposits from weathered rhyolite settling between rocks and in fissures. These soils are however, enriched with organic matter rendering their texture somewhat peat-like, with greater water holding capacity than less organic soils on broader landforms. These niches are almost exclusively occupied by low growing heath-type plants, mostly with microphyll or reduced needle-like leaves. Where trees have established, these are stunted, wind-sheared forms with coarse, often tessellated bark. Nearly all the ridge sites inspected had been affected by fire in the latter half of 2009 (probably around October). Clearing of ridgelines could result in the loss or reduction of specialist plant communities reliant on the unusually characterised substrate and extreme exposure. Proposed clearing of this landform type will be limited to tracks of between 5 and 10 m (expected to regenerate to 5 m width after construction), and turbine footprints of 30 x 40 m. Turbines are spatially separated by 300-400 m, and therefore, gross modification is unlikely to occur. There is also some probability that species of conservation interest could occupy these niches given their relatively small area and inaccessible locations, which renders them less prone to disturbance from anthropogenic sources. Species that are known to occur in this type of landform include *Homoranthus porteri*, *Grevillea glossadenia*, *Acacia purpureopetala*, and the poorly known *Melaleuca uxorum* amongst others. Detailed ground searches would be required at each proposed turbine location to determine whether such species occur.

Ridges to the north of the power line and dominated by trees of *Eucalyptus granitica* and *E. portuensis* did not support the same diversity of plant species described above, and have a simpler ground flora with lower abundance of heath-like plants.

10.3.1 Summary of Habitat Types

The rugged, dissected terrain of the study area creates several habitat types for flora and fauna. These habitats include:

- Dissected and rocky ridgelines of granite and rhyolite geology, including knolls of outcropping rock. The vegetation structure in these exposed situations rarely develops beyond woodland and is primarily sparse, low open woodland. Around wind turbine site 44, the vegetation structure is open forest, probably due to the marginally higher shelter aspect and less exposure to constant wind.
- Undulating hills of less rugged terrain supporting woodland to open forest (occasionally). Trees on this landform are taller, have wider girths and present a number of tree hollows greater than 10 cm diameter. Kangaroo grass (*Themeda triandra*) and giant spear grass (*Heteropogon triticeus*) dominate the grass layer. The primary species of trees in this situation are *Corymbia citriodora*, *Eucalyptus cloeziana*, and *E. portuensis*.
- Low bank environments adjacent to watercourses with temporary flow (steeper bank systems occur where land falls away from the ‘plateau’ to lower-lying areas to the east of the project area). This habitat type is characterised by exposed root systems of *Lophostemon grandiflorus* and sometimes *Callitris intratropica* trees, which along with large, angular rocks and boulders create deep crevices and capture points for organic matter with higher moisture content an localised humidity than the surrounding woodland.
- Rock pavements, generally in elevated situations, are exposed and support wind-sheared, heath-like plants. Trees when present, are sparsely represented, and are invariably stunted with gnarled forms. Wattles (usually *Acacia calyculata* and *A. leptostachya*) sometimes create dense, impenetrable thickets around bare rock surfaces where some semblance of soil development has occurred. The resurrection plant *Borya septentrionalis* finds a foothold in hollowed scoops on these rock pavements. These small surface hollows also afford short-lived watering points for fauna on an otherwise desiccated landform. This landform is also the preferred habitat for rare and threatened plants including *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus*.
- Sheltered valleys and broad gullies supporting higher densities of trees (bloodwoods). Some of these areas should be considered as partially fire-resistant niches, and are therefore important as refugial zones for fauna and nodes of more mesophytic vegetation than surrounding sclerophyll vegetation. These zones also support a longer-term soil-water status and promote a higher percentage foliage cover; where the vegetation structure merges to open forest communities where the moisture gradient is highest and more persistent.

- Micro-gilgai and semi-aquatic environments (algae encrusted depressions on flat, clay plains and country with no or slight surface relief). These are temporary features and dependent solely on rainfall, and thus evaporate relatively quickly. Algal crusts are occasionally present where grasses have not been able to establish. These are potential micro-habitats for semi-aquatic plants such as *Rhamphicarpa australiensis*. Although this conservation significant species was not observed, it has been collected from north of the project area around Nardello's Lagoon.

10.3.2 Significant Flora

A number of conservation significant plants were identified in the desktop review of literature and databases (HERBRECS, Wildlife Online, EPBC Act's Protected Matters search tool) as potentially (or confirmed) occurring in the project area. These searches provide a useful background from which to determine where targeted ground investigations are best directed. Field surveys were then made of the range of habitats for conservation significant flora considered to be representative of the project area that will be potentially affected (impacted) by the proposed wind farm.

Ground searches detected three species of plants noted as being of conservation interest under both Queensland and Commonwealth legislation. These were the shrubs *Grevillea glossadenia* (**Plate 1**) and *Homoranthus porteri* (**Plate 2**), and the succulent *Plectranthus amoenus*. These species are found in association with ridge topography, skeletal soils and rock pavements (for example, RE 7.12.65).

No other species rare or threatened flora species were recorded during the surveys; however, this does not imply that species such as *Acacia purpureopetala* and *Melaleuca uxorum* do not occur in the project area. It is also important to recognise that the probability of emergence of the ground flora is imminent following rainfall, and therefore a range of forbs, grasses and subshrubs may become apparent from March onwards (April and May are considered to be appropriate months for gaining a representative account of the ground layer vegetation in north Queensland). In this respect, it is recommended that detailed flora surveys of the groundlayer at potentially affected sites should be undertaken prior to construction when conditions are conducive to active growth and flowering of this important vegetation stratum.

For species of flora listed under the EPBC Act 1999, a separate referral under the Act is being submitted to SEWPAC to address the appropriate strategies for mitigation.

For those species of conservation significant flora listed under Queensland's *Nature Conservation Act 1992* (and the schedules of the associated *Nature Conservation (Wildlife) Regulation 2006*), a clearing permit will be required. The permit is issued by DERM and requires information regarding the number of each species to be cleared, the respective schedule of the Regulation under which the species is listed, and a range of strategies outlined to offset the impacts from clearing the species.

In respect to the the NCA, the following species are listed under Schedule 3 of the Regulation: *Acacia purpureopetala*, *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus* (all vulnerable). *Melaleuca uxorum* is listed under Schedule 2 (endangered).

Plate 1. *Grevillea glossadenia*. Top – whole plant (shrub to 1.2 m). Bottom – seedling.

Plate 2. *Homoranthus porteri*. Top – whole plant (shrub to 1.7 m). Bottom – flower and leaves.

Photos taken from Mt Emerald wind farm site (S. Gleed, 2010)

11.0 Potential Impacts to Vegetation and Flora

11.1 Vegetation & Flora Impacts

The potential impacts of the project are difficult to categorise and quantify at this stage of the investigation as the preliminary layout may change as a result of detailed site planning and approval conditions. Nevertheless, it is expected that linear and patch clearing of vegetation will be required for the construction pad of each turbine (approximately 30m x 40m), construction of access tracks and where underground cabling is required to connect each turbine and finally connect to the main electricity grid. Such clearing has the potential to interrupt connectivity of vegetation and remove important wildlife microhabitats such as standing and fallen tree hollows and boulder piles in some areas. This is particularly relevant for the narrow ridges that characterise a majority of the sites chosen for turbine placement. These impacts can however, be mitigated or substantially reduced with considered placement of each wind turbine and the incorporation into the construction phase of a range of specially developed impact mitigation strategies.

Direct impacts on flora are expected to occur during the construction phase of the project. Hard stand construction pads, access tracks and trenching for underground cabling that links each turbine and eventually feeds into the electricity grid will require vegetation clearing. In non-remnant areas (i.e. the existing cleared corridor of the power line easement), these impacts are considered of less significance from an environmental perspective. Nevertheless, the immediate effects of linear clearing within woodland remnants introduces a range of impacts, most of which could be managed and offset through the provision of stringent work practices determined through the compilation of detailed Environmental Work Plans (EMPs).

The ingress of weeds into otherwise weed-free sites is also a possibility, with confirmed evidence that the grass weed *Themeda quadrivalvis* (grader grass) has already established in linear strips and patches associated with the existing powerline through the project area. This species tends to establish in thick, banded swards and can quickly out-compete native grasses and other native plants. The dry bulk (dead foliage and seed heads) of grader grass has the capacity to exacerbate fires by developing abnormal fuel loads.

Given that the project area is relatively unaffected by serious weed incursion, the ecological integrity of vegetation has the potential to be compromised, and in the worst case scenario, irreversibly altered by the ingress of noxious plants.

Human visitation and machinery movement (during construction and infrequently during maintenance activities) is likely to have a temporary impact assuming that such activities are undertaken and offset with consideration to Weed Management Plans, EMPs and other specifically prepared management strategies.

The stripping and loss of ground vegetation has the potential to exacerbate soil erosion unless checked by appropriate erosion and sediment control measures and a recovering of bare soil surfaces with plant matter. It is recommended that a suite of locally occurring native plants are researched and designated for site rehabilitation.

The construction of access tracks and the turbine construction pads could result in impacts to plants of conservation interest, particularly in the south of the project area. Here, plant diversity is influenced by the proximity to Mount Emerald, as this area is known for its concentration of species of conservation interest, where plants such as *Acacia purpureopetala*, *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus* have been collected.

Based on HERBRECS data (Queensland Herbarium, 2001a), it is noted that these species are not entirely restricted to this portion of the project area, and their presence, and possibly other species could occur in the vicinity of Walsh Bluff and in similar habitats along ridges of the western portion of the project area. Dedicated rare and threatened plant surveys should be undertaken prior to the construction stage and when the final configuration of the wind farm is determined.

Direct impacts to vegetation communities will be most prevalent at each turbine site and along the road and cabling network that is proposed to connect each turbine and eventually to the main electricity grid. These impacts will result from vegetation clearing and ground surface levelling expected to be in the order of 20 or 30m wide for turbine construction pads, and road-cabling access tracks expected to be approximately 10 metres wide.

Removal of vegetation along narrow ridges at a number of turbine sites will result in a thin band of trees remaining either side of the clearing. Clearing of vegetation in these width-restricted situations could result in loss of discrete vegetation communities – many of which are too narrow or small in area to accurately show on mapping. For example, short sections of the ridgeline between turbines 42 and 50 support a band of *Eucalyptus abergiana* (range bloodwood) trees. Generally, this community is expressed as an area no wider than 20m, where the ridge falls away abruptly and almost vertically to the northeast and more gradually to the southwest. Loss of the canopy in these situations could result in a different group of species developing in the ground layer at the edge of the clearing.

Ridges also support heath-type vegetation comprising low shrubs and plants which occupy small niches. These inconspicuous plant communities could be irreversibly altered given the scale of clearing required to accommodate a wind turbine. It is not known how these communities will respond to disturbance of this nature, or what successional traits will occur. For example, whether the communities will be replaced by a similar floristic composition of whether a different suite of colonising plants will eventuate. One scenario could be a community dominated by the wattle *Acacia calyculata*, which occurs naturally, but could preclude the growth of other native species.

Vegetation clearing will also remove and modify the groundcover, whether this comprises grasses and herbaceous plants, or rocky cover. On rocky country, plants are woody sub-shrubs with stunted and contorted forms – an adaptation to persistent wind shearing, lower temperatures, lengthy periods of dry and rapidly drained substrates. Whether these plant communities are able to recuperate after significant alteration is unknown. A possible result is a change in floristic composition to more herbaceous species, or replacement by colonisers such as wattles (*Acacia* spp.) as discussed above.

The creation or widening of access tracks could in some situations, result in the ground surface being, at least temporarily, destabilised by machinery beyond its natural condition. Possible impacts in this sense could include the transport of sediment, the development of rill and gully erosion, as well as possible sheet erosion after heavy rainfall events. Given the gravelly-clay nature of the substrate over most of the study area, the movement of finer soil particles can be expected. It was observed during the surveys that the vehicle track entering the site to higher elevations had recently been resurfaced by a bulldozer, and within five days of traversing this track, the surface had been reduced in many sections to fine dust. This effect could be heightened along ridges where the zone of erosion is not contained due to the ridge dropping off either side. In this situation, surface erosion of narrow ridges could ‘spill’ over, carrying sediment to downhill settlement areas. Accumulated soil deposits could create favourable niches for weed development. Rock armouring of these edges is advised, and should be incorporated into the mitigation methods implemented under the erosion and sediment control plan.

A discernible characteristic of the study area is its rugged and markedly dissected ridge topography. This landscape situation becomes increasingly pronounced at the study area's southern end, and sections of the western edge. The provision of wind turbines on these ridges (many of which are narrow with very steep to near-vertical sides) will require the establishment of a series of access tracks and construction pads and the need to clear undisturbed vegetation. Clearing of these ridgeline communities could result in fragmentation of the vegetation's current contiguous condition. It is noted however, that the original cleared width of 10 m will be allowed to regenerate under natural circumstances to 5 m width: at which stage vegetation connectivity will be in an improved state.

12.0 Impact Mitigation – Vegetation & Flora

12.1 Vegetation Clearing

- All vegetation clearing should be restricted to the actual development footprint. Careful micro-site locating of roads, cabling and turbine construction pads should be undertaken to minimise potential impacts. All areas to be cleared should be visibly marked taking into account poorly represented plant communities, important habitats and conservation significant flora.
- Turbine locations should be 'micro-sited' to take advantage of areas of least ecological significance to further protect native vegetation and habitats.
- Access roads and cabling should be aligned along existing tracks wherever possible to minimise vegetation removal and loss of hollow-bearing trees, the number of easements, and the spread of weeds.
- Power line (cabling) between turbines should be constructed underground and along existing road and track infrastructure to minimise the area of remnant vegetation clearing and potential for disrupting vegetation connectivity. After initial clearing and construction, the cabling and road network should be allowed to regenerate under natural conditions to 5 m cleared width. Similarly, natural regeneration of plants should be promoted around wind turbines at each construction footprint as soon as possible after clearing and disturbance.
- A wildlife 'spotter-catcher' should be engaged to oversee construction work at each site where clearing of vegetation, particularly mature trees with hollows, is required. In the event that fauna are found in hollows or other nests, these individuals should be relocated to an appropriate site and the Queensland Parks and Wildlife Service should be contacted with the details of the find. Stranded or injured fauna should be cared for by a qualified and licensed wildlife carer.
- Where possible, all dead standing timber and living, hollow-bearing trees should be retained. These hollow-bearing trees have reached mature age and senesced as a natural consequence, and old trees such as these provide important and nesting and roosting habitats for a variety of fauna species, including many of conservation significance.
- Where construction requires felling of vegetation, logs and coarse woody debris should be retained on the site and as close to where it was felled as possible without increasing fire hazards in the immediate vicinity of turbine sites. Retention of this woody matter increases the diversity of the ground layer habitat. Stockpiling of felled timber should be avoided in order that fuel loads and the potential for severe bushfires is offset to most practical level. Scattering felled vegetation around the cleared site is less likely to concentrate fuel loads in one place.

12.2 Weed Management

- Weed management is critical given that invasive species such as *Themeda quadrivalvis* (Grader Grass) are well-known to have a detrimental effect on the function of woodland and open forest plant communities in north Queensland and elsewhere in Australia. The invasion of some introduced pasture grasses (e.g. Gamba Grass, Thatch Grass and Grader Grass) is of particular concern, as these species can out-compete native grasses and increase fuel loads promoting intense, extensive late dry season fires. Such fires may be detrimental to conservation significant species by causing direct mortality both from exacerbated fire frequency and intensity, or by promoting the development of exclusive, exotic plant communities.
- A property-based Weed Management Plan (WMP) should be developed that addresses the strategies and impact mitigation for deleterious species. The WMP should be informed by the findings of a pre-construction weed survey, and evaluated and adapted according to a post-

construction weed survey (see following recommendation).

- A pre and post-construction weed survey should be completed once the final layout is confirmed. The pre-construction weed survey will identify the location and severity of weeds and their populations in the project area. The post-construction weed survey should be undertaken after construction is completed and allowing for the seasonal emergence of weeds; for example, 6-12 months after final construction. This survey is important to evaluate the effectiveness of weed control measures (e.g. vehicle and machinery washdown facilities, pre-control of weeds along entry road). The post-construction survey will inform whether the WMP requires adaptation according to actual field conditions.
- In the event that serious environmental or declared weeds are detected prior to the post-construction survey, control should be implemented as a matter of priority in order to arrest seed-set. Small populations of weeds are easier and can be more effectively controlled than established populations.
- All incidences of new weed introductions should be controlled and managed as a priority. This is particularly relevant to 'declared' species listed under Queensland legislation. Exotic species of pasture legumes such as Wynn Cassia (*Chamaecrista rotundifolia*) and Stylo (*Stylosanthes* spp.), as well as exotic grasses and plants should not be used for soil stabilisation. These species can be serious detractors from natural vegetation values and can become problematic weeds that compromise the integrity of native plant communities, and limit the rate of successful natural plant regeneration.
- A properly designed and managed vehicle wash-down bay should be constructed at the base of the project area in a weed free zone. During construction and maintenance, all vehicles and machinery should be washed down and prior to entering the site. Appropriate vehicle inspections and protocols should be stringently followed.
- Both sides of the access road at the base of the project area are currently infested with weeds such as Grader Grass (*Themeda quadrivalvis*) and Hyptis (*Hyptis suaveolens*) amongst several other species. This stretch of the road poses a significant risk in transporting weeds into the site, and concerted weed control is required prior construction machinery entering the site. Concurrently, consideration should be given to revegetating this entry point with locally occurring native plants; notably wattles (*Acacia* spp.) that will over time, assist in precluding the re-establishment of invasive grasses and weeds.

12.3 Vegetation Mapping

- The Regional Ecosystem mapping for the section of the project area south of the existing powerline (i.e. the area represented in the Wet Tropics bioregion) is incorrect. Mapping erroneously identifies the Of Concern RE 7.12.57 as occurring along ridges and the land that is intersected by a number of proposed wind turbines. It is recommended that the mapping is rectified by way of submitting an appropriate map amendment to the Queensland Herbarium (DERM). Although the mapping is provisional at this stage and will require further refinement prior to submission to DERM, the proposed mapping units to replace RE 7.12.57 is a heterogeneous polygon that includes RE 7.12.30b / 7.12.65k with an approximate representation of each type of 80 / 20 percent respectively. These communities are listed as Least Concern under the *Vegetation Management Act 1999*. Therefore, from a legislative viewpoint, an approved mapping amendment negates the requirement to clear Of Concern remnant communities. It is also noted that endangered remnant communities do not occur in the project area.

12.4 Vegetation Connectivity

- Initial vegetation clearing should be kept to the absolute minimum width necessary to facilitate machinery movement and access. Clearing should not exceed 10 m wide for tracks and 30 m for turbine construction pads. All access tracks should be allowed to regenerate to a width of 5 m or less. The regenerating vegetation should comprise native species only, and vigilance will need to be exercised to ensure that weeds are not allowed to establish.

12.5 Vegetation Integrity

- Any vegetation rehabilitation efforts should adopt the use of locally occurring plants species, and with a regional provenance with consideration given to the geology and distinct landforms of the project site. No introduced plants should be used for this purpose or for landscaping for 'aesthetic' reasons. Weeds should not be allowed to detract from the vegetation or floristic integrity of the project site.

12.6 Rare and Threatened Plants

- Avoidance of populations of rare and threatened plants is the preferred mitigation measure. This can be achieved by micro-situating each turbine where such species are found. In the event that rare and threatened plants are found along access tracks or in positions where clearing is unavoidable, a translocation plan or propagation plan should take effect.
- A dedicated, property-based Threatened Plant Management Plan should be developed. This should include photographic and descriptive accounts of the conservation significant plants likely to be present on the site, and strategies for translocation in accordance with the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and Queensland's *Nature Conservation Act 1992.* Specific reference should be made to the guidelines presented in Vallee *et al.* (2004) for the translocation of threatened plants.
- All populations of rare and threatened plants should be identified in the areas where vegetation is to be cleared prior to the vegetation being removed. Species that will be encountered include *Grevillea glossadenia*, *Homoranthus porteri* and *Plectranthus amoenus*. Others species that may be encountered include *Acacia purpureopetala* and possibly *Melaleuca uxorum*. For species listed under the NCA, a clearing permit will be required from DERM. For species listed under the EPBC Act, a referral is being submitted to SEWPAC.
- There is a reasonable probability that conservation significant plants can be successfully managed, and opportunities for translocating or propagating such species should be investigated. For example, *Grevillea glossadenia* was observed to successfully establish in highly disturbed ground around the wind monitoring tower. Similarly, *Homoranthus porteri* has been successfully propagated in the nursery industry. The succulent *Plectranthus amoenus* is unlikely to present difficulties in cultivation due to its known ease of reproduction through vegetative cuttings. Rare and threatened plants should be considered for incorporation into rehabilitated areas. For example, there may be opportunities to use these species around the turbine construction pad after construction or in machinery turn-around areas.

12.7 Landscape Rehabilitation

- After construction, cleared land such as machinery turn-around areas, borrow pits and peripheral areas to turbine construction pads should be rehabilitated using native plants known to occur in the region surrounding the project site and on similar landform and geology. The use of exotic species of plants should not be permitted.
- A Rehabilitation Plan should be prepared in accordance with the fundamental criteria outlined

above, and should include a strategic element of rehabilitation monitoring to assess the success or otherwise of rehabilitation works.

- To assist the natural regeneration process, any topsoil or soil matter from the upper horizon should be scraped to the edge of the tracks and turbine construction footprints. This 'medium has the potential to hold reserves of native plant seed, and should be re-spread over the construction footprint after turbines are erected and related construction work is finalised.
- Seed collection of plant species from a localised provenance (i.e. within the project area), should be considered prior to vegetation clearing in order to accumulate suitable stock for rehabilitation work.
- Consideration should be given to incorporating rare and threatened plant species such as *Grevillea glossadenia* and *Homoranthus porteri* into rehabilitation. Opportunities will be presented where individuals of these species (and others) could be transplanted *in situ*, thereby maximising their chances of successful establishment. *Grevillea glossadenia* was observed to successfully establish on disturbed ground around the wind monitoring tower near proposed turbine 50.

12.8 Fire Management

This report does not propose specific fire management protocols or regimes. Nevertheless, fire is an important landscape function and should be managed in respect to vegetation communities, cultural significance and human safety. Appropriate advice should be sort in respect to this matter. Burning of cleared (windrowed) vegetation should not be allowed, unless specifically endorsed in a Fire Management Plan.

13.0 Conclusion – Vegetation & Flora

Environmental diligence should be commensurate with many of the unique the ecological values held in the project site. Some of these important values include the dominance of undisturbed vegetation communities, where almost the entire site where wind turbines are proposed to be located is covered by remnant vegetation (as defined under the *Vegetation Management Act 1999* and shown on current Regional Ecosystem mapping). The project site's elevation, vegetation coverage and presence of a number of rare and threatened plant species requires the need to observe and practice higher order levels of environmental stewardship.

In regard to the conservation status of remnant vegetation, the current RE mapping incorrectly indicates that RE 7.12.57 (Of Concern) is present along a majority of the ridges south of the existing powerline, and where a number of turbines are proposed to be located. Field surveys identified that RE 7.12.57 is not present in any of the areas mapped. Amended mapping showing the presence of RE 7.12.65k (Least Concern) is provided with this report. Polygons containing the RE 7.12.57 label will be relabelled as a heterogeneous polygon of RE 7.12.30b / 7.12.65k with a respective proportional representation of each community of 80 / 20 percent.

Vegetation clearing should be managed appropriately and with consideration of the unique landform characteristics of the project area. All clearing should be kept to an absolute minimum in order to avoid significant levels of impacts. Particular emphasis is placed on the risk and long-term impacts associated with the ingress of weeds that can have irreversible impacts to native plant communities, their composition and ecological function.

Tracks and associated cabling layouts presented in this report are provisional and based on spatial analysis of the 5 metre contour interval to determine routes of lower ecological impact. Some gradients are in the order of 50-33 percent slope, which will require a holistic design approach encompassing engineering and environmental concepts.

The design of the final layout will require a greater level of understanding of micro-topographical relief and the relevance of watercourses and drainage features. To achieve this, detailed walk-through surveys of vegetation and flora habitats prior to track construction and vegetation clearing will be undertaken to locate the most appropriate routes and locations of turbine footprints.

Consideration has been given to allowing tracks to naturally regenerate to approximately 5 m width after construction. Rehabilitation of turn-around areas and other areas of vegetation disturbance should also be taken into account, where emphasis is placed on the use of native plants known to occur in the region and on similar geology and landforms. Maintenance of vegetation, floristic and ecological integrity is crucial.

Stringent and project-focussed impact mitigation measures will need to be formulated and implemented at the pre-construction and construction stages. Similarly, longer-term measures will need to be considered for decommissioning.

Given the high integrity of the vegetation and the presence of rare and threatened species, a high level of attention to impact mitigation and implementation will be required. The probability of reducing the significance of impacts will be considerably enhanced if the range of mitigation strategies such as weed management plans, rare and threatened plant translocation plans, and general environmental management strategies are implemented and progressed for the life of the project.

It is therefore concluded that potential impacts to conservation significant flora and the values of vegetation can be managed such that permanent or long-term impacts to these values are maintained at acceptable environmental levels in accordance with Commonwealth and State legislation and policies.

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Appendix A1. Location of fauna survey sites and survey methodology used

May 2010 Dry Season Survey Sites.

Site	Easting	Northing	Elliot Trapping	Pitfall Trapping	Anabat Detection	Harp Trapping	Funnel Trapping	Spotlighting	Bird Survey	Habitat Assessment
20	326789	8099837	X	X				X	X	X
21	327190	8099583							X	X
South 22	327386	8099294								
Far South 22	327747	8099082							X	X
Granite Creek	327430	8099808	X	X	X	X			X	X
25	327648	8099782							X	X
24	327562	8100046								X
56	328572	8100957	X					X		
55	328764	8100673						X		
57	328506	8101234	X					X		
67	328969	8101927	X					X		
42	330751	8098270							X	X
43	330481	8098514							X	X
44	330210	8098705							X	X
45	329985	8098930							X	X
46	329820	8099174							X	X
47	329729	8099441							X	X
48	329404	8099649							X	X
49	329203	8099946							X	
50	329091	8100198						X		
51	329040	8100460						X		
Powerline creek	328506	8100633					X			
17	325934	8100748	X	X				X	X	X

March-April 2011 Late Wet Season Survey Sites

Site Name	Easting	Northing	Active Reptile Search	Bird Survey	Habitat Assessment	Raptor Search	Owl Call Playback	Anabat
22	327386	8099294			X	X		
26	327915	8099518	X		X			X
27	328230	8099829	X		X			
30	328029	8099220	X		X			X
31	328146	8098962	X		X			
32	328425	8098766	X		X			
33	328786	8098927			X			
34	329002	8098559			X			
35	329234	8098320			X			
47	329729	8099441	X		X			
48	329404	8099649	X		X			
49	329203	8099946	X		X			
50	329091	8100198			X	X		
51	329040	8100460		X	X	X		
55	328773	8100681		X	X			X
56	328578	8100955	X	X	X			X
57	328506	8101239		X	X	X		
58	328368	8101559			X			
59	328507	8101817		X	X			
60	328450	8102087		X	X			X
61	328384	8102361		X	X			
62	328250	8102610		X	X			
63	328123	8102866		X	X			
64	326730	8101936		X	X			
65	328792	8102560		X	X			
66	328891	8102237		X	X			
67	328964	8101930		X	X		X	
68	328019	8101756	X		X			
69	327636	8101937	X		X			
70	327578	8102225	X		X			
71	327508	8102611			X			
Creek #2	328407	8100217		X	X			
Creek #1	328203	8100475		X	X			
Owl#1	327900	8099713					X	
Owl#2	328930	810049			X	X		
Owl#3	328421	8100510					X	

Appendix B1. List of fauna species recorded or predicted to occur on the site

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
AMPHIBIANS								
Bufonidae	Cane Toad	*Bufo marinus*				✓	Recorded	
Hylidae	Striped Burrowing Frog	*Cyclorana alboguttata*					Possible	
Hylidae	Long-footed Frog	*Cyclorana longipes*					Possible	
Hylidae	New Holland Frog	*Cyclorana novaehollandiae*					Possible	
Hylidae	Northern Dwarf Tree Frog	*Litoria bicolor*				✓	Possible	
Hylidae	Green Tree Frog	*Litoria caerulea*					Recorded	
Hylidae	Eastern Sedgefrog	*Litoria fallax*				✓	Possible	
Hylidae	Dainty Tree Frog	*Litoria gracilenta*					Possible	
Hylidae	Floodplain Frog	*Litoria inermis*				✓	Recorded	
Hylidae	Giant White-lipped Tree Frog	*Litoria infrafrenata*					Possible	
Hylidae	Broad-palmed Frog	*Litoria latopalmata*					Recorded	
Hylidae	Javelin Frog	*Litoria microbelos*					Possible	
Hylidae	Waterfall Frog	*Litoria nannotis*	E	✓	E		Unlikely	No suitable waterfalls along permanent flowing creeks adjacent to rainforest habitats present on site
Hylidae	Rocket Frog	*Litoria nasuta*					Recorded	
Hylidae	Bridled Frog	*Litoria nigrofrenata*					Possible	
Hylidae	Mountain Mistfrog	*Litoria nyakalensis*	CE	✓	E		Unlikely	No suitable rainforest stream habitats present on the site
Hylidae	Pale Frog	*Litoria pallida*					Possible	
Hylidae	Common Mistfrog	*Litoria rheocola*	E	✓			Unlikely	No suitable rainforest stream habitats present on the site
Hylidae	Roth's Tree Frog	*Litoria rothi*				✓	Possible	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Hylidae	Desert Tree Frog	*Litoria rubella*					Recorded	
Hylidae	Cairns Lacelid	*Nyctimystes dayi*	E	✓			Unlikely	No suitable rainforest stream habitats present on the site
Myobatrachidae	Remote Froglet	*Crinia remota*					Possible	
Myobatrachidae	Marbled Marsh Frog	*Limnodynastes convexiusculus*					Possible	
Myobatrachidae	Striped Marsh Frog	*Limnodynastes peroni*					Possible	
Myobatrachidae	Spotted Marsh Frog	*Limnodynastes tasmaniensis*					Possible	
Myobatrachidae	Northern Banjo Frog	*Limnodynastes terraereginae*					Possible	
Myobatrachidae	Northern Spadefoot Toad	*Notaden melanoscaphus*					Possible	
Myobatrachidae	Ornate Burrowing Frog	*Opisthodon ornatus*					Possible	
Myobatrachidae	Magnificent Brood Frog	*Pseudophryne covacevichae*	V	✓	V		Unlikely	This species is known only from a small area near Ravenshoe, north Queensland, were it has been found at 22 discrete sites with 36 populations (McDonald *et al*. 2000). The species has only a small area of occupancy (less than 50ha; McDonald *et al*. 2000). All records of the species have been from above 800m a.s.l (McDonald *et al*. 2000). It is known from Timber Reserve 245, State Forest 754,488, and 251; Millstream National Park and Ravenshoe rubbish dump reserve, road reserves and freehold land (Ingram and Corben 1994; McDonald *et al*. 2000).
Myobatrachidae	Montane Toadlet	*Uperoleia altissima*				✓	Recorded	
Myobatrachidae	Stonemason Toadlet	*Uperoleia lithomoda*					Possible	
Myobatrachidae	Mimic Toadlet	*Uperoleia mimula*					Possible	
BIRDS								
Acanthizidae	Yellow Thornbill	*Acanthiza nana*					Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Acanthizidae	Buff-rumped Thornbill	*Acanthiza reguloides*					Possible	
Acanthizidae	Large-billed Gerygone	*Gerygone magnirostris*					Possible	
Acanthizidae	Brown Gerygone	*Gerygone mouki*				✓	Unlikely	No suitable rainforest present on site
Acanthizidae	White-throated Gerygone	*Gerygone olivacea*				✓	Possible	
Acanthizidae	Fairy Gerygone	*Gerygone palpebrosa*					Possible	
Acanthizidae	Fernwren	*Oreoscopus gutturalis*				✓	Unlikely	No suitable rainforest present on site
Acanthizidae	Yellow-throated Scrubwren	*Sericornis citreogularis*				✓	Unlikely	No suitable rainforest present on site
Acanthizidae	White-browed Scrubwren	*Sericornis frontalis*				✓	Unlikely	No suitable rainforest present on site
Acanthizidae	Atherton Scrubwren	*Sericornis keri*				✓	Unlikely	No suitable rainforest present on site
Acanthizidae	Weebill	*Smicrornis brevirostris*					Recorded	
Accipitridae	Collared Sparrowhawk	*Accipiter cirrocephalus*	M				Recorded	
Accipitridae	Brown Goshawk	*Accipiter fasciatus*	M			✓	Recorded	
Accipitridae	Grey Goshawk	*Accipiter novaehollandiae*	M		NT	✓	Possible	
Accipitridae	Wedge-tailed Eagle	*Aquila audax*	M			✓	Recorded	
Accipitridae	Pacific Baza	*Aviceda subcristata*	M				Possible	
Accipitridae	Swamp Harrier	*Circus approximans*	M			✓	Possible	
Accipitridae	Spotted Harrier	*Circus assimilis*	M			✓	Possible	Flying high (>200m above ground) in vicinity of proposed turbine # 56
Accipitridae	Black-shouldered Kite	*Elanus axillaris*	M			✓	Possible	
Accipitridae	Letter-winged Kite	*Elanus scriptus*	M			✓	Possible	
Accipitridae	Red Goshawk	*Erythrotriochis radiatus*	V, M	✓	E	✓	Possible	
Accipitridae	White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M	✓		✓	Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Accipitridae	Brahminy Kite	*Haliastur indus*	M				Possible	
Accipitridae	Whistling Kite	*Haliastur sphenurus*	M			✓	Recorded	
Accipitridae	Black-breasted Buzzard	*Hamirostra melanosternon*	M				Possible	
Accipitridae	Little Eagle	*Hieraaetus morphnoides*	M				Recorded	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Accipitridae	Square-tailed Kite	*Lophoictinia isura*	M		NT	✓	Possible	Suitable open grassy woodland habitat is present on site, however no recent records in the region. Occasional records from Chillagoe, ~ 90km to the west
Accipitridae	Black Kite	*Milvus migrans*	M			✓	Possible	
Acrocephalidae	Australian reed-warbler	*Acrocephalus australis*				✓	Unlikely	No suitable dense streamside reeds or grasses occurs on site
Aegothelidae	Australian Owlet-nightjar	*Aegotheles cristatus*					Possible	
Alaudidae	Horsfield's Bushlark	*Mirafra javanica*					Possible	
Alcedinidae	Azure Kingfisher	*Ceyx azureus*					Recorded	
Anatidae	Chestnut Teal	*Anas castanea*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Grey Teal	*Anas gracilis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Northern Mallard	*Anas platyrhynchos*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Australasian Shoveler	*Anas rhynchotis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

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Anatidae	Pacific Black Duck	*Anas superciliosa*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Hardhead	*Aythya australis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Australian Wood Duck	*Chenonetta jubata*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Black Swan	*Cygnus atratus*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Wandering Whistling-Duck	*Dendrocygna arcuata*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Plumed Whistling-Duck	*Dendrocygna eytoni*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Pink-eared Duck	*Malacorhynchus membranaceus*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Cotton Pygmy-goose	*Nettapus coromandelianus*	M	✓	NT	✓	Unlikely	
Anatidae	Green Pygmy-goose	*Nettapus pulchellus*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anatidae	Radjah Shelduck	*Tadorna radjah*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

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Anhingidae	Australasian Darter	*Anhinga novaehollandiae*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Anseranatidae	Magpie Goose	*Anseranas semipalmata*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Apodidae	Australian Swiftlet	*Aerodramus terrareginae*			NT		Possible	
Apodidae	House Swift	*Apus affinis*					Possible	
Apodidae	Fork-tailed Swift	*Apus pacificus*	M	✓			Possible	
Apodidae	White-throated Needletail	*Hirundapus caudacutus*	M	✓			Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Great Egret	*Ardea alba*	M	✓			Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Cattle Egret	*Ardea ibis*	M	✓			Possible	
Ardeidae	Intermediate Egret	*Ardea intermedia*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	White-necked Heron	*Ardea pacifica*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Great-billed Heron	*Ardea sumatrana*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Striated Heron	*Butorides striata*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

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Ardeidae	Little Egret	*Egretta garzetta*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	White-faced Heron	*Egretta novaehollandiae*				✓	Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Pied Heron	*Egretta picata*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Black Bittern	*Ixobrychus flavicollis*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Little Bittern	*Ixobrychus minutus*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ardeidae	Nankeen Night-Heron	*Nycticorax caledonicus*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Artamidae	Black-faced Woodswallow	*Artamus cinereus*					Possible	
Artamidae	Dusky Woodswallow	*Artamus cyanopterus*					Possible	
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*				✓	Possible	
Artamidae	Little Woodswallow	*Artamus minor*					Possible	
Artamidae	Masked Woodswallow	*Artamus personatus*					Possible	
Artamidae	White-browed Woodswallow	*Artamus superciliosus*					Possible	
Artamidae	Pied Butcherbird	*Cracticus nigrogularis*				✓	Recorded	
Artamidae	Grey Butcherbird	*Cracticus torquatus*					Recorded	

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Artamidae	Australian Magpie	*Gymnorhina tibicen*				✓	Recorded	
Artamidae	Pied Currawong	*Strepera graculina*				✓	Recorded	
Burhinidae	Bush Stone-curlew	*Burhinus grallarius*				✓	Possible	
Cacatuidae	Sulphur-crested Cockatoo	*Cacatua galerita*				✓	Recorded	
Cacatuidae	Little Corella	*Cacatua sanguinea*					Possible	
Cacatuidae	Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*				✓	Possible	
Cacatuidae	Galah	*Eolophus roseicapillus*					Possible	
Cacatuidae	Cockatiel	*Nymphicus hollandicus*					Possible	
Campephagidae	Barred Cuckoo-shrike	*Coaracina lineata*					Possible	
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				✓	Possible	
Campephagidae	White-bellied Cuckoo-shrike	*Coracina papuensis*				✓	Recorded	
Campephagidae	Cicadabird	*Coracina tenuirostris*				✓	Possible	
Campephagidae	Varied Triller	*Lalage leucomela*				✓	Unlikely	No suitable habitat present on site. May fly over site at rotor height between rainforest areas.
Campephagidae	White-winged Triller	*Lalage sueurii*				✓	Possible	
Caprimulgidae	Large-tailed Nightjar	*Caprimulgus macrurus*					Possible	
Caprimulgidae	Spotted Nightjar	*Eurostopodus argus*					Possible	
Caprimulgidae	White-throated Nightjar	*Eurostopodus mystacalis*					Possible	
Casuariidae	Southern Cassowary (Australian)		E	✓		E	Unlikely	
Casuariidae	Emu	*Dromaius novaehollandiae*					Possible	
Centropodidae	Pheasant Coucal	*Centropus phasianinus*				✓	Recorded	

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Charadriidae	Black-fronted Dotterel	*Elseyornis melanops*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Charadriidae	Red-kneed Dotterel	*Erythrogonys cinctus*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Charadriidae	Pacific Golden Plover	*Pluvialis fulva*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Charadriidae	Masked Lapwing	*Vanellus miles*				✓	Possible	
Charadriidae	Banded Lapwing	*Vanellus tricolor*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Ciconiidae	Black-necked Stork	*Ephippiorhynchus asiaticus*			NT		Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Climacteridae	White-throated Treecreeper	*Climacteris leucophaea*				✓	Unlikely	Not often observed in NQ outside of rainforest and nearby wet sclerophyll forests.
Climacteridae	Brown Treecreeper	*Climacteris picumnus*					Recorded	
Columbidae	Diamond Dove	*Geopelia cuneata*					Possible	
Columbidae	Bar-shouldered Dove	*Geopelia humeralis*					Recorded	
Columbidae	Rock Dove	*Geopelia livia*				✓	Unlikely	No suitable human modifed habitat present on site
Columbidae	Peaceful Dove	*Geopelia striata*				✓	Recorded	
Columbidae	Squatter Pigeon	*Geophaps scripta scripta (southern subspecies)*	V		V	✓	Possible	

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Columbidae	Brown Cuckoo-Dove	*Macropygia amboinensis*				✓	Unlikely	No suitable rainforest habitat present on site. Unlikely to utilize site for foraging but may fly over at rotor height as moves between rainforest patches e.g. Mt Emerald and Lamb Range; one recent recent in Mareeba (Babara warren, pers. com.)
Columbidae	Crested Pigeon	*Ocyphaps lophotes*				✓	Possible	
Columbidae	Common Bronzewing	*Phaps chalcoptera*					Recorded	
Coraciidae	Dollarbird	*Eurystomus orientalis*				✓	Possible	
Corcoracidae	Apostlebird	*Struthidea cinerea*					Possible	
Corvidae	Australian Raven	*Corvus coronoides*					Possible	
Corvidae	Torresian Crow	*Corvus orru*				✓	Recorded	
Cuculidae	Chestnut-breasted Cuckoo	*Cacomantis castaneiventris*					Possible	
Cuculidae	Fan-tailed Cuckoo	*Cacomantis flabelliformis*					Possible	
Cuculidae	Pallid Cuckoo	*Cacomantis pallidus*					Recorded	
Cuculidae	Brush Cuckoo	*Cacomantis variolosus*					Possible	
Cuculidae	Horsfield's Bronze-Cuckoo	*Chalcites basalis*				✓	Possible	
Cuculidae	Shining Bronze-Cuckoo	*Chalcites lucidus*					Possible	
Cuculidae	Little Bronze-Cuckoo	*Chalcites minutillus*					Possible	
Cuculidae	Black-eared Cuckoo	*Chalcites osculans*					Possible	
Cuculidae	Oriental Cuckoo	*Cuculus optatus*					Possible	
Cuculidae	Eastern Koel	*Eudynamys orientalis*				✓	Possible	
Cuculidae	Channel-billed Cuckoo	*Scythrops novaehollandiae*				✓	Possible	
Dicaeidae	Mistletoebird	*Dicaeum hirundinaceum*				✓	Recorded	

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Dicruridae	Spangled Drongo	*Dicrurus bracteatus*				✓	Recorded	
Dicruridae	Magpie-lark	*Grallina cyanoleuca*				✓	Possible	
Dicruridae	Black-faced Monarch	*Monarcha melanopsis*	M	✓		✓	Unlikely	Recent recorded (10/03/11) from Mareeba (Cairns Birds, 2011). May fly over site within rotor strike zone as dispersed between rainforest areas
Dicruridae	Shining Flycatcher	*Myiagra alecto*				✓	Possible	
Dicruridae	Satin Flycatcher	*Myiagra cyanoleuca*	M	✓			Possible	
Dicruridae	Restless Flycatcher	*Myiagra inquieta*					Possible	
Dicruridae	Leaden Flycatcher	*Myiagra rubecula*				✓	Recorded	
Dicruridae	Grey Fantail	*Rhipidura albiscapa*				✓	Recorded	
Dicruridae	Willie Wagtail	*Rhipidura leucophrys*				✓	Possible	
Dicruridae	Rufous Fantail	*Rhipidura rufifrons*	M	✓		✓	Recorded	
Dicruridae	Northern Fantail	*Rhipidura rufiventris*					Possible	
Dicruridae	Spectacled Monarch	*Symposiarchus trivirgatus*	M	✓		✓	Unlikely	
Falconidae	Brown Falcon	*Falco berigora*	M			✓	Recorded	
Falconidae	Nankeen Kestrel	*Falco cenchroides*	M			✓	Recorded	
Falconidae	Grey Falcon	*Falco hypoleucos*	M		NT		Possible	
Falconidae	Australian Hobby	*Falco longipennis*	M				Possible	
Falconidae	Peregrine Falcon	*Falco peregrinus*	M				Possible	
Falconidae	Black Falcon	*Falco subniger*	M				Possible	
Fringillidae	Gouldian Finch	*Erythrura gouldiae*	E, M	✓	E	✓	Possible	
Fringillidae	Pictorella Mannikin	*Heteromunia pectoralis*					Possible	
Fringillidae	Chestnut-breasted Mannikin	*Lonchura castaneothorax*				✓	Possible	
Fringillidae	Nutmeg Mannikin	*Lonchura punctulata*				✓	Recorded	

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Fringillidae	Star Finch (eastern)	*Neochima ruficauda ruficauda*	E	✓	E		Possible	No suitable rainforest habitat present on the site
Fringillidae	Crimson Finch	*Neochmia phaeton*					Possible	
Fringillidae	Red-browed Finch	*Neochmia temporalis*				✓	Possible	
Fringillidae	Black-throated Finch (northern black-rumped subspecies)	*Poephila cincta atropydialis*					Recorded	
Fringillidae	Masked Finch	*Poephila personata*					Possible	
Fringillidae	Double-barred Finch	*Taeniopygia bichenovii*					Possible	
Fringillidae	Zebra Finch	*Taeniopygia guttata*					Possible	
Gruidae	Sarus Crane	*Grus antigone*	M	✓		✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Gruidae	Brolga	*Grus rubicunda*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Halcyonidae	Blue-winged Kookaburra	*Dacelo leachii*				✓	Recorded	
Halcyonidae	Laughing Kookaburra	*Dacelo novaeguineae*				✓	Recorded	
Halcyonidae	Forest Kingfisher	*Todiramphus macleayii*				✓	Possible	
Halcyonidae	Red-backed Kingfisher	*Todiramphus pyrrhopygius*				✓	Possible	
Halcyonidae	Sacred Kingfisher	*Todiramphus sanctus*					Possible	
Hirundinidae	White-backed Swallow	*Cheramoeca leucosterna*				✓	Unlikely	Site is well outside known distribution of this species. Likely to be a misidentification in the DERM Wildlife Online database
Hirundinidae	Welcome Swallow	*Hirundo neoxena*				✓	Possible	
Hirundinidae	Barn Swallow	*Hirundo rustica*	M	✓			Possible	
Hirundinidae	Fairy Martin	*Petrochelidon ariel*					Possible	

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Hirundinidae	Tree Martin	*Petrochelidon nigricans*					Possible	
Maluridae	Red-backed Fairy-wren	*Malurus melanocephalus*				✓	Recorded	
Megapodiidae	Australian Brush-turkey	*Alectura lathami*				✓	Possible	
Megapodiidae	Orange-footed Scrubfowl	*Megapodius reinwardti*				✓	Unlikely	No suitable rainforest habitat present on site
Meliphagidae	Eastern Spinebill	*Acanthorhynchus tenuirostris*				✓	Possible	
Meliphagidae	Banded Honeyeater	*Cissomela pectoralis*					Possible	
Meliphagidae	Blue-faced Honeyeater	*Entomyzon cyanotis*				✓	Possible	
Meliphagidae	Yellow-faced Honeyeater	*Lichenostomus chrysops*				✓	Possible	
Meliphagidae	Yellow Honeyeater	*Lichenostomus flavus*				✓	Possible	
Meliphagidae	Bridled Honeyeater	*Lichenostomus frenatus*				✓	Recorded	Unusual record of single individual in the vicinity of proposed turbine #36
Meliphagidae	Fuscous Honeyeater	*Lichenostomus fuscus*					Possible	
Meliphagidae	White-gaped Honeyeater	*Lichenostomus unicolor*					Possible	
Meliphagidae	Brown Honeyeater	*Lichmera indistincta*				✓	Recorded	
Meliphagidae	Yellow-throated Miner	*Manorina flavigula*					Possible	
Meliphagidae	Noisy Miner	*Manorina melanocephala*					Recorded	
Meliphagidae	White-throated Honeyeater	*Melithreptus albogularis*				✓	Recorded	
Meliphagidae	Black-chinned Honeyeater	*Melithreptus gularis*			NT	✓	Possible	
Meliphagidae	White-naped Honeyeater	*Melithreptus lunatus*				✓	Possible	
Meliphagidae	Dusky Honeyeater	*Myzomela obscura*				✓	Possible	
Meliphagidae	Scarlet Honeyeater	*Myzomela sanguinolenta*				✓	Recorded	
Meliphagidae	Silver-crowned Friarbird	*Philemon argenticeps*					Possible	

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Meliphagidae	Helmeted Friarbird	*Philemon buceroides*				✓	Possible	
Meliphagidae	Little Friarbird	*Philemon citreogularis*					Possible	
Meliphagidae	Noisy Friarbird	*Philemon corniculatus*				✓	Recorded	
Meliphagidae	White-cheeked Honeyeater	*Phylidonyris niger*				✓	Possible	
Meliphagidae	Bar-breasted Honeyeater	*Ramsayornis fasciatus*				✓	Possible	
Meliphagidae	Brown-backed Honeyeater	*Ramsayornis modestus*					Possible	
Meropidae	Rainbow Bee-eater	*Merops ornatus*	M	✓		✓	Recorded	
Motacillidae	Australasian Pipit	*Anthus novaeseelandiae*					Possible	
Nectariniidae	Olive-backed Sunbird	*Nectarinia jugularis*					Possible	
Neosittidae	Varied Sittella	*Daphoenositta chrysoptera*					Recorded	
Oriolidae	Yellow Oriole	*Oriolus flavocinctus*					Possible	
Oriolidae	Olive-backed Oriole	*Oriolus sagittatus*					Recorded	One individual recorded along ephemeral creek in April 2011
Oriolidae	Australasian Figbird	*Sphecotheres vieilloti*					Possible	Scattered *Ficus spp.* occur in deep rocky ephemeral creek lines
Otididae	Australian Bustard	*Ardeotis australis*					Possible	
Pachycephalidae	Grey Shrike-thrush	*Colluricincla harmonica*					Recorded	
Pachycephalidae	Golden Whistler	*Pachycephala pectoralis*				✓	Possible	
Pachycephalidae	Rufous Whistler	*Pachycephala rufiventris*				✓	Recorded	
Pardalotidae	Spotted Pardalote	*Pardalotus punctatus*					Recorded	
Pardalotidae	Red-browed Pardalote	*Pardalotus rubricatus*				✓	Possible	
Pardalotidae	Striated Pardalote	*Pardalotus striatus*				✓	Possible	
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*					Possible	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

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Petroicidae	Jacky Winter	*Microeca fascinans*					Possible	
Petroicidae	Lemon-bellied Flycatcher	*Microeca flavigaster*					Possible	
Phalacrocoracidae	Little Pied Cormorant	*Microcarbo melanoleucos*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Phalacrocoracidae	Little Black Cormorant	*Phalacrocorax sulcirostris*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Phalacrocoracidae	Pied Cormorant	*Phalacrocorax varius*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Phasianidae	King Quail	*Coturnix chinensis*					Possible	
Phasianidae	Brown Quail	*Coturnix ypsilophora*				✓	Recorded	
Podargidae	Papuan Frogmouth	*Podargus papuensis*					Possible	
Podargidae	Tawny Frogmouth	*Podargus strigoides*					Recorded	
Podicipedidae	Great Crested Grebe	*Podiceps cristatus*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Podicipedidae	Hoary-headed Grebe	*Poliocephalus poliocephalus*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Podicipedidae	Australasian Grebe	*Tachybaptus novaehollandiae*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

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Pomatostomidae	Grey-crowned Babbler	*Pomatostomus temporalis*				✓	Recorded	
Psittacidae	Red-winged Parrot	*Aprosmictus erythropterus*				✓	Possible	
Psittacidae	Little Lorikeet	*Glossopsitta pusilla*					Recorded	
Psittacidae	Pale-headed Rosella	*Platycercus adscitus*				✓	Recorded	
Psittacidae	Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*				✓	Recorded	
Psittacidae	Rainbow Lorikeet	*Trichoglossus haematodus*				✓	Recorded	
Ptilonorhynchidae	Great Bowerbird	*Chlamydera nuchalis*					Recorded	
Rallidae	Pale-vented Bush-hen	*Amaurornis moluccana*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Eurasian Coot	*Fulica atra*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Dusky Moorhen	*Gallinula tenebrosa*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Buff-banded Rail	*Gallirallus philippensis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Purple Swamphen	*Porphyrio porphyrio*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	White-browed Crake	*Porzana cinerea*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Rallidae	Australian Spotted Crake	*Porzana fluminea*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Baillon's Crake	*Porzana pusilla*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Spotless Crake	*Porzana tabuensis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Red-necked Crake	*Rallina tricolor*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rallidae	Black-tailed Native-hen	*Tribonyx ventralis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Recurvirostridae	Red-necked Avocet	*Recurvistrosta novaehollandiae*				✓	Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Rostratulidae	Australian Painted Snipe	*Rostratula australis*	M	✓	V		Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Scolopacidae	Sharp-tailed Sandpiper	*Calidris acuminata*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Latham's Snipe	*Gallinago hardwickii*	M	✓			Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Eastern Curlew	*Numenius madagascariensis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Whimbrel	*Numenius phaeopus*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Grey-tailed Tattler	*Tringa brevipes*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Wood Sandpiper	*Tringa glareola*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Common Greenshank	*Tringa nebularia*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Scolopacidae	Terek Sandpiper	*Xenus cinereus*					Unlikely	No suitable habitat present on site and unlikely to utilise small ephemeral water bodies. May fly over site at rotor height between suitable nearby water bodies.
Strigidae	Barking Owl	*Ninox connivens*				✓	Possible	
Strigidae	Southern Boobook	*Ninox novaeseelandiae*				✓	Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Strigidae	Rufous Owl	*Ninox rufa*					Possible	
Sturnidae	Common Myna	*Acridotheres tristis*			I	✓	Unlikely	No suitable human modified habitat present on site
Sylviidae	Rufous Songlark	*Cincloramphus mathewsi*					Recorded	
Sylviidae	Golden-headed Cisticola	*Cisticola exilis*					Possible	
Threskiornithidae	Yellow-billed Spoonbill	*Platalea flavipes*					Unlikely	May fly over site at rotor height; unlikely to utilise small ephemeral water bodies
Threskiornithidae	Royal Spoonbill	*Platalea regia*					Unlikely	May fly over site at rotor height; unlikely to utilise small ephemeral water bodies
Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*					Unlikely	May fly over site at rotor height; unlikely to utilise small ephemeral water bodies
Threskiornithidae	Australian White Ibis	*Threskiornis molucca*					Unlikely	May fly over site at rotor height; unlikely to utilise small ephemeral water bodies
Threskiornithidae	Straw-necked Ibis	*Threskiornis spinicollis*				✓	Unlikely	May fly over site at rotor height whilst moving between nearby water bodies.; unlikely to utilise small ephemeral water bodies
Turnicidae	Red-backed Button-quail	*Turnix maculosus*					Possible	
Turnicidae	Buff-breasted Button-quail	*Turnix olivii*	E		V		Possible	
Turnicidae	Red-chested Button-quail	*Turnix pyrrhothorax*					Possible	
Turnicidae	Painted Button-quail	*Turnix varius*					Possible	
Tytonidae	Pacific Barn Owl	*Tyto javanica*				✓	Possible	
Tytonidae	Eastern Grass Owl	*Tyto longimembris*				✓	Possible	
Tytonidae	Masked Owl	*Tyto novaehollandiae kimberli*	V		V		Possible	
Zosteropidae	Silvereye	*Zosterops lateralis*	M			✓	Possible	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
MAMMALS								
Acrobatidae	Feathertail Glider	*Acrobates pygmaeus*					Possible	
Canidae	Dingo/Wild Dog	*Canis lupus dingo/C. Familiaris*					Recorded	
Canidae	Red Fox	*Vulpes vulpes*					Possible	
Dasyuridae	Northern Quoll	*Dasyurus hallucatus*	E	✓	E	✓	Recorded	
Dasyuridae	Tiger Quoll	*Dasyurus maculatus gracilis*	E	✓			Unlikely	Only NQ populations known from rainforest areas above 900m a.s.l in the Lamb Range and Mt Lewis/Mt Carbine Tablelands.
Dasyuridae	Brush-tailed Phascogale	*Phascogale tapoatafa*					Possible	
Dasyuridae	Common Planigale	*Planigale maculata*				✓	Possible	
Dasyuridae	Common Dunnart	*Sminthopsis murina taei*					Possible	Recorded from Brooklyn Station, approximately 70km to the north
Dasyuridae	Red-cheeked Dunnart	*Sminthopsis virginiae*					Possible	
Emballonuridae	Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*					Recorded	
Emballonuridae	Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	CE	✓	E		Possible	Several call were detected that could belong to this species but it was not possible to differentiate it from other similar calls belonging to *Saccolaimus flaviventris* or *Taphozous troughtoni*
Emballonuridae	Common Sheathtail Bat	*Taphozous georgianus*					Possible	
Emballonuridae	Troughton's Sheathtail Bat	*Taphozous troughtoni*			E		Possible	Several calls were detected that could belong to this species but it was not possible to differentiate if from calls belonging to *Saccolaimus spp.* or *Mormopteris beccarii*
Equidae	Domestic Horse	*Equus caballus*					Recorded	
Felidae	House Cat	*Felis silvestris catus*					Recorded	
Hipposideridae	Dusky Leafnosed Bat	*Hipposideros ater*					Possible	
Hipposideridae	Diadem Leafnosed	*Hipposideros diadema*			NT	✓	Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
	Bat	*reginae*						
Hipposideridae	Semon's Leafnosed Bat	*Hipposideros semoni*	E	✓			Possible	
Leporidae	European Rabbit	*Oryctolagus cuniculus*				✓	Recorded	
Macropodidae	Spectacled Hare-wallaby	*Lagorchestes conspicillatus*					Possible	
Macropodidae	Agile Wallaby	*Macropus agilis*				✓	Possible	
Macropodidae	Eastern Grey Kangaroo	*Macropus giganteus*					Possible	
Macropodidae	Whiptail Wallaby	*Macropus parryi*				✓	Recorded	
Macropodidae	Wallaroo or Euro	*Macropus robustus*					Recorded	
Macropodidae	Mareeba Rock-wallaby	*Petrogale mareeba*			NT	✓	Unlikely	No scats or observations of individuals recorded despite extensive foot surveys of all rocky habitats. No suitable deeply dissected granite rocky outcrops present on site.
Macropodidae	Red-legged Pademelon	*Thylogale stigmatica*				✓	Unlikely	No suitable rainforest habitat occuring on site or directly adjacent to site
Macropodidae	Swamp Wallaby	*Wallabia bicolor*					Possible	
Megadermatidae	Ghost Bat	*Macroderma gigas*			V		Possible	
Molossidae	White-striped Freetail Bat	*Austronomus australis*					Recorded	
Molossidae	Northern Freetail Bat	*Chaerephon jobensis*					Recorded	
Molossidae	Beccari's Freetail Bat	*Mormopterus beccarii*					Possible	
Molossidae	Little Northern Freetail Bat	*Mormopterus loriae*					Possible	
Molossidae	Eastern Freetail Bat	*Mormopterus ridei*					Recorded	
Muridae	Brush-tailed Rabbit Rat	*Conilurus penicillatus*	V	✓			Unlikely	Only QLD records are known from Bentinck Island in the Gulf of Carpentaria.
Muridae	Water Rat	*Hydromys chrysogaster*					Recorded	
Muridae	Lakeland Downs Mouse	*Leggadina lakedownensis*					Possible	Recorded from Brooklyn Station, approximately 70km to the north

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Muridae	Grassland Melomys	*Melomys burtoni*					Recorded	
Muridae	Fawn-footed Melomys	*Melomys cervinipes*					Possible	
Muridae	Black-footed Tree-rat	*Mesembriomys gouldi*					Possible	
Muridae	House Mouse	*Mus musculus*					Possible	
Muridae	Delicate Mouse	*Pseudomys delicatulus*					Possible	
Muridae	Eastern Chestnut Mouse	*Pseudomys gracilicaudatus*					Possible	Recorded from Brooklyn Station, approximately 70km to the north
Muridae	Bush Rat	*Rattus fuscipes*					Possible	Unidentified *Rattus spp.* were recorded on the site during camera trapping surveys
Muridae	Black Rat	*Rattus rattus*					Possible	Unidentified *Rattus spp.* were recorded on the site during camera trapping surveys
Muridae	Canefield Rat	*Rattus sordidus*				✓	Possible	Unidentified *Rattus spp.* were recorded on the site during camera trapping surveys
Muridae	Pale Field Rat	*Rattus tunneyi*					Possible	Unidentified *Rattus spp.* were recorded on the site during camera trapping surveys
Muridae	Giant White-tailed Rat	*Uromys caudimaculatus*					Recorded	
Muridae	Common Rock-rat	*Zyzomys argurus*					Possible	
Peramelidae	Northern Brown Bandicoot	*Isoodon macrourus*					Recorded	
Peramelidae	Southern Brown Bandicoot (Cape York subspecies)	*Isoodon obesulus peninsulae*					Possible	Population known from from Lamb Range, ~ 20km to the east
Peramelidae	Long-nosed Bandicoot	*Perameles nasuta*				✓	Possible	
Petauridae	Striped Possum	*Dactylopsila trivirgata*				✓	Unlikely	No rainforest or well-developed riparian vegetation present on site
Petauridae	Yellow-bellied Glider	*Petaurus australis (unamed subspecies)*	V	✓	V		Unlikely	This species is only known from open forests with *Eucalyptus resinifera* which is not present on the site
Petauridae	Sugar Glider	*Petaurus breviceps*					Possible	
Petauridae	Squirrel Glider	*Petaurus norfolcensis*					Possible	
Phalangeridae	Common Brushtail	*Trichosurus vulpecula*				✓	Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
	Possum							
Phascolarctidae	Koala	*Phascolarctos cinereus*					Possible	
Potoroidae	Rufous Bettong	*Aepyprymnus rufescens*				✓	Possible	
Potoroidae	Northern Bettong	*Bettongia tropica*	E	✓	E	✓	Unlikely	Regional surveys conducted by Scott Burnett from QPWS failed to detect this species outside of known Davies Creek. Bioclim modelling by Brooke Bateman (JCU) identifies the site as a potential reintroduction location
Pseudocheiridae	Greater Glider	*Petauroides volans*					Possible	
Pseudocheiridae	Common Ringtail Possum	*Pseudocheirus peregrinus*				✓	Possible	
Pseudocheiridae	Green Ringtail Possum	*Pseudochirulus archeri*			NT	✓	Unlikely	No suitable rainforest vegetation present on site
Pteropidae	Black Flying-fox	*Pteropus alecto*					Possible	
Pteropidae	Spectacled Flying-fox	*Pteropus conspicillatus*	V	✓	V	✓	Possible	
Pteropidae	Grey-headed Flying-fox	*Pteropus poliocephalus*	V	✓			Unlikely	Nearest population occurs in the vicinity of Rockhampton, ~ 1000km to the south
Pteropidae	Little Red Flying-fox	*Pteropus scapulatus*				✓	Possible	
Rhinolophidae	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*					Recorded	
Rhinolophidae	Large-eared Horseshoe Bat	*Rhinolophus philippinensis maros*	E	✓	E		Possible	
Suidae	Pig	*Sus scrofa*					Recorded	
Tachyglossidae	Short-beaked Echidna	*Tachyglossus aculeatus*				✓	Recorded	
Vespertilionidae	Gould's Wattled Bat	*Chalinolobus gouldii*					Recorded	
Vespertilionidae	Hoary Wattled Bat	*Chalinolobus nigrogriseus*					Possible	Several calls were detected that could belong to this species but it was not possible to differentiate if from calls belonging to *Scotorepens sanborni*
Vespertilionidae	Little Bentwing Bat	*Miniopterus australis*					Recorded	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Vespertilionidae	Large Bentwing Bat	*Miniopterus orianae oceanensis*					Recorded	
Vespertilionidae	Northern Large-footed Myotis	*Myotis moluccarium*					Possible	
Vespertilionidae	Northern Longeared Bat	*Nyctophilus bifax*					Possible	Calls belonging to Nyctophillus spp. were recorded but not possible to distinguish between *N. bifax, N. geoffroyi* and *N. gouldii*
Vespertilionidae	Lesser Longeared Bat	*Nyctophilus geoffroyi*					Possible	Calls belonging to Nyctophillus spp. were recorded but not possible to distinguish between *N. bifax, N. geoffroyi* and *N. gouldii*
Vespertilionidae	Gould's Long-eared Bat	*Nyctophilus gouldii*					Possible	Calls belonging to Nyctophillus spp. were recorded but not possible to distinguish between *N. bifax, N. geoffroyi* and *N. gouldii*
Vespertilionidae	Greater Broadnosed Bat	*Scoteanax rueppellii*					Possible	
Vespertilionidae	Eastern Broadnosed Bat	*Scotorepens orion*					Recorded	
Vespertilionidae	Northern Broadnosed Bat	*Scotorepens sanborni*					Recorded	
Vespertilionidae	Eastern Forest Bat	*Vespadelus pumilus*					Possible	
Vespertilionidae	Eastern Cave Bat	*Vespadelus troughtoni*					Recorded	
REPTILES								
Agamidae	Nobbi dragon	*Amphibolurus nobbi*					Possible	
Agamidae	Frill-necked dragon	*Chlamydosaurus kingii*					Possible	
Agamidae	Tommy roundhead	*Diporiphora australis*					Recorded	
Agamidae	Two-lined dragon	*Diporiphora bilineata*					Possible	
Agamidae	Eastern water dragon	*Physignathus lesueurii*					Possible	
Agamidae	Eastern bearded dragon	*Pogona barbata*					Possible	
Cheluidae	Saw-shelled turtle	*Wollumbinia latisternum*					Recorded	Several specimens observed in large, deep pool at base of waterfall along a ephemeral

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
								watercourse
Colubridae	Brown tree snake	*Boiga irregularis*					Possible	
Colubridae	Common tree snake	*Dendrelaphis punctulatus*					Recorded	
Colubridae	Keelback	*Tropidonophis mairii*				✓	Possible	
Elapidae	Common death adder	*Acanthophis antarcticus*			NT	✓	Possible	
Elapidae	Robust burrowing snake	*Antaioserpens warro*					Possible	
Elapidae	Australian coral snake	*Brachyurophis australis*					Possible	
Elapidae		*Cacophis churchilli*				✓	Unlikely	No suitable rainforest habitat present on site
Elapidae	Carpentaria snake	*Cryptophis boschmai*					Possible	
Elapidae	Black-striped snake	*Cryptophis nigrostriatus*					Recorded	
Elapidae	Greater black whipsnake	*Demansia papuensis*					Possible	
Elapidae	Yellow-faced whipsnake	*Demansia psammophis*					Possible	
Elapidae	Collared whipsnake	*Demansia torquata*					Possible	
Elapidae	Lesser black whipsnake	*Demansia vestigiata*					Possible	
Elapidae	Yellow-naped snake	*Furina barnardi*			NT		Possible	
Elapidae	Orange-naped snake	*Furina ornata*					Possible	
Elapidae	Pale-headed snake	*Hoplocephalus bitorquatus*					Possible	
Elapidae	Coastal taipan	*Oxyuranus scutellatus*					Possible	
Elapidae	Mulga snake	*Pseudechis australis*					Possible	Shed skin found with 17 mid-body scales and divided anal scale which could belong to *Psuedechis australia, Psuedonaja nuchalis* or *P. textilis.*

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Elapidae	Western brown snake	*Pseudonaja nuchalis*					Possible	Shed skin found with 17 mid-body scales and divided anal scale which could belong to *Psuedechis australia, Psuedonaja nuchalis* or *P. textilis*.
Elapidae	Eastern brown snake	*Pseudonaja textilis*				✓	Possible	Shed skin found with 17 mid-body scales and divided anal scale which could belong to *Psuedechis australia, Psuedonaja nuchalis* or *P. textilis*.
Elapidae	Eastern small-eyed snake	*Rhinoplocephalus nigrescens*				✓	Unlikely	No suitable rainforest habitat present on site
Elapidae	Curl snake	*Suta suta*					Possible	
Elapidae	Bandy-bandy	*Vermicella annulata*					Possible	
Gekkonidae	Ring-tailed gecko	*Cyrtodactylus louisiadensis*					Possible	
Gekkonidae	Fat-tailed gecko	*Diplodactylus conspicillatus*					Possible	
Gekkonidae	Box-patterned gecko	*Diplodactylus steindachneri*					Possible	
Gekkonidae	Dubious dtella	*Gehyra dubia*					Recorded	
Gekkonidae	Northern spotted rock dtella	*Gehyra nana*					Recorded	
Gekkonidae	Bynoe's gecko	*Heteronotia binoei*					Recorded	
Gekkonidae	Chevert's gecko	*Nactus cheverti*					Possible	
Gekkonidae	Prickly knob-tailed gecko	*Nephrurus asper*					Possible	
Gekkonidae	Northern velvet gecko	*Oedura castelnaui*					Possible	
Gekkonidae	Northern spotted velvet gecko	*Oedura coggeri*					Recorded	
Gekkonidae	Zigzag velvet gecko	*Oedura rhombifer*				✓	Possible	
Gekkonidae	Eastern spiny-tailed gecko	*Strophurus williamsi*					Possible	
Pygopodidae	Excitable delma	*Delma tincta*					Recorded	
Pygopodidae	Burton's legless lizard	*Lialis burtonis*					Possible	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Pythonidae	Spotted python	*Antaresia maculosa*					Possible	
Pythonidae	Black-headed python	*Aspidites melanocephalus*				✓	Possible	
Pythonidae	Water python	*Liasis mackloti*					Possible	
Pythonidae	Scrub python	*Morelia kinghorni*				✓	Recorded	
Pythonidae	Carpet python	*Morelia spilota*				✓	Possible	
Scincidae	Speckled worm-skink	*Anomalopus gowi*					Possible	
Scincidae		*Carlia foliorum*					Possible	
Scincidae	Lined rainbow-skink	*Carlia jarnoldae*					Recorded	
Scincidae		*Carlia longipes*					Recorded	
Scincidae	Shaded-litter rainbow-skink	*Carlia munda*					Recorded	
Scincidae		*Carlia mundivensis*					Recorded	
Scincidae	Open-litter rainbow-skink	*Carlia pectoralis*					Possible	
Scincidae	Black-throated rainbow-skink	*Carlia rostralis*					Recorded	
Scincidae	Robust rainbow-skink	*Carlia schmeltzii*					Possible	
Scincidae		*Carlia stori*				✓	Possible	
Scincidae	Lively rainbow skink	*Carlia vivax*					Possible	
Scincidae		*Cryptoblepharus plagiocephalus*					Recorded	
Scincidae	Wall skink	*Cryptoblepharus virgatus*					Possible	
Scincidae	Black-backed yellow-lined ctenotus	*Ctenotus eutaenius*					Possible	
Scincidae	Atherton ctenotus	*Ctenotus monticola*					Possible	
Scincidae	Eastern striped skink	*Ctenotus robustus*					Possible	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Scincidae	Straight-browed ctenotus	*Ctenotus spaldingi*					Possible	
Scincidae	Copper-tailed skink	*Ctenotus taeniolatus*					Recorded	
Scincidae	Pink-tongued skink	*Cyclodomorphus gerrardii*					Possible	
Scincidae	Major skink	*Egernia frerei*					Recorded	
Scincidae	Hosmer's skink	*Egernia hosmeri*					Possible	
Scincidae	Yakka skink	*Egernia rugosa*	V	✓	V		Possible	
Scincidae	Northern barsided skink	*Eulamprus brachysoma*				✓	Recorded	Listed in Wildlife Online search as *Eulamprus tenuis,* which has undergone taxonomic revision and now only occurs in QLD between Eungella to the SE corner
Scincidae	Cape York mulch-skink	*Glaphyromorphus crassicaudus*					Possible	
Scincidae	Grass skink	*Lampropholis delicata*					Possible	
Scincidae	Common dwarf skink	*Menetia greyii*					Possible	
Scincidae	Dwarf litter-skink	*Menetia timlowi*					Possible	
Scincidae	Fire-tailed skink	*Morethia taeniopleura*					Recorded	
Scincidae	Northern soil-crevice skink	*Proablepharus tenuis*					Possible	
Scincidae	Common blue-tongued skink	*Tiliqua scincoides*					Possible	
Typhlopidae	Faint-striped blind snake	*Ramphotyphlops broomi*			NT		Possible	
Typhlopidae	North-eastern blind snake	*Ramphotyphlops polygrammicus*					Possible	
Typhlopidae	Claw-snouted blind snake	*Ramphotyphlops unguirostris*					Possible	
Varanidae	Sand goanna	*Varanus gouldii*					Possible	
Varanidae	Yellow-spotted monitor	*Varanus panoptes*					Possible	
Varanidae	Spotted tree monitor	*Varanus scalaris*					Possible	
Varanidae	Storr's monitor	*Varanus storri*					Possible	

Family	Common Name	Scientific Name	EPBC	EPBC Protected Matters Report	NCA	DERM Wildlife Online Search	Likelihood of Occurrence	Notes
Varanidae	Black-headed monitor	*Varanus tristis*					Possible	
Varanidae	Lace monitor	*Varanus varius*					Possible	

Appendix C1. QLD Wildlife Online Search Results

Search Criteria: Species List for a Specified Point

Species: Animals
Type: All
Status: All
Records: All
Date: All
Latitude: 17.1667
Longitude: 145.387
Distance: 10 km
Email: jeff.middleton@rpsgroup.com.au
Date submitted: Tuesday 19 Jul 2011 11:34:39
Date extracted: Tuesday 19 Jul 2011 11:46:02
The number of records retrieved = 194

Disclaimer

As the DERM is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

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Description of the CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.
Q - Indicates the Queensland conservation status of each taxon under the Nature Conservation Act 1992. The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).
A - Indicates the Australian conservation status of each taxon under the

Environment Protection and Biodiversity Conservation Act 1999. The values of EPBC are:
Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).

The second number located after the / indicates the number of specimen records for the taxon.

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
amphibians	Bufonidae	*Rhinella marina*	Cane Toad	Y			1	0
amphibians	Hylidae	*Litoria fallax*	Eastern Sedgefrog		C		2	0
amphibians	Hylidae	*Litoria rothii*	Northern Laughing Treefrog		C		1	0
amphibians	Hylidae	*Litoria bicolor*	Northern Sedgefrog		C		1	0
amphibians	Hylidae	*Litoria caerulea*	Common Green Treefrog		C		1	0
amphibians	Hylidae	*Litoria inermis*	Bumpy Rocketfrog		C		1	0
amphibians	Myobatrachidae	*Uperoleia altissima*	Tableland Gungan		C		1	0
birds	Acanthizidae	*Sericornis citreogularis*	Yellow-Throated Scrubwren		C		1	0
birds	Acanthizidae	*Smicrornis brevirostris*	Weebill		C		2	0
birds	Acanthizidae	*Sericornis keri*	Atherton Scrubwren		C		1	0
birds	Acanthizidae	*Sericornis frontalis*	White-Browed Scrubwren		C		1	0
birds	Acanthizidae	*Oreoscopus gutturalis*	Fernwren		C		1	0
birds	Acanthizidae	*Sericornis magnirostra*	Large-Billed Scrubwren		C		2	0
birds	Acanthizidae	*Gerygone albogularis*	White-Throated Gerygone		C		4	0
birds	Acanthizidae	*Gerygone mouki*	Brown Gerygone		C		2	0
birds	Accipitridae	*Aquila audax*	Wedge-Tailed Eagle		C		1	0
birds	Accipitridae	*Haliaeetus leucogaster*	White-Bellied Sea-Eagle		C		4	0
birds	Accipitridae	*Haliastur sphenurus*	Whistling Kite		C		3	0
birds	Accipitridae	*Accipiter fasciatus*	Brown Goshawk		C		2	0
birds	Accipitridae	*Lophoictinia isura*	Square-Tailed Kite		NT		2	0
birds	Accipitridae	*Circus approximans*	Swamp Harrier		C		1	0

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
birds	Accipitridae	*Elanus axillaris*	Black-Shouldered Kite		C		6	0
birds	Accipitridae	*Circus assimilis*	Spotted Harrier		C		2	0
birds	Accipitridae	*Elanus scriptus*	Letter-Winged Kite		C		1	0
birds	Accipitridae	*Milvus migrans*	Black Kite		C		11	0
birds	Accipitridae	*Erythrotriorchis radiatus*	Red Goshawk		E	V	1	0
birds	Accipitridae	*Accipiter novaehollandiae*	Grey Goshawk		NT		1	0
birds	Acrocephalidae	*Acrocephalus australis*	Australian Reed-Warbler		C		1	0
birds	Anatidae	*Cygnus atratus*	Black Swan		C		5	0
birds	Anatidae	*Nettapus coromandelianus*	Cotton Pygmy-Goose		NT		1	0
birds	Anatidae	*Malacorhynchus membranaceus*	Pink-Eared Duck		C		1	0
birds	Anatidae	*Nettapus pulchellus*	Green Pygmy-Goose		C		1	0
birds	Anatidae	*Anas superciliosa*	Pacific Black Duck		C		6	0
birds	Anatidae	*Dendrocygna arcuata*	Wandering Whistling-Duck		C		1	0
birds	Anhingidae	*Anhinga novaehollandiae*	Australasian Darter		C		3	0
birds	Anseranatidae	*Anseranas semipalmata*	Magpie Goose		C		1	0
birds	Ardeidae	*Egretta novaehollandiae*	White-Faced Heron		C		2	0
birds	Artamidae	*Cracticus nigrogularis*	Pied Butcherbird		C		3	0
birds	Artamidae	*Artamus leucorynchus*	White-Breasted Woodswallow		C		2	0
birds	Artamidae	*Strepera graculina*	Pied Currawong		C		1	0
birds	Artamidae	*Cracticus tibicen*	Australian Magpie		C		4	0
birds	Burhinidae	*Burhinus grallarius*	Bush Stone-Curlew		C		4	0
birds	Cacatuidae	*Cacatua galerita*	Sulphur-Crested Cockatoo		C		7	0
birds	Cacatuidae	*Calyptorhynchus banksii*	Red-Tailed Black-Cockatoo		C		3	0
birds	Campephagidae	*Lalage sueurii*	White-Winged Triller		C		2	0
birds	Campephagidae	*Lalage leucomela*	Varied Triller		C		2	0
birds	Campephagidae	*Coracina papuensis*	White-Bellied Cuckoo-Shrike		C		8	0
birds	Campephagidae	*Coracina novaehollandiae*	Black-Faced Cuckoo-Shrike		C		7	0
birds	Campephagidae	*Coracina tenuirostris*	Cicadabird		C		1	0
birds	Charadriidae	*Vanellus miles*	Masked Lapwing		C		4	0
birds	Cisticolidae	*Cisticola exilis*	Golden-Headed Cisticola		C		2	0
birds	Climacteridae	*Cormobates leucophaea minor*	White-Throated Treecreeper (Northern)		C		2	0

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
birds	Columbidae	*Columba livia*	Rock Dove	Y			1	0
birds	Columbidae	*Macropygia amboinensis*	Brown Cuckoo-Dove		C		1	0
birds	Columbidae	*Streptopelia chinensis*	Spotted Dove	Y			4	0
birds	Columbidae	*Geopelia humeralis*	Bar-Shouldered Dove		C		1	0
birds	Columbidae	*Geopelia striata*	Peaceful Dove		C		9	0
birds	Columbidae	*Geophaps scripta*	Squatter Pigeon		C		2	1
birds	Columbidae	*Ocyphaps lophotes*	Crested Pigeon		C		2	0
birds	Coraciidae	*Eurystomus orientalis*	Dollarbird		C		2	0
birds	Corvidae	*Corvus orru*	Torresian Crow		C		5	0
birds	Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo		C		1	0
birds	Cuculidae	*Scythrops novaehollandiae*	Channel-Billed Cuckoo		C		2	0
birds	Cuculidae	*Centropus phasianinus*	Pheasant Coucal		C		6	1
birds	Cuculidae	*Eudynamys orientalis*	Eastern Koel		C		1	0
birds	Dicruridae	*Dicrurus bracteatus*	Spangled Drongo		C		7	0
birds	Estrildidae	*Erythrura gouldiae*	Gouldian Finch		E	E	3	0
birds	Estrildidae	*Lonchura punctulata*	Nutmeg Mannikin	Y			1	0
birds	Estrildidae	*Taeniopygia bichenovii*	Double-Barred Finch		C		3	0
birds	Estrildidae	*Neochmia temporalis*	Red-Browed Finch		C		4	0
birds	Estrildidae	*Lonchura castaneothorax*	Chestnut-Breasted Mannikin		C		2	0
birds	Falconidae	*Falco berigora*	Brown Falcon		C		1	0
birds	Falconidae	*Falco cenchroides*	Nankeen Kestrel		C		2	0
birds	Gruidae	*Grus antigone*	Sarus Crane		C		1	0
birds	Gruidae	*Grus rubicunda*	Brolga		C		1	0
birds	Halcyonidae	*Dacelo leachii*	Blue-Winged Kookaburra		C		1	0
birds	Halcyonidae	*Dacelo novaeguineae*	Laughing Kookaburra		C		11	0
birds	Halcyonidae	*Todiramphus macleayii*	Forest Kingfisher		C		1	0
birds	Halcyonidae	*Todiramphus pyrrhopygius*	Red-Backed Kingfisher		C		1	0
birds	Hirundinidae	*Hirundo neoxena*	Welcome Swallow		C		5	0
birds	Hirundinidae	*Cheramoeca leucosterna*	White-Backed Swallow		C		2	0
birds	Jacanidae	*Irediparra gallinacea*	Comb-Crested Jacana		C		2	0
birds	Laridae	*Gygis alba*	White Tern		C		1	0

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
birds	Maluridae	*Malurus melanocephalus*	Red-Backed Fairy-Wren		C		2	0
birds	Megapodiidae	*Alectura lathami*	Australian Brush-Turkey		C		6	0
birds	Megapodiidae	*Megapodius reinwardt*	Orange-Footed Scrubfowl		C		1	0
birds	Meliphagidae	*Meliphaga notata*	Yellow-Spotted Honeyeater		C		1	0
birds	Meliphagidae	*Myzomela obscura*	Dusky Honeyeater		C		1	0
birds	Meliphagidae	*Entomyzon cyanotis*	Blue-Faced Honeyeater		C		2	0
birds	Meliphagidae	*Lichenostomus flavus*	Yellow Honeyeater		C		5	0
birds	Meliphagidae	*Philemon buceroides*	Helmeted Friarbird		C		1	0
birds	Meliphagidae	*Phylidonyris niger*	White-Cheeked Honeyeater		C		3	0
birds	Meliphagidae	*Meliphaga lewinii*	Lewin's Honeyeater		C		6	0
birds	Meliphagidae	*Lichmera indistincta*	Brown Honeyeater		C		9	0
birds	Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern Spinebill		C		1	0
birds	Meliphagidae	*Melithreptus albogularis*	White-Throated Honeyeater		C		5	0
birds	Meliphagidae	*Myzomela sanguinolenta*	Scarlet Honeyeater		C		4	0
birds	Meliphagidae	*Lichenostomus frenatus*	Bridled Honeyeater		C		1	0
birds	Meliphagidae	*Lichenostomus chrysops*	Yellow-Faced Honeyeater		C		2	0
birds	Meliphagidae	*Ramsayornis fasciatus*	Bar-Breasted Honeyeater		C		1	0
birds	Meliphagidae	*Philemon corniculatus*	Noisy Friarbird		C		2	0
birds	Meliphagidae	*Melithreptus lunatus*	White-Naped Honeyeater		C		1	0
birds	Meropidae	*Merops ornatus*	Rainbow Bee-Eater		C		6	0
birds	Monarchidae	*Myiagra rubecula*	Leaden Flycatcher		C		2	0
birds	Monarchidae	*Myiagra cyanoleuca*	Satin Flycatcher		C		1	0
birds	Monarchidae	*Symposiarchus trivirgatus*	Spectacled Monarch		C		2	0
birds	Monarchidae	*Monarcha melanopsis*	Black-Faced Monarch		C		1	0
birds	Monarchidae	*Grallina cyanoleuca*	Magpie-Lark		C		24	0
birds	Nectariniidae	*Nectarinia jugularis*	Olive-Backed Sunbird		C		1	0
birds	Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird		C		4	0
birds	Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella		C		1	0
birds	Oriolidae	*Oriolus sagittatus*	Olive-Backed Oriole		C		2	0
birds	Oriolidae	*Sphecotheres vieilloti*	Australasian Figbird		C		3	0
birds	Otididae	*Ardeotis australis*	Australian Bustard		C		1	0

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
birds	Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-Thrush		C		2	0
birds	Pachycephalidae	*Colluricincla megarhyncha*	Little Shrike-Thrush		C		1	0
birds	Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler		C		5	0
birds	Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler		C		1	0
birds	Pardalotidae	*Pardalotus striatus*	Striated Pardalote		C		4	0
birds	Pardalotidae	*Pardalotus rubricatus*	Red-Browed Pardalote		C		1	0
birds	Passeridae	*Passer domesticus*	House Sparrow	Y			2	0
birds	Petroicidae	*Eopsaltria australis*	Eastern Yellow Robin		C		2	0
birds	Petroicidae	*Heteromyias cinereifrons*	Grey-Headed Robin		C		1	0
birds	Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant		C		4	0
birds	Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant		C		3	0
birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little Black Cormorant		C		2	0
birds	Phasianidae	*Coturnix ypsilophora*	Brown Quail		C		1	0
birds	Podicipedidae	*Podiceps cristatus*	Great Crested Grebe		C		1	0
birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe		C		5	0
birds	Pomatostomidae	*Pomatostomus temporalis*	Grey-Crowned Babbler		C		2	0
birds	Psittacidae	*Platycercus adscitus*	Pale-Headed Rosella		C		3	0
birds	Psittacidae	*Cyclopsitta diophthalma macleayana*	Macleay's Fig-Parrot		V		1	0
birds	Psittacidae	*Trichoglossus haematodus moluccanus*	Rainbow Lorikeet		C		9	0
birds	Psittacidae	*Trichoglossus chlorolepidotus*	Scaly-Breasted Lorikeet		C		5	0
birds	Psittacidae	*Aprosmictus erythropterus*	Red-Winged Parrot		C		1	0
birds	Psophodidae	*Psophodes olivaceus*	Eastern Whipbird		C		1	0
birds	Ptilonorhynchidae	*Ailuroedus melanotis*	Spotted Catbird		C		6	2
birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	Great Bowerbird		C		1	0
birds	Ptilonorhynchidae	*Scenopoeetes dentirostris*	Tooth-Billed Bowerbird		C		2	0
birds	Rallidae	*Fulica atra*	Eurasian Coot		C		3	0
birds	Recurvirostridae	*Recurvirostra novaehollandiae*	Red-Necked Avocet		C		1	0
birds	Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail		C		5	0
birds	Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail		C		8	0
birds	Rhipiduridae	*Rhipidura rufifrons*	Rufous Fantail		C		1	0
birds	Strigidae	*Ninox boobook*	Southern Boobook		C		1	0

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
birds	Strigidae	*Ninox connivens*	Barking Owl		C		1	0
birds	Sturnidae	*Sturnus tristis*	Common Myna	Y			19	0
birds	Threskiornithidae	*Threskiornis spinicollis*	Straw-Necked Ibis		C		2	0
birds	Timaliidae	*Zosterops lateralis*	Silvereye		C		6	0
birds	Turdidae	*Zoothera heinei*	Russet-Tailed Thrush		C		1	0
birds	Turnicidae	*Turnix maculosus*	Red-Backed Button-Quail		C		1	0
birds	Tytonidae	*Tyto javanica*	Eastern Barn Owl		C		1	1
birds	Tytonidae	*Tyto longimembris*	Eastern Grass Owl		C		3	0
birds	Tytonidae	*Tyto tenebricosa multipunctata*	Lesser Sooty Owl		C		1	0
bony fish	Belonidae	*Strongylura krefftii*	Freshwater Longtom				1	0
bony fish	Clupeidae	*Nematalosa erebi*	Bony Bream				1	0
bony fish	Eleotridae	*Hypseleotris galii*	Firetail Gudgeon				1	0
bony fish	Melanotaeniidae	*Melanotaenia eachamensis*	Lake Eacham Rainbowfish			E	1	1
bony fish	Melanotaeniidae	*Melanotaenia splendida splendida*	Eastern Rainbowfish				2	0
bony fish	Melanotaeniidae	*Melanotaenia splendida inornata*	Checkered Rainbowfish				1	0
bony fish	Terapontidae	*Leiopotherapon unicolor*	Spangled Perch				1	0
mammals	Dasyuridae	*Planigale maculata*	Common Planigale		C		3	2
mammals	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll		C	E	2	1
mammals	Leporidae	*Oryctolagus cuniculus*	Rabbit	Y			2	0
mammals	Macropodidae	*Petrogale mareeba*	Mareeba Rock-Wallaby		NT		3	2
mammals	Macropodidae	*Macropus robustus*	Common Wallaroo		C		1	0
mammals	Macropodidae	*Macropus parryi*	Whiptail Wallaby		C		1	0
mammals	Macropodidae	*Macropus agilis*	Agile Wallaby		C		2	0
mammals	Macropodidae	*Thylogale stigmatica*	Red-Legged Pademelon		C		2	0
mammals	Muridae	*Rattus rattus*	Black Rat	Y			1	1
mammals	Muridae	*Uromys caudimaculatus*	Giant White-Tailed Rat		C		1	0
mammals	Muridae	*Rattus sordidus*	Canefield Rat		C		1	1
mammals	Peramelidae	*Perameles nasuta*	Long-Nosed Bandicoot		C		2	1
mammals	Petauridae	*Petaurus breviceps*	Sugar Glider		C		2	2
mammals	Petauridae	*Dactylopsila trivirgata*	Striped Possum		C		1	0
mammals	Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum		C		3	1

Class	Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
mammals	Potoroidae	*Aepyprymnus rufescens*	Rufous Bettong		C		1	0
mammals	Pseudocheiridae	*Pseudochirops archeri*	Green Ringtail Possum		NT		2	2
mammals	Pseudocheiridae	*Pseudocheirus peregrinus*	Common Ringtail Possum		C		1	1
mammals	Pteropodidae	*Pteropus scapulatus*	Little Red Flying-Fox		C		1	0
mammals	Pteropodidae	*Pteropus conspicillatus*	Spectacled Flying-Fox		C	V	9	2
mammals	Tachyglossidae	*Tachyglossus aculeatus*	Short-Beaked Echidna		C		2	2
reptiles	Boidae	*Morelia spilota*	Carpet Python		C		4	0
reptiles	Boidae	*Morelia kinghorni*	Amethystine Python (Australian Form)		C		1	0
reptiles	Boidae	*Aspidites melanocephalus*	Black-Headed Python		C		2	0
reptiles	Colubridae	*Tropidonophis mairii*	Freshwater Snake		C		1	1
reptiles	Elapidae	*Cacophis churchilli*			C		1	1
reptiles	Elapidae	*Pseudonaja textilis*	Eastern Brown Snake		C		1	1
reptiles	Elapidae	*Acanthophis antarcticus*	Common Death Adder		NT		1	1
reptiles	Elapidae	*Rhinoplocephalus nigrescens*	Eastern Small-Eyed Snake		C		1	1
reptiles	Gekkonidae	*Oedura rhombifer*	Zig-Zag Gecko		C		1	0
reptiles	Scincidae	*Carlia storri*			C		1	1
reptiles	Scincidae	*Eulamprus tenuis*			C		1	1
reptiles	Scincidae	*Cryptoblepharus metallicus*	Metallic Snake-Eyed Skink		C		1	0

Appendix D1. EPBC Protected Matters Search Tool Results

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

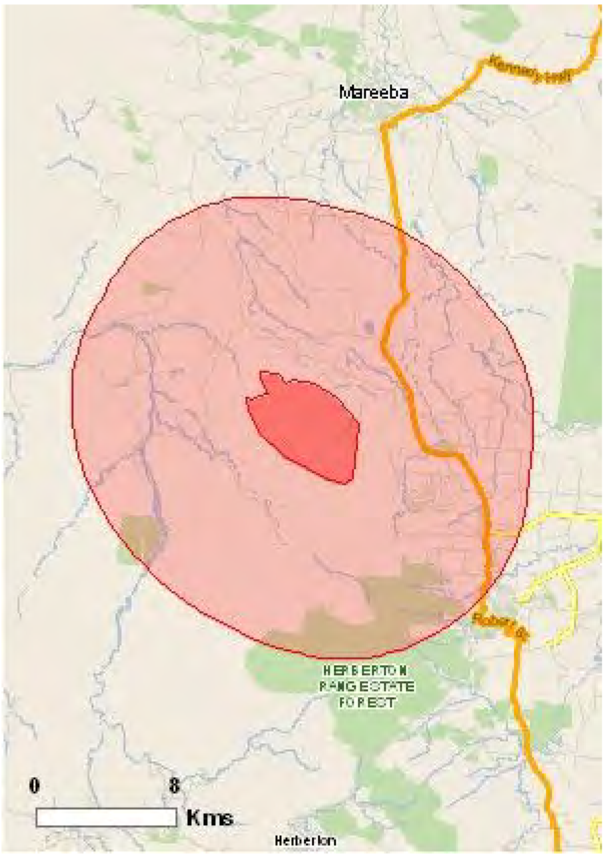
EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 26/07/11 12:29:23



Coordinates

Buffer: 10.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	1
Threatened Species:	41
Migratory Species:	19

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	1
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Mabi Forest (Complex Notophyll Vine Forest 5b)	Critically Endangered	Community known to occur within area

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Casuarius casuarius johnsonii		
Southern Cassowary (Australian), Southern Cassowary [25986]	Endangered	Species or species habitat known to occur within area
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae		
Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Neochmia ruficauda ruficauda		
Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
FISH		
Melanotaenia eachamensis		
Lake Eacham Rainbowfish [26185]	Endangered	Species or species habitat known to occur within area

FROGS		
Litoria nannotis		
Waterfall Frog, Torrent Tree Frog [1817]	Endangered	Species or species habitat may occur within area
Litoria nyakalensis		
Mountain Mistfrog [1820]	Critically Endangered	Species or species habitat likely to occur within area
Litoria rheocola		
Common Mistfrog [1802]	Endangered	Species or species habitat may occur within area
Nyctimystes dayi		
Lace-eyed Tree Frog, Australian Lacelid [1813]	Endangered	Species or species habitat may occur within area
Pseudophryne covacevichae		
Magnificent Brood Frog [64385]	Vulnerable	Species or species habitat likely to occur within area
MAMMALS		
Bettongia tropica		
Northern Bettong [214]	Endangered	Species or species habitat likely to occur within area
Conilurus penicillatus		
Brush-tailed Rabbit-rat, Brush-tailed Tree-rat [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat known to occur within area
Dasyurus maculatus gracilis		
Spotted-tailed Quoll or Yarri (North Queensland subspecies) [64475]	Endangered	Species or species habitat likely to occur within area
Hipposideros semoni		
Semon's Leaf-nosed Bat, Greater Wart-nosed Horseshoe-bat [180]	Endangered	Species or species habitat may occur within area
Petaurus australis unnamed subsp.		
Yellow-bellied Glider (Wet Tropics), Fluffy Glider [66668]	Vulnerable	Species or species habitat likely to occur within area
Pteropus conspicillatus		
Spectacled Flying-fox [185]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Species or species habitat may occur within area
Rhinolophus philippinensis (large form)		
Greater Large-eared Horseshoe Bat [66890]	Endangered	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus		
Bare-rumped Sheathtail Bat [66889]	Critically Endangered	Species or species habitat may occur within area
OTHER		
Cycas platyphylla		
a cycad [55796]	Vulnerable	Species or species habitat likely to occur within area
PLANTS		

Acacia guymeri [20972]	Vulnerable	Species or species habitat likely to occur within area
Acacia ramiflora [7242]	Vulnerable	Species or species habitat may occur within area
Alloxylon flammeum Red Silky Oak, Queensland Waratah, Tree Waratah [56400]	Vulnerable	Species or species habitat likely to occur within area
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat likely to occur within area
Cajanus mareebensis [8635]	Endangered	Species or species habitat likely to occur within area
Chamaesyce carissoides [67187]	Vulnerable	Species or species habitat likely to occur within area
Dendrobium superbiens Curly Pinks [64885]	Vulnerable	Species or species habitat likely to occur within area
Grevillea glossadenia [7979]	Vulnerable	Species or species habitat likely to occur within area
Hodgkinsonia frutescens Atherton Turkey Bush [14763]	Vulnerable	Species or species habitat likely to occur within area
Huperzia filiformis Rat's Tail Tassel-fern [24163]	Endangered	Species or species habitat likely to occur within area
Huperzia marsupiiformis Water Tassel-fern [56632]	Vulnerable	Species or species habitat likely to occur within area
Huperzia phlegmarioides Layered Tassel-fern [24166]	Vulnerable	Species or species habitat likely to occur within area
Phalaenopsis rosenstromii [15984]	Endangered	Species or species habitat likely to occur within area
Sauropus macranthus [13189]	Vulnerable	Species or species habitat likely to occur within area
Taeniophyllum muelleri Minute Orchid, Ribbon-root Orchid [10771]	Vulnerable	Species or species habitat likely to occur within area
Tropilis callitrophilis Thin Feather Orchid [82771]	Vulnerable	Species or species habitat likely to occur within area
Tylophora rupicola [55237]	Endangered	Species or species habitat likely to occur within area
Tylophora williamsii [55235]	Vulnerable	Species or species habitat likely to occur within area

SHARKS		
Pristis microdon		
Freshwater Sawfish [66182]	Vulnerable	Species or species habitat likely to occur within area

Migratory Species		**[Resource Information]**
Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Marine Species		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Erythrura gouldiae		
Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Breeding may occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Breeding likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Breeding may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Grus antigone		
Sarus Crane [904]		Species or species habitat likely to occur within area

Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Defence - ATHERTON RIFLE RANGE

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Breeding may occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Breeding likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Breeding may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]		Species or species habitat may occur within area

Reptiles	
Crocodylus johnstoni	
Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]	Species or species habitat may occur within area
Crocodylus porosus	
Salt-water Crocodile, Estuarine Crocodile [1774]	Species or species habitat likely to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	Status
Natural	
Brydes Granite Gorge Beetle Site QLD	Indicative Place

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica		
Prickly Acacia [6196]		Species or species habitat may occur within area
Annona glabra		
Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India		Species or species habitat likely to occur within area

Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]	
Hymenachne amplexicaulis	
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]	Species or species habitat likely to occur within area
Lantana camara	
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]	Species or species habitat likely to occur within area
Parthenium hysterophorus	
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]	Species or species habitat likely to occur within area
Salvinia molesta	
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]	Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-17.15419 145.35489,-17.15471 145.35634,-17.15351 145.3618,-17.15241 145.36547,-17.14409 145.36138,-17.14093 145.36211,-17.14191 145.37088,-17.14705 145.37561,-17.14465 145.37858,-17.14683 145.38974,-17.15376 145.40073,-17.16774 145.41225,-17.19577 145.40927,-17.19832 145.40485,-17.19551 145.39454,-17.18454 145.37422,-17.1727 145.3623,-17.16678 145.35825,-17.16032 145.35571,-17.15419 145.35489

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW

-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix E1. Microchiropteran Bat Analysis Reports

Anabat echolocation data interpretation summary

Client: RPS (Cairns/Townsville) **Job no.:** RPS-1002 **Analysis Date:** 11/06/2010

Project name/location: Arriga Palteau (May 2010 Survey)

Numbers in columns represent number of calls attributed to each species or species group

Species	10-May	11-May	12-May	13-May	Total calls for species
Calls positively identified					
Hipposideros diadema			1		1
Scotorepens sanborni	3				3
Vespadelus troughtoni	1				1
Miniopterus australis	5		1	4	10
Miniopterus orianae oceanensis	20	3	13	21	57
Austronomus australis	1		4		5
Chaerephon jobensis	1				1
Mormopterus ridei				2	2
Saccolaimus flaviventris	1				1
Total calls positively identified	32	3	19	27	81
Calls NOT positively identified					
Chalinolobus nigrogriseus / S. sanborni	1				1
S. flaviventris / C. jobensis	2	1		2	5
unknown bat call	24	1	4	13	42
Total calls NOT positively identified	88	8	41	69	206
Total calls for night	59	5	23	42	129

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

Call identification was based on published call descriptions for southern Queensland (Reinhold *et al* 2001) and the Northern Territory (Milne 2002) and on reference calls collected from central and northern Qld.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes to the table - discussion of species/groups with low reliability of identification

Chalinolobus nigrogriseus / S. sanborni	calls are at similar frequencies; usually differentiated on slightly different pulse shapes but one call form this survey with intermediate shape and could have been either species
S. flaviventris / C. jobensis	call frequency overlaps; usually have different pulse shapes but a few brief calls could have been either species
Unknown calls	these are calls that were too brief, weak or noisy to enable reliable species identification; they represent species already listed above, not additional species

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory* . Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

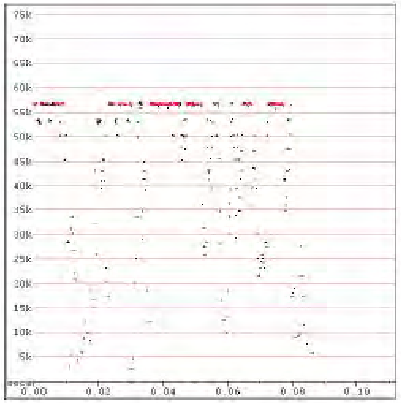
van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

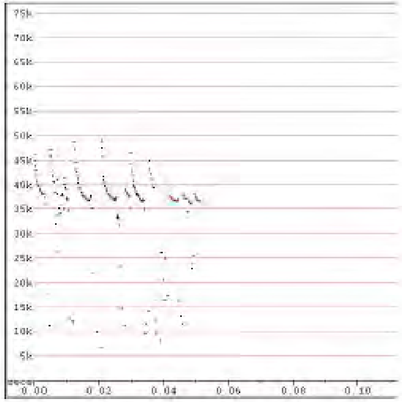
Sample calls extracted from theArriga Plateau survey data (RPS Townsville; May 2010)

Scale: 10 msec per tick; time between pulses removed (*AnalookW* F7 compressed mode)

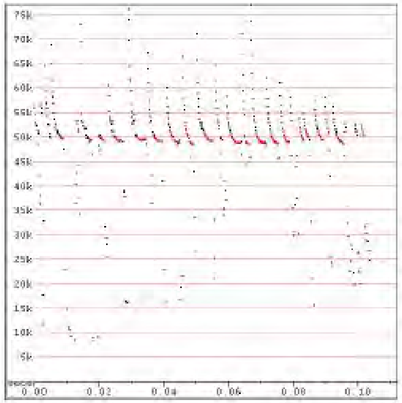
Species positively identified



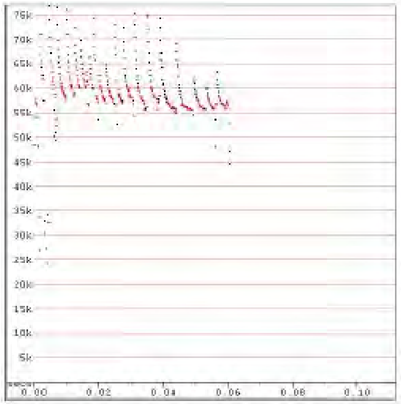
Hipposideros diadema



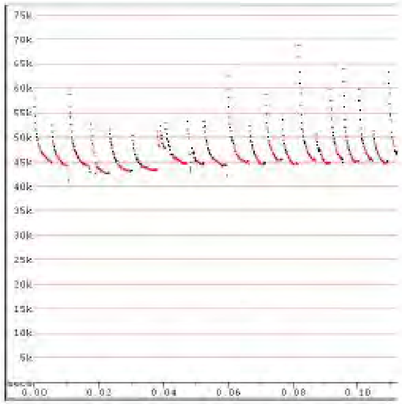
Scotorepens sanborni



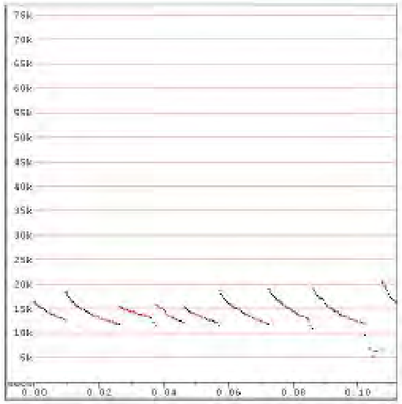
Vespadelus troughtoni



Miniopterus australis



Miniopterus orianae oceanensis



Austronomus australis

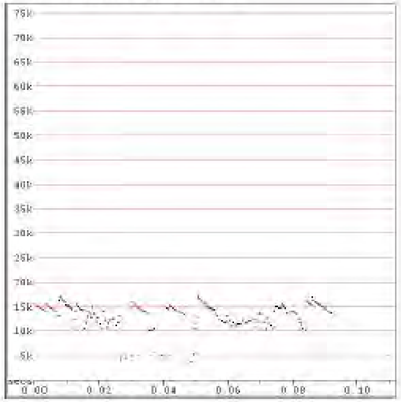
balance!
PO Box 1744, Toowoomba Qld 4350

Anabat Data Analysis Summary

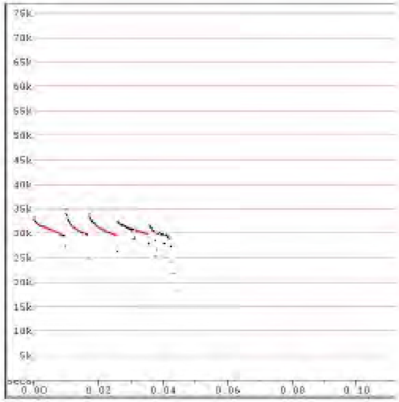
Sample calls extracted from theArriga Plateau survey data (RPS Townsville; May 2010)

Scale: 10 msec per tick; time between pulses removed (*AnalookW* F7 compressed mode)

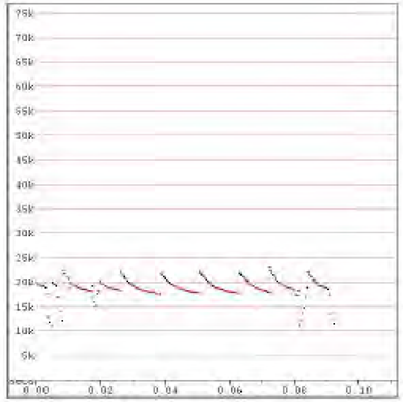
Species positively identified



Chaerephon jobensis

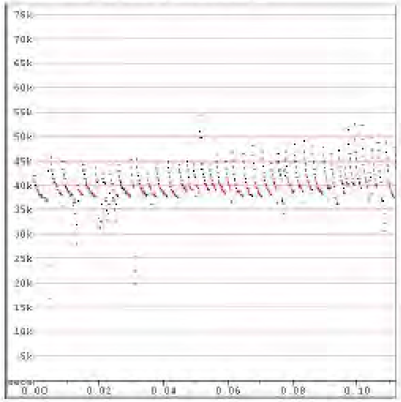


Mormopterus ridei

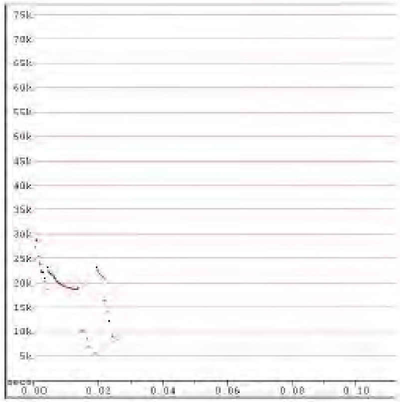


Saccolaimus flaviventris

Calls NOT positively identified



Chalinolobus nigrogriseus / S. sanborni



S. flaviventris / C. jobensis

Prepared by Greg Ford
11/06/2010

balance!
PO Box 1744, Toowoomba Qld 4350

Anabat echolocation data interpretation summary

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

Species identification summary:

Numbers in columns represent number of calls attributed to each species or species group

Detector:	AB01				AB03			RPS Zcaim			
Date:	**28-Mar**	**29-Mar**	**30-Mar**	**31-Mar**	**28-Mar**	**29-Mar**	**31-Mar**	**28-Mar**	**29-Mar**	**30-Mar**	**31-Mar**
Species positively identified											
Rhinolophus megaphyllus			3		7	1					
Chalinolobus gouldii							4				
Nyctophilus species	2	1	1			3			1		
Scotorepens orion	3	1	1		4	1			1		
Vespadelus troughtoni										1	
Miniopterus australis	1	1	6	1	33	15	6	3	5	2	3
Miniopterus orianae oceanensis	1	5	122	39	11	8	54	29	16	1	1
Chaerephon jobensis			3			1					
Mormopterus beccarii	2	4	5							1	
Saccolaimus flaviventris	2	3	7		2		2	3	2	2	
Total positively identified calls	11	15	148	40	57	29	66	35	25	7	4
Calls NOT positively identified *											
Scotorepens sanborni or *Chalinolobus nigrogriseus*	7	3	7		11	81		1	2	5	2
C. jobensis or *S. flaviventris*	1		1								
M. beccarii or *Taphozous troughtoni*	1		3								
M. beccarii or S. flaviventris	1		1								
S. flaviventris or ***S. saccolaimus*** or *T. troughtoni*			1								
Unidentified bat calls	1		10	1	5	10				1	
Total calls NOT positively identified	11	3	23	1	16	91	0	1	2	6	2
Total calls recorded	22	18	171	41	73	120	66	36	27	13	6

***** Species listed in this section and not above should be considered as possibly present in the study area.
See notes below regarding species identity for calls with poor resolution.

P.O. Box 1744, Toowoomba QLD 4350

Anabat Data Analysis Summary

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

No call descriptions or key exists for the survey region; however, published keys and descriptions from other regions (Milne 2001; Reinhold *et al.* 2001; Pennay *et al.* 2004) were used to guide this analysis. Reference was also made to calls collected from bats of known identity in southern, central and north-eastern Queensland.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes - species/calls not reliably identified

***Nyctophilus* species**
The long-eared bats produce distinctive linear calls that are usually distinguishable from other species; however, the species within the genus *Nyctophilus* cannot be differentiated using Anabat data. Three species potentially occur in the survey area: *N. bifax*, *N. geoffroyi* and *N. gouldii*.

Scotorepens sanborni or Chalinolobus nigrogriseus
Calls from these species are virtually impossible to differentiate and both are likely to occur in the study area.

C. jobensis or S. flaviventris
Most calls from these bats are easy to distinguish; however, brief and/or weak calls in the frequency overlap zone (*ca.* 17-20kHz) can sometimes be confused. A few such calls from this survey could not be reliably identified.

M. beccarii or Taphozous troughtoni
These species overlap in frequency around 23-25kHz, but can usually be distinguished due to unique pulse shapes. *M. beccarii* was positively identified from a number of calls; however, a few low quality calls in the frequency range had insufficient definition in the pulse shape to reliably attribute to either species.

M. beccarii or S. flaviventris
Some attack-phase pulses from *S. flaviventris* are similar in appearance to the erratic, steep pulses of *M. beccarii*. Most calls were positively attributed to either species based on distinctive search-phase pulses, but a couple of noisy and weak calls could not be reliably differentiated.

S. flaviventris or S. saccolaimus or T. troughtoni
A single call from AB01 on 30/3 contains clear search-phase pulses like those of *S. flaviventris*, but the frequency is higher than expected for such a call (around 22kHz). It is possible that the call came from *T. troughtoni*, but that species usually generates flatter pulses than those exhibited in this call. With a frequency at *ca*. 22kHz and smoothly-curved, low-bandwidth pulses, it is considered highly probable that this call came from the endangered *S. saccolaimus* as they match the description provided by Corben (2010).

Unidentified bat calls
These were calls that were too brief and/or weak and/or noisy to allow reliable attribution to any species or species group. All such calls were within the frequency ranges of species otherwise listed in the table and are unlikely to represent additional species.

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2010). Acoustic identification of *Saccolaimus* . *Proceedings of the 14th Australasian Bat Society Conference, Darwin, Australia, 12-14 July 2010* .

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales.* Department of Environment and Conservation, Hurstville.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

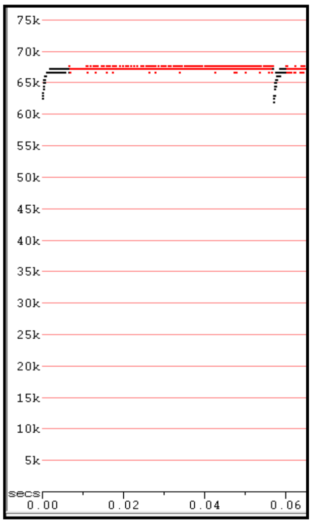
Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

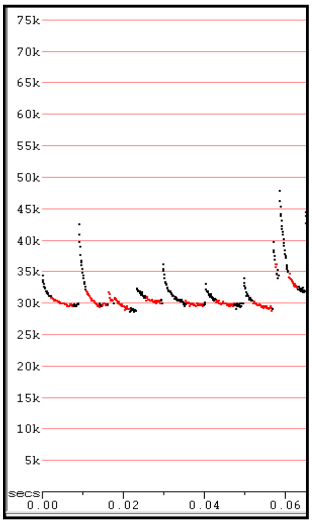
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

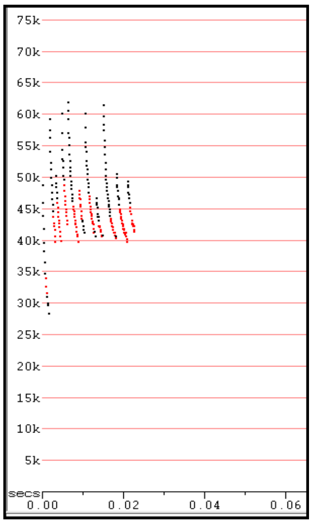
Species positively identified



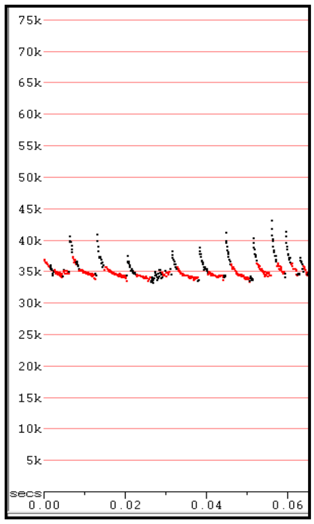
Rhinolophus megaphyllus



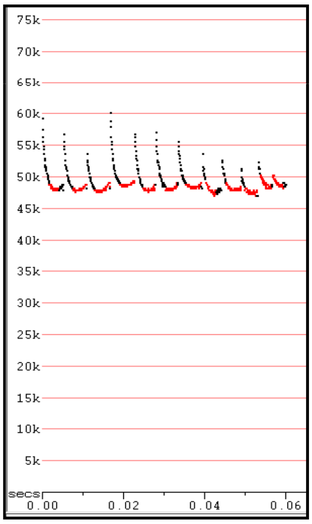
Chalinolobus gouldii



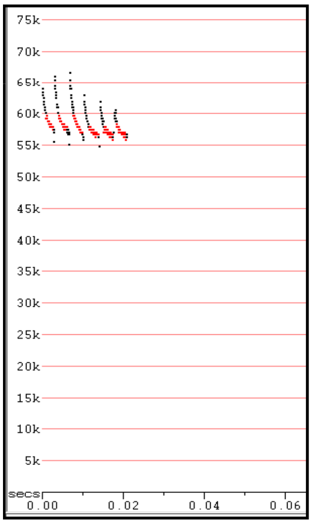
Nyctophilus species



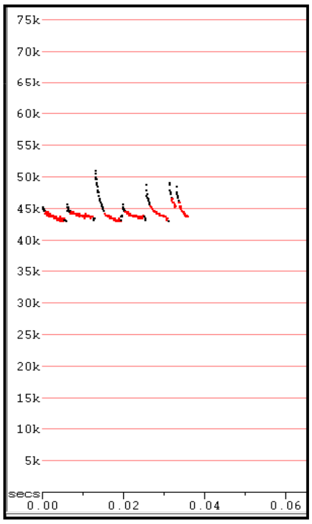
Scotorepens orion



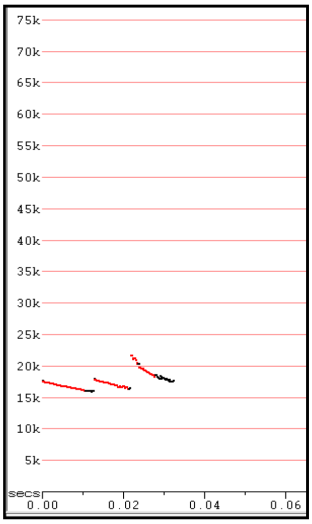
Vespadelus troughtoni



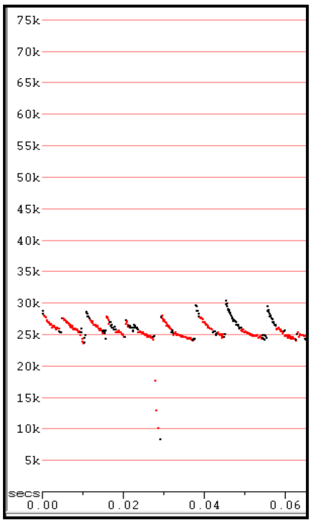
Miniopterus australis



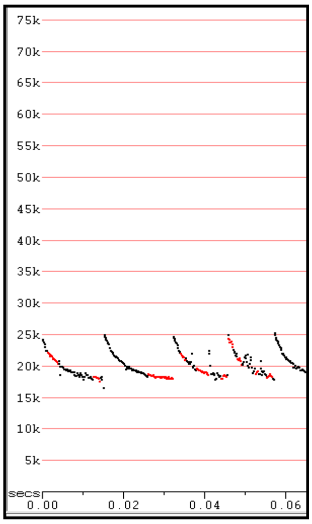
Miniopterus orianae oceanensis



Chaerephon jobensis



Mormopterus beccarii



Saccolaimus flaviventris

Anabat Data Analysis Summary

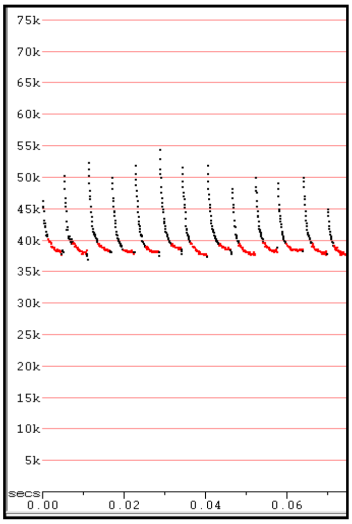
Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

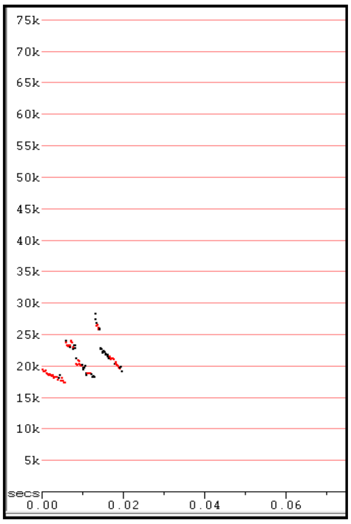
Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

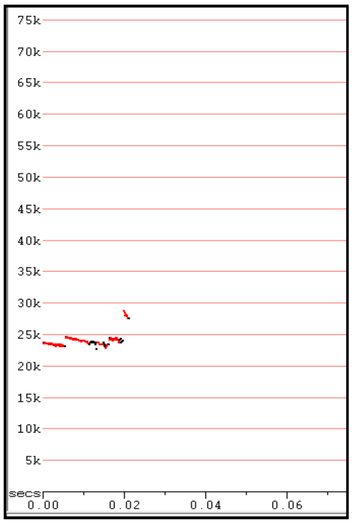
Sample calls extracted from the survey data.

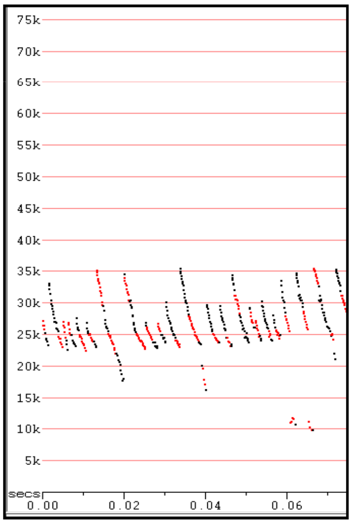
Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

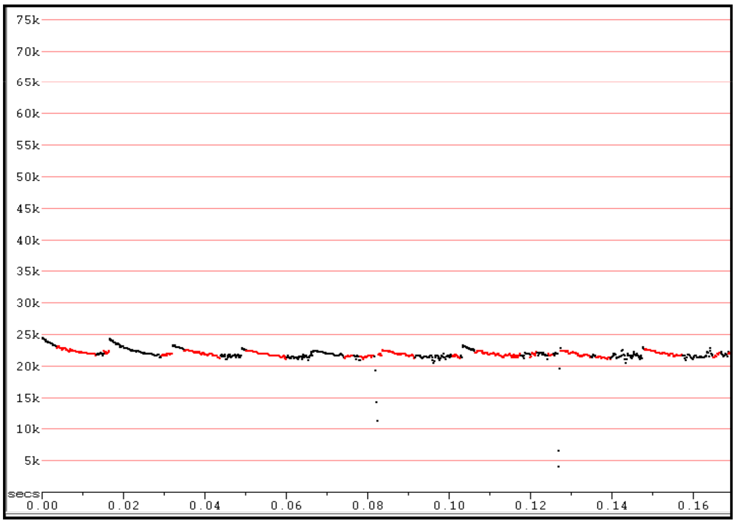
Calls not positively identified


S. sanborni or *C. nigrogriseus*


C. jobensis or *S. flaviventris*


M. beccarii or *Taphozous troughtoni*


M. beccarii or S. flaviventris


S. flaviventris or ***S. saccolaimus*** or *T. troughtoni*

Anabat Data Analysis Summary

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Data received for analysis

The echolocation call data analysed here was recorded using several Wildlife Acoustics SongMeter SM2BAT detectors (192kHz Stereo model).

Data was received as WAC files (Wildlife Acoustics proprietary lossless compression format), sorted by SM2BAT unit number or Turbine (site) number.

WAC files were converted to zero-crossing files (ZCA) using *WAC2WAV Version 3.2.3* (Wildlife Acoustics, 2011).

ZCA files were then viewed and calls identified in *AnalookW Version 3.7w* (Corben, 2009).

The WAC to ZCA conversion process generated very large data sets (2,000-10,000 ZCA files) for each detector; however, noise filters applied in *AnalookW* (and also in additional trials using *WAC2WAV*) produced relatively low numbers of files that actually contained bat calls(<100 per night per detector).

TABLE 1 Species identified from the Mt Emerald echolocation call data

Note: The following three SM2BAT detectors were operated with just one microphone connected to the ***Left*** channel and set at shrub level.

Detector	SM2BAT_005106				
Date	8/06/2011	9/06/2011	10/06/2011	11/06/2011	Total Calls
Channel	left	left	left	left	
Species					
Austronomus australis	2	8	6	17	33
Chaerephon jobensis		2			2
Chalinolobus nigrogriseus or *Scotorepens sanborni*	3	3		2	8
Miniopterus australis	4	7	2	8	21
Miniopterus orianae oceanensis	11	27	23	15	76
Mormopterus ridei					0
Rhinolophus megaphyllus		2			2
***Taphozous troughtoni* or *Saccolaimus* species**		**1**			1
Unidentified bat calls	7	11	4	7	29
Total calls recorded	27	61	35	49	172

Detector	SM2BAT_0057322			SM2BAT_005733	
Date	8/06/2011	9/06/2011	Total Calls	8/06/2011	Total Calls
Channel	left	left		left	
Species					
Austronomus australis	1		1	4	4
Chaerephon jobensis			0	2	2
Chalinolobus nigrogriseus or *Scotorepens sanborni*	2		2		0
Miniopterus australis			0	13	13
Miniopterus orianae oceanensis	1	2	3	6	6
Mormopterus ridei			0		0
Rhinolophus megaphyllus			0		0
Taphozous troughtoni or *Saccolaimus* species			0		0
Unidentified bat calls	1		1	3	3
Total calls recorded	5	2	7	28	28

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Anabat Data Analysis Summary

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Table 1 (cont.)

Note: Both channels were used at the following turbine sites. ***Left*** channel microphone was placed at approximately 80m above ground level. ***Right*** channel microphone was placed at approximately 30m above ground level.

Detector	Turbine #15						
Date	1/06/2011		2/06/2011		3/06/2011		Total Calls
Channel	left	right	left	right	left	right	
Species							
Austronomus australis		3				3	6
Chaerephon jobensis							0
Chalinolobus nigrogriseus or *Scotorepens sanborni*		8				1	9
Miniopterus australis		4				1	5
Miniopterus orianae oceanensis		13		2		3	18
Mormopterus ridei						1	1
Rhinolophus megaphyllus							0
Taphozous troughtoni or *Saccolaimus* species							0
Unidentified bat calls		1		6			7
Total calls recorded	0	29	0	8	0	9	46

Detector	Turbine #47								
Date	1/06/2011		2/06/2011		3/06/2011		4/06/2011		Total Calls
Channel	left	right	left	right	left	right	left	right	
Species									
Austronomus australis	5		15	8	12	3	1	1	45
Chaerephon jobensis		3		1				1	5
Chalinolobus nigrogriseus or *Scotorepens sanborni*	2								2
Miniopterus australis									0
Miniopterus orianae oceanensis	1	1			1				3
Mormopterus ridei					1				1
Rhinolophus megaphyllus									0
Taphozous troughtoni or *Saccolaimus* species									0
Unidentified bat calls	9	8	17	4	20	1	7	1	67
Total calls recorded	17	12	32	13	34	4	8	3	123

Anabat Data Analysis Summary

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

Call identification for this data set was based on call descriptions and keys presented in Reinhold *et al.* (2001) and Milne (2002) as well as reference calls collected in eastern & northern Queensland and the Northern Territory.

Species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes on species present and reliably of call identification

POSSIBLE OCURRENCE OF THREATENED SPECIES - *SACCOLAIMUS SACCOLAIMUS*

Taphozous troughtoni or Saccolaimus species

The calls of these species are dificult to differentiate, as there is significant overlap in their characteristic frequency range and pulse shapes. Typical characteristics, extracted from available reference calls, are compared in Table 2.

A single call of fair quality, recorded on 9/6 by SM2BAT_005106, could have been from any of these three species.

A comparison of major call parameter means (t-test) between the Mt Emerald call and reference calls of these three species suggest it is significantly different from *S. saccolaimus* but that most parameters are not significantly different from either of the other species. It should be noted, however, that the Mt Emerald call only provided 10 pulses for this comparison. The P values for these t-tests are shown in Table 3.

Further analysis by plotting values for major parameters against one-another suggest the call is most similar to reference calls from *T. troughtoni* , although the spread of points for *S. saccolaimus* reference calls (D. Milne, NT specimens) further reduces the reliability of this analysis. See Figures 1-4 for this comparison.

TABLE 2 Typical call characteristics of *Taphozous troughtoni* and two *Saccolaimus species*

Species	*Pulse shape*	*Characteristic freq.*	*Maximum frequency*	*Pulse duration*
T. troughtoni	mostly curved; short initial sweep	21-23 kHz	24 kHz	3-10 ms
S. flaviventris	flat to curved; often steep initial sweep	18-21 kHz	28 kHz	5-15 ms
S. saccolaimus	flat to curved; no apparent steep initial sweep	20-23 kHz	27 kHz	10-25 ms

OTHER SPECIES IDENTIFIED IN THIS DATA SET

Austronomus australis

Calls are distinctive - lower frequency than most other species. Minor frequency overlap with *C. jobensis* (at ca. 14-17kHz), but calls from *A. australis* in overlap zone are 'approach-phase' with steep erratic pulses, *cf.* flat 'search phase' pulses from *C. jobensis* .

Chalinolobus nigrogriseus or Scotorepens sanborni

These two species produce very similar calls, with characteristic frequency around 36-40kHz, that are difficult to differentiate. Both species are likely to be present in the study area, so all relevant calls were considered to potentially represent either.

Chaerephon jobensis

Search phase calls have mainly flat pulses around 14-17kHz and are generally easy to identify. 'Approach phase' calls have steeper pulses that overlap in frequency with those of *Saccolaimus flaviventris* (around 17-21kHz), but which have erratic changes in pulse shape and frequency within the call sequence (*cf.* uniform pulses in *S. flaviventris*). All calls in the relevant frequency range were attributable to *C. jobensis* with no evidence of typical *S. flaviventris* calls.

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Miniopterus australis

Highly distinctive calls with characteristic frequency 56-60kHz - not possible to confuse with any other species that would occur in the study area.

Miniopterus orianae oceanensis

Distinctive calls around 44-48kHz, which are not likely to be confused with any other species that would be present in the study area.

Mormopterus ridei

Calls are fairly distinctive, with flat pulses and frequency range around 30-35kHz. Frequency overlaps with several other species that may be present (e.g. *Scoteanax rueppellii* , *Scotorepens orion*), but those species almost always have steep, curved pulses, rather than the flat pulses typical of *Mormopterus* species.

Rhinolophus megaphyllus

Cannot confuse this species with any other that would be present in the study area. It produces long-duration, constant-frequency pulses around 65-70kHz.

Unidentified bat calls

These were calls that contained only one or two pulses, usually of indeterminate shape, or incompletely recorded, or confused amongst background noise. All such calls were within frequency ranges of species listed above and are unlikely to indicate additional species present in the survey area.

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D. (2002). *Key to the Bat Calls or the Top End of the Northern Territory.* Technical Report No. 71; Parks and Willdife Commission of the Northern Territory; Darwin.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales* . Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Table 3 Results of t-tests for Mt Emerald suspect *Saccolaimus saccolaimus* call against reference calls for similar species.

	P values for call parameters										
	Dur	TBP	Fmax	Fmin	Fmean	Tk	Fk	Tc	Fc	S1	Sc
Mt Emerald & *S. saccolaimus* (NT)	0.1717	0.0000	0.0000	0.2127	0.1056	0.0099	0.1693	0.4254	0.5472	0.4233	0.0003
Mt Emerald & *T. troughtoni* (NW Qld)	0.0000	0.0000	0.0000	0.6402	0.0031	0.0576	0.0000	0.0000	0.1483	0.0000	0.0000
Mt Emerald & *S. flaviventris* (SEQld)	0.2233	0.0000	0.0000	0.0004	0.5600	0.0000	0.2290	0.1579	0.0006	0.0000	0.0000

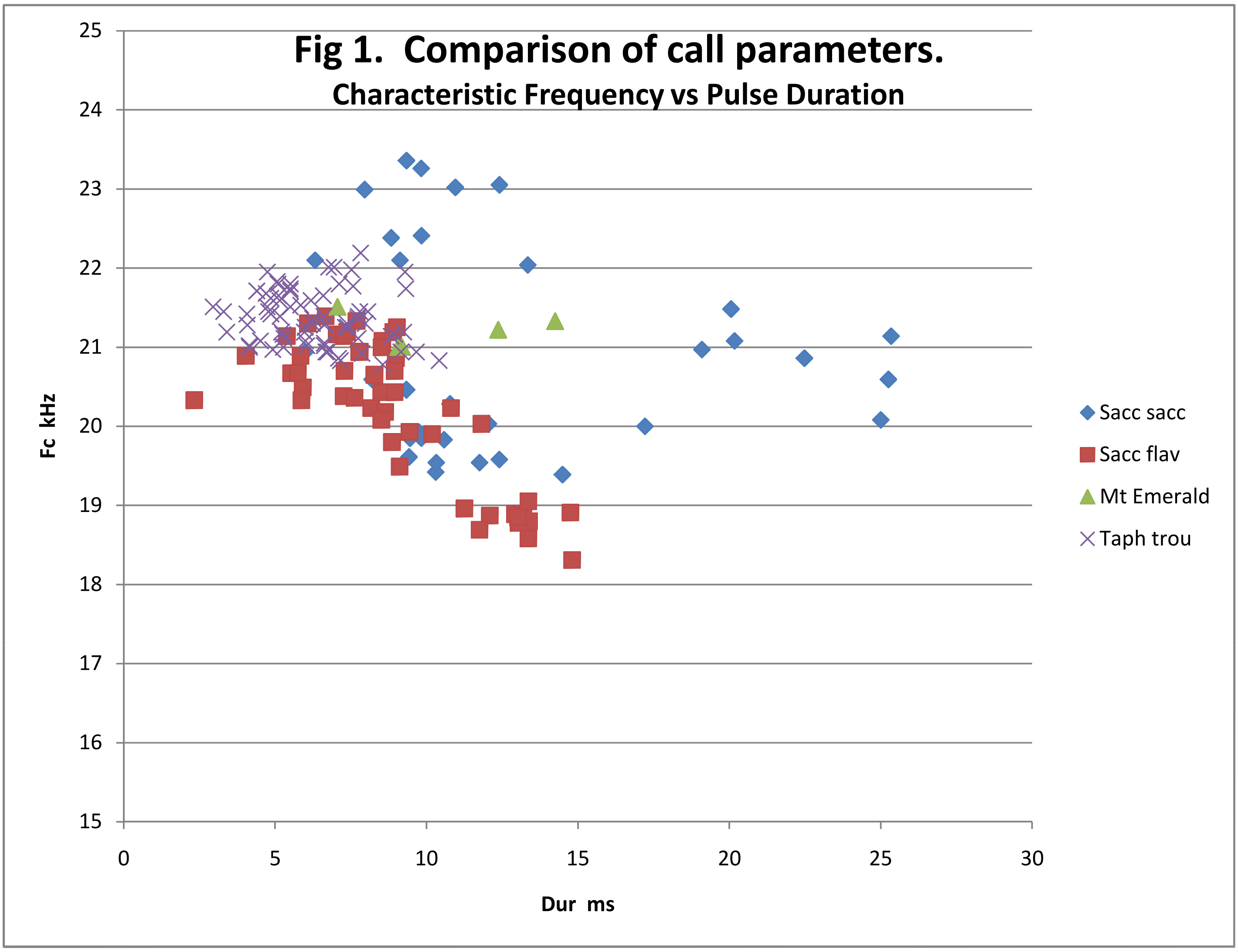
Call parameter glossary:

Dur Pulse duration
Prev Time between pulses
Fmax Maximum frequency of pulses
Fmin Minimum frequency of pulses
Fmean Mean frequency of pulses
Tk Time to knee (from start of pulse to first significant change in slope)
Fk Frequency of knee (frequency at which pulse slope changes)
Tc Time from start of pulse to beginning of characteristic section ('body')
Fc Characteristic frequency (lowest frequency in the characteristic section)
S1 Slope of initial frequency sweep (before knee)
Sc Slope of characteristic frequency section

Anabat Data Analysis Summary

Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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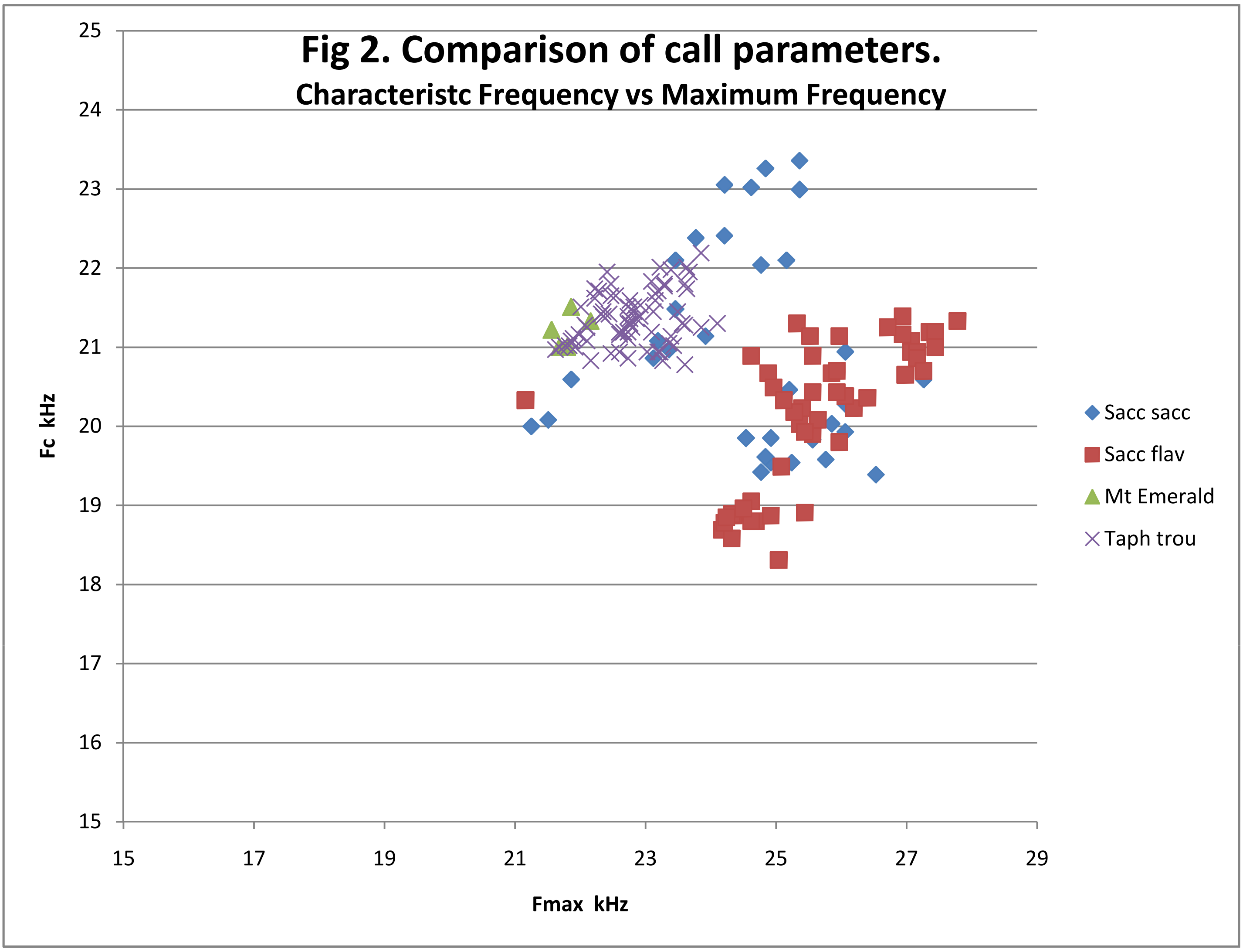
Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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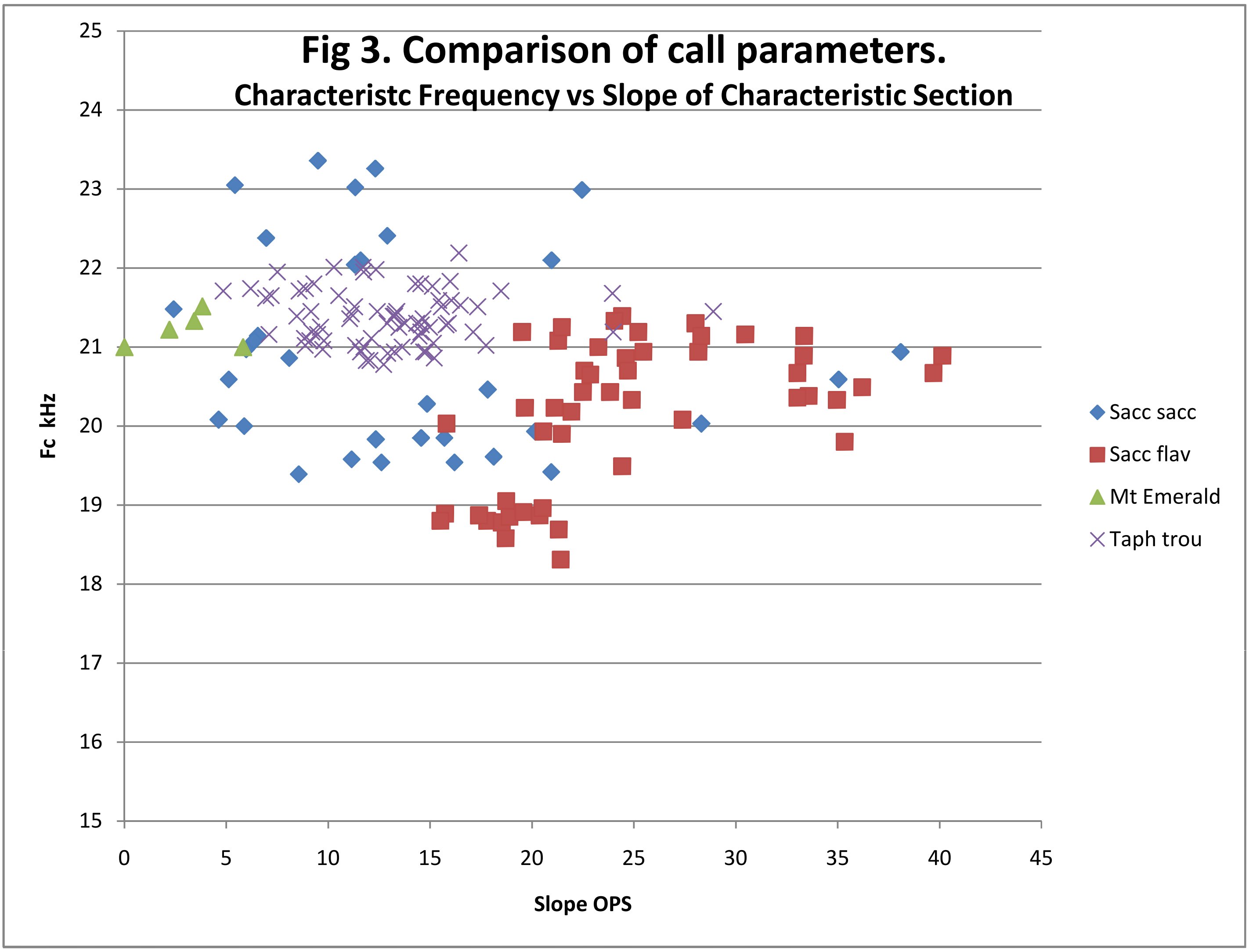
Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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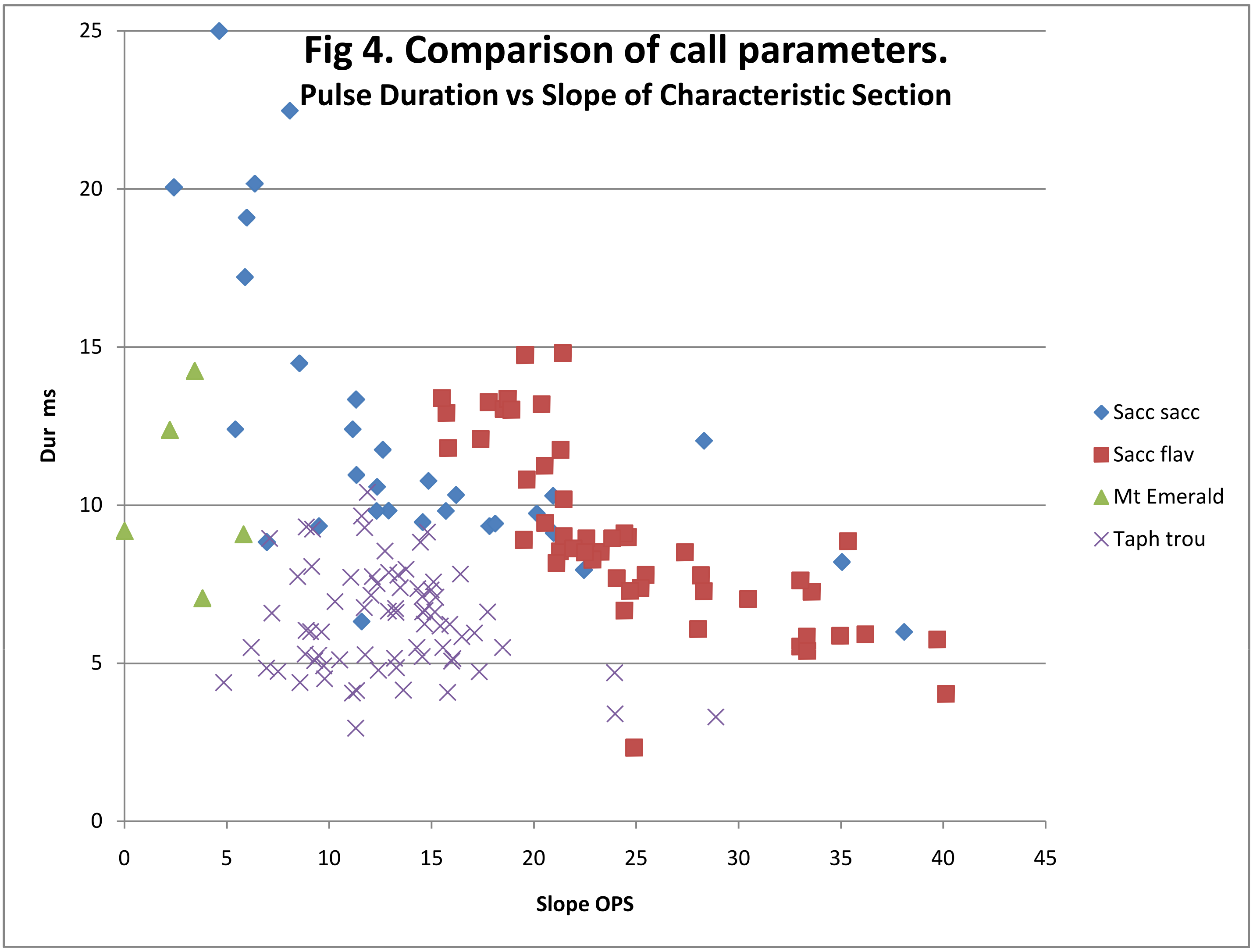
Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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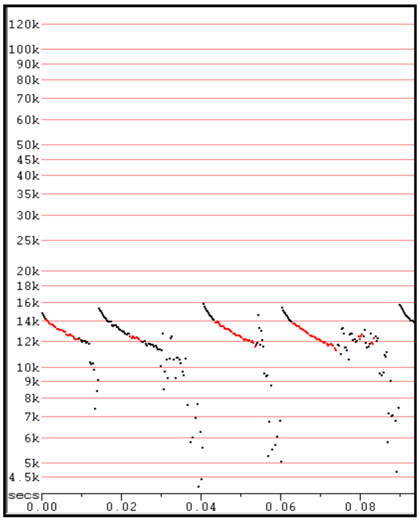
Anabat Data Analysis Summary

Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

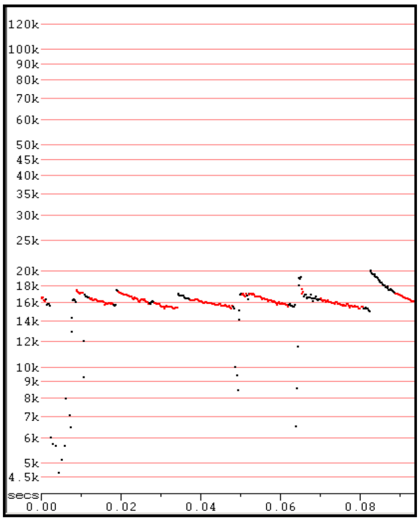
Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Sample calls extracted from the survey data

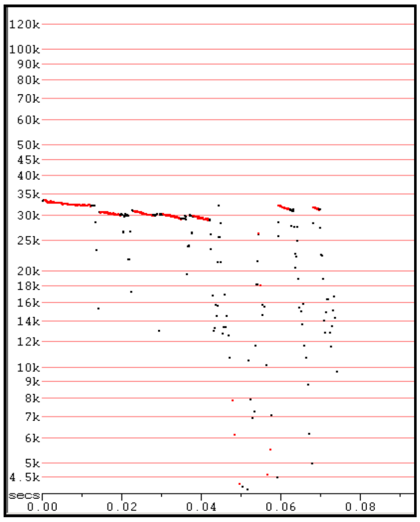
Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)



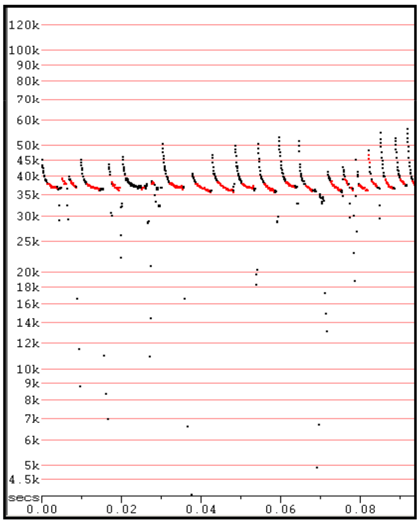
Austronomus australis



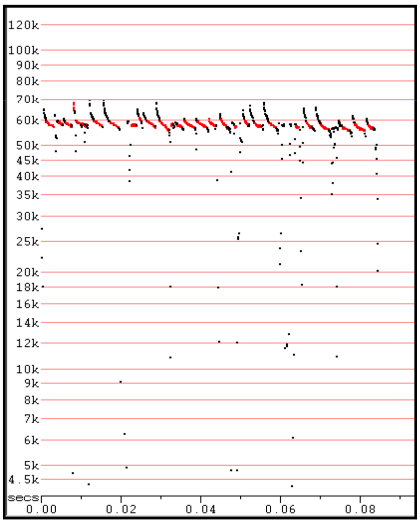
Chaerephon jobensis



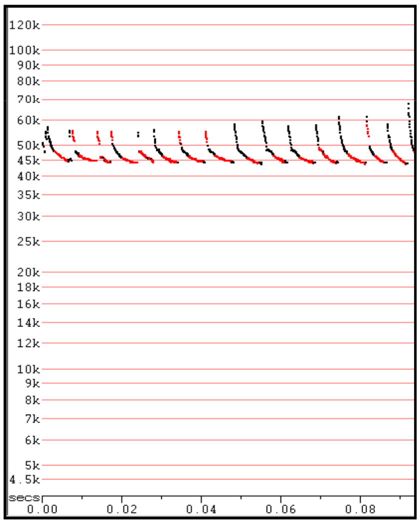
Mormopterus ridei



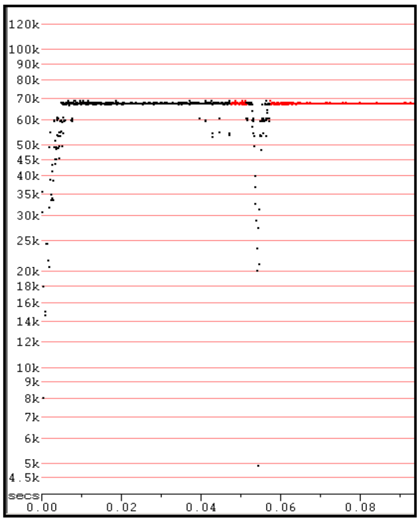
C. nigrogriseus or *S. sanborni*



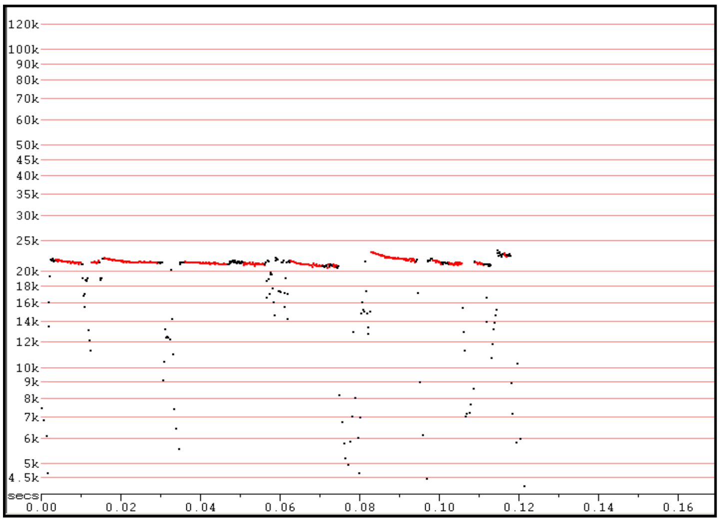
Miniopterus australis



Miniopterus orianae oceanensis

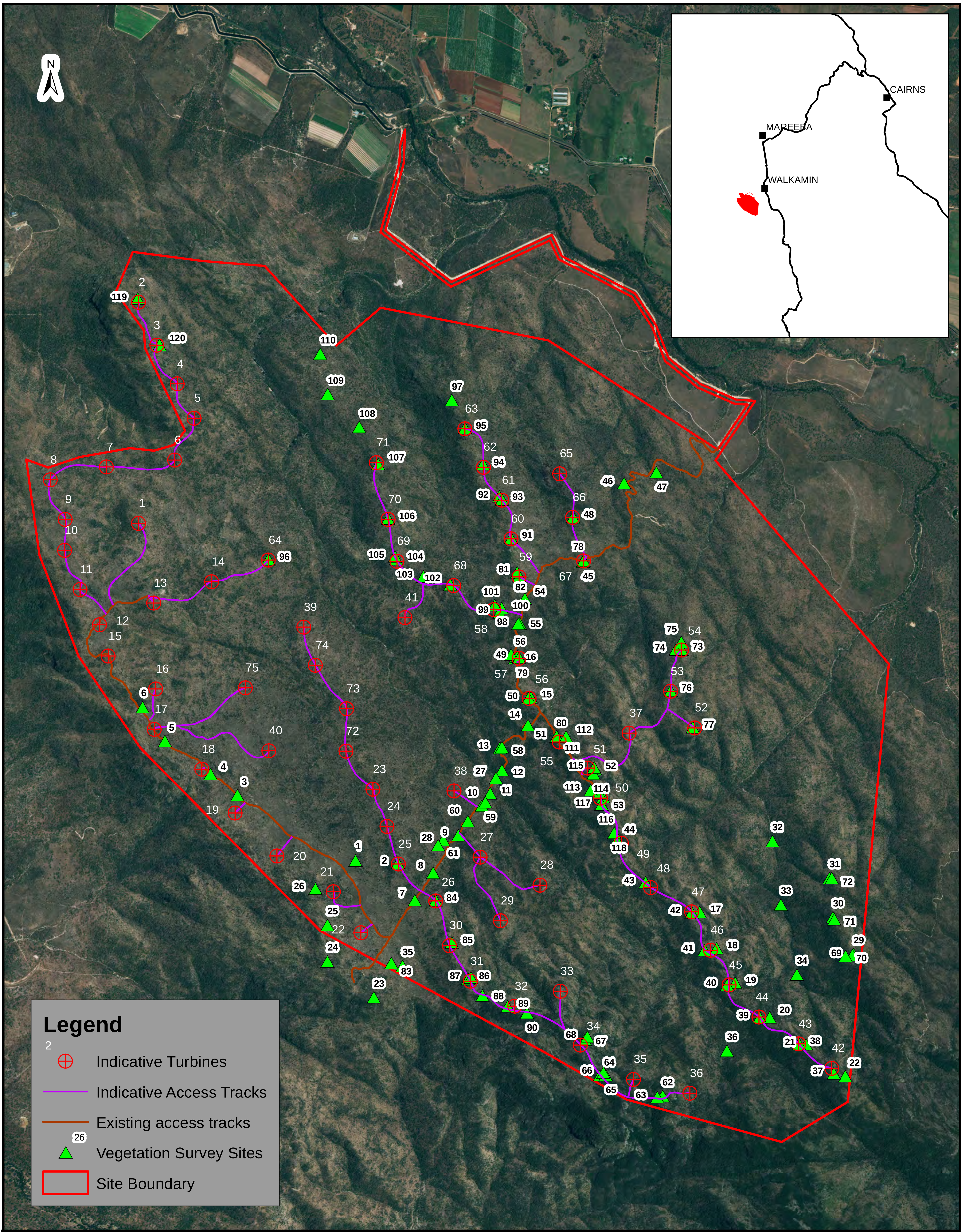


Rhinolophus megaphyllus



Taphozous troughtoni or *Saccolaimus* sp

Appendix A2. Vegetation Survey Sites



DIGITAL CADASTRAL DATA BASE - BOUNDARY INFORMATION.
REGIONAL ECOSYSTEM VERSION 6 DATA
Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2010. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Regional ecosystem linework compiled at scale greater than 1:100,000, except in designated areas, where a compilation scale of 1:50,000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100,000 is +/-100 metres.

D. FINNEY
Compiled by J. MIDDLETON
Map Projection MGAz55
Map Datum GDA94
File Reference PR100246-05.mxd
Sheet Number 1 of 1

Client
Transfield Services
Mount Emerald Wind Farm

Title
Vegetation Survey Sites

0 0.6 1.2 km

RPS Australia East Pty Ltd
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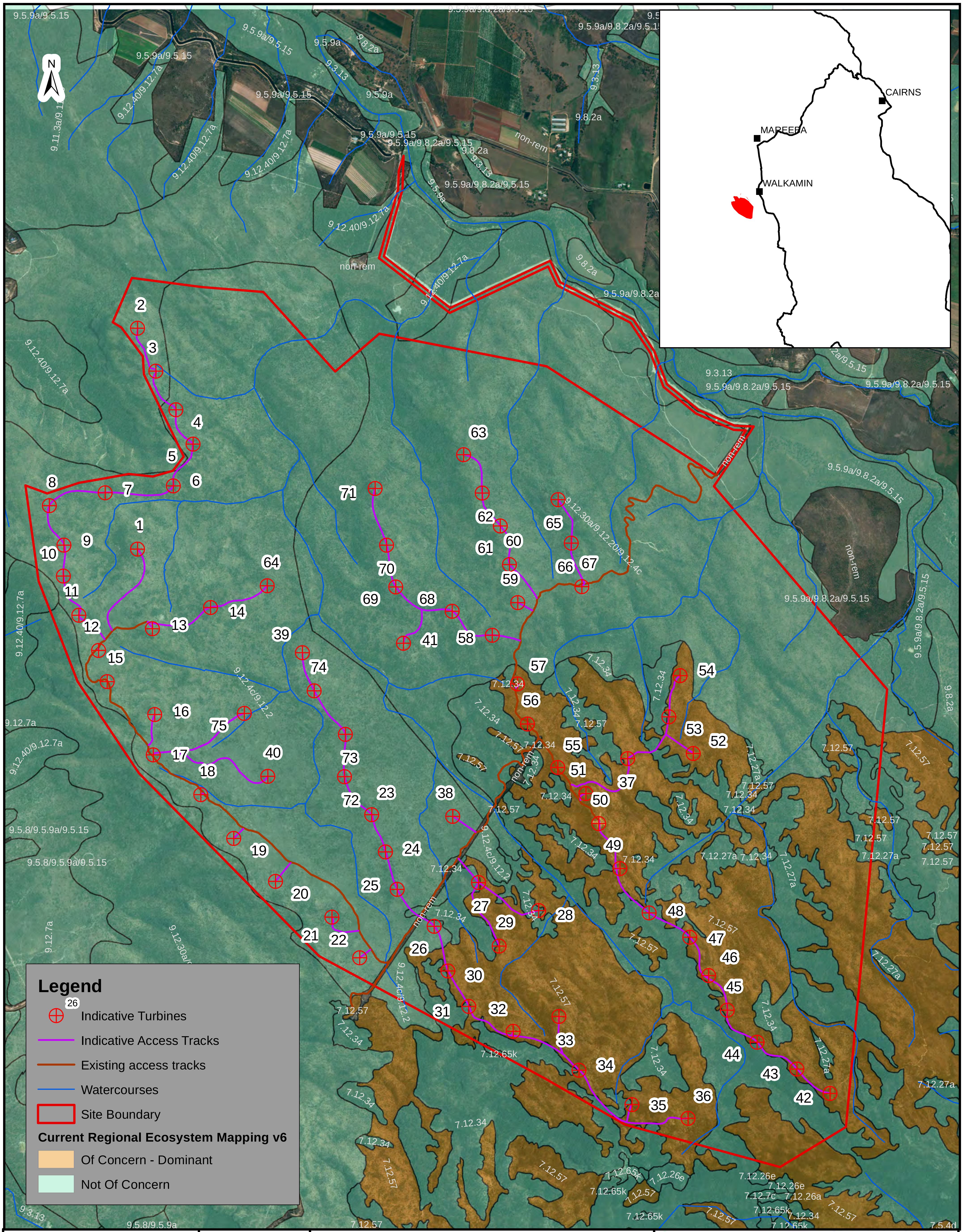
SCALE (A3)	DATE	DRAWING NO.	ISSUE
1:24,000	10/08/2011	PR100246-5	

Appendix B2.



DIGITAL CADASTRAL DATA BASE - BOUNDARY INFORMATION.
REGIONAL ECOSYSTEM VERSION 6 DATA
Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2010. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Regional ecosystem linework compiled at scale greater than 1:100,000, except in designated areas, where a compilation scale of 1:50,000 is available. Linework should be used as a guide only.
The positional accuracy of RE data mapped at a scale of 1:100,000 is +/-100 metres.

D. FINNEY
Compiled by: J. MIDDLETON
Map Projection: MGAz55
Map Datum: GDA94
File Reference: PR100246-84.mxd
Sheet Number: 1 of 1

Client: Transfield Services
Mount Emerald Wind Farm

Title: Current Regional Ecosystem Mapping v6

0 0.6 1.2 km

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Appendix C2.

Regional ecosystem 7.12.34

Vegetation Management Act class (November 2009) Least concern

Biodiversity status No concern at present

Subregion 5, 9.3, 6, 4, 7, 9.6, 9, (9.4) Estimated extent In December 2006, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained.

Extent in reserves High

Short description Eucalyptus portuensis and/or E. drepanophylla, +/- C. intermedia +/- C. citriodora, +/- E. granitica open-woodland to open-forest, on uplands on granite

Structure category Sparse

Description Eucalyptus portuensis (white mahogany) and/or E. drepanophylla (ironbark), +/- C. intermedia (pink bloodwood) +/- C. citriodora (lemon-scented gum), +/- E. granitica (granite ironbark) open-woodland to open-forest. Uplands on granite, of the dry rainfall zone.

Supplementary description Stanton and Stanton (2005), G16m, R16m; Tracey and Webb (1975), 16m

Protected areas Hann Tableland NP, Girringun NP, Paluma Range NP, Mount Windsor NP, Dinden NP, Herberton Range NP, Bare Hill CP, Mount Lewis FR, Davies Creek NP, Herberton Range CP, Mount Cook NP, Herberton Range NP (R), Kirrama NP, Danbulla NP, Dinden NP (R), Koombooloomba South FR, Mount Windsor NP (R), Dinden FR, Tully Falls NP, [Danbulla NP (R)].

Regional ecosystem 7.12.57

Vegetation Management Act class (November 2009) Of concern

Biodiversity status Of concern

Subregion 4, 6, 9.6, 5, (9), (7), (9.4), (9.3)

Estimated extent In December 2006, remnant extent was < 10,000 ha and >30% of the pre-clearing area remained

Extent in reserves Low

Short description Shrubland and low woodland mosaic with Syncarpia glomulifera, Corymbia abergiana, Eucalyptus portuensis, Allocasuarina littoralis and Xanthorrhoea johnsonii, on uplands and highlands on granite

Structure category Mid-dense

Description Shrubland and low woodland mosaic with Syncarpia glomulifera (turpentine), Corymbia abergiana (range bloodwood), Eucalyptus portuensis (white mahogany), Allocasuarina littoralis (black sheoak) and Xanthorrhoea johnsonii (grasstree). Uplands and highlands on granite and rhyolite, of the moist and dry rainfall zones.

Supplementary description Stanton and Stanton (2005), G55, R55

Protected areas Mount Lewis FR, [Herberton Range NP], [Koombooloomba South FR]

Regional ecosystem 9.12.2

Vegetation Management Act class (November 2009) Least concern

Biodiversity status No concern at present

Subregion 6, 4, 3, (2), (7.6), (7.5)

Estimated extent In December 2006, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained.

Extent in reserves High

Short description Eucalyptus portuensis, Corymbia citriodora, E. granitica or E. crebra, C. intermedia or C. clarksoniana mixed open forest on steep hills and ranges on acid and intermediate volcanics close to Wet Tropics boundary

Structure category Mid-dense

Description Mixed open forest to occasionally low open woodland including combinations of the species Eucalyptus portuensis (white mahogany), Corymbia citriodora (lemon-scented gum), E. granitica (granite ironbark) or E. crebra (narrow-leaved ironbark), C. intermedia (pink bloodwood) or C. clarksoniana (Clarkson's bloodwood) +/- E. cloeziana (Gympie messmate) +/- Corymbia spp. There is often an open to mid-dense sub-canopy containing canopy species +/- Melaleuca viridiflora (broad-leaved paperbark) +/- Lophostemon suaveolens (swamp mahogany) +/- C. leichhardtii (yellowjacket) . The shrub layer varies from scattered shrubs to mid-dense and includes juvenile canopy species, Acacia flavescens (yellow wattle), Callitris intratropica (cypress pine), L. suaveolens, Xanthorrhoea johnsonii (grasstree) and Petalostigma pubescens (quinine). The dense grassy ground layer is generally dominated by Themeda triandra (kangaroo grass) +/- Heteropogon triticeus (giant speargrass) +/- Mnesithea rottboellioides (northern canegrass). In some areas, patches dominated by E. moluccana (gum-topped box) or E. cloeziana may occur. Occurs on rises, hill and ranges.

Protected areas Girringun NP, Paluma Range NP, Hann Tableland NP, Mount Windsor NP, Mount Lewis FR.

Regional ecosystem 9.12.4

Vegetation Management Act class (November 2009) Least concern

Biodiversity status No concern at present

Subregion 4, 2, (5)

Estimated extent In December 2006, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained. Extent in reserves Low

Short description Eucalyptus shirleyi and/or E. melanophloia and/or Corymbia peltata and/or Callitris intratropica low open woodland on acid volcanic rocks

Structure category Very sparse

Description Low open woodland to woodland of Eucalyptus shirleyi (silver-leaved ironbark) and/or E. melanophloia (silver-leaved ironbark) +/- Corymbia peltata (rustyjacket) +/- Callitris intratropica (cypress pine). The mid layer varies from absent to a mid-dense sub canopy and/or shrub layer and the ground layer is dense and grassy. Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills.

Major vegetation communities include:

9.12.4a: Low open woodland to occasionally a low open forest of Eucalyptus shirleyi (silver-leaved ironbark) or E. melanophloia (silver-leaved ironbark) and Corymbia peltata (rustyjacket) +/- E. crebra (narrow-leaved ironbark) (sens. lat.) +/- Acacia leptostachya (slender wattle). E. crebra may also occur as an emergent. A sub-canopy containing E. shirleyi, Alphitonia excelsa, Acacia spp. and Persoonia falcata can occur. E. shirleyi can occur as a dense sub-canopy under C. peltata. The shrub layer varies from absent to mid-dense with an extremely variable species mix including Maytenus cunninghamii (yellowberry bush), Acacia leptostachya, Petalostigma banksii (smooth-leaved quinine), Persoonia falcata, Alphitonia spp. and Acacia spp. Xanthorrhoea johnsonii (grass-tree) can also occur in a lower shrub layer. The dense grassy ground layer is dominated by Heteropogon spp., Schizachyrium fragile (firegrass) and Themeda triandra (kangaroo grass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills.

9.12.4b: Low open woodland of Eucalyptus shirleyi (silver-leaved ironbark) and/or Corymbia dallachiana (Dallachy's gum) +/- C. erythrophloia (red bloodwood) +/- Bursaria incana (prickly pine). The mid-layer is generally absent but scattered Maytenus spp. can occur. The dense grassy ground layer is dominated by Heteropogon contortus (black speargrass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills.

9.12.4c: Low woodland to low open woodland of Callitris intratropica (cypress pine) and Eucalyptus shirleyi (silver-leaved ironbark) and/or E. melanophloia (silver-leaved ironbark) +/- Corymbia leichhardtii (yellowjacket). The sparse mid layer can include juvenile canopy species, Melaleuca monantha (teatree), Dolichandrone heterophylla (lemonwood), Alphitonia obtusifolia, Petalostigma pubescens (quinine), Acacia bidwillii (corkwood wattle) and Grevillea spp. The dominants in the grassy ground can include Schizachyrium fragile (firegrass), Heteropogon contortus (black speargrass) or Themeda triandra (kangaroo grass). Occurs predominantly on sandy shallow soils derived from granite on rolling low hills to hills.

Supplementary description Godwin and Jago (1998): Bc23; Perry et al. (1964): Georgetown Unit 1; Perry et al. (1964): Kilbogie; Perry et al. (1964): Leichhardt Unit 1

Protected areas Blackbraes NP, Blackbraes RR, Dalrymple NP, Paluma Range NP

Regional ecosystem 9.12.20

Vegetation Management Act class (November 2009) Least concern

Biodiversity status No concern at present

Subregion 6, 3

Estimated extent In December 2006, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained.

Extent in reserves Low

Short description Eucalyptus pachycalyx +/- E. cloeziana +/- Corymbia leichhardtii woodland on steep granite hills

Structure category Sparse

Description Woodland to low woodland of Eucalyptus pachycalyx (pumpkin gum) +/- E. cloeziana (Gympie messmate) +/- Corymbia leichhardtii (yellowjacket) +/- Callitris intratropica (cypress pine) +/- E. portuensis (white mahogany) +/- E. cullenii (Cullen's ironbark) or E. atrata. The mid-dense shrub layer includes juvenile canopy species, Grevillea glauca (bushmans clothepeg), Persoonia falcata and Xanthorrhoea johnsonii (grass-tree). The medium to dense grassy ground layer is mostly dominated by Themeda triandra (kangaroo grass). Occurs on steep rugged hills on acid volcanics.

Protected areas Evelyn Creek CP

Regional ecosystem 9.12.30

Vegetation Management Act class (November 2009) Least concern

Biodiversity status No concern at present

Subregion 6, (3)

Estimated extent In December 2006, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained.

Extent in reserves Low

Short description Corymbia leichhardtii and Eucalyptus cloeziana mixed woodland on rhyolite hills

Structure category Sparse

Description Mixed woodland to open forest of Corymbia leichhardtii (yellowjacket) and Eucalyptus cloeziana (Gympie messmate) +/- Eucalyptus spp. and Corymbia spp. as subdominants. The shrub layer is sparse to mid dense with an shrubland of Acacia spp. sometimes occurring. The ground layer is grassy. Occurs on rocky hills to steep hills on rhyolite geologies.

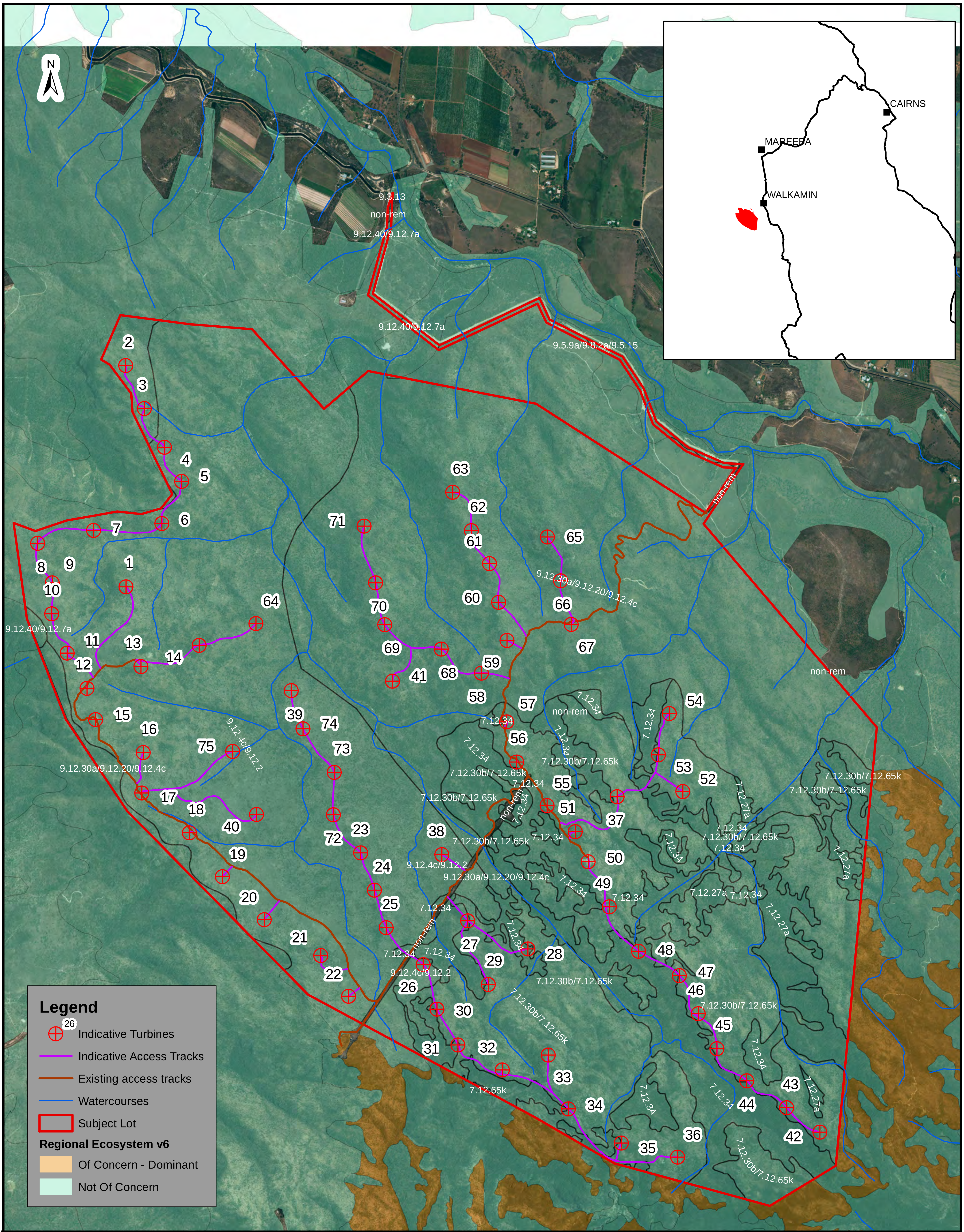
Major vegetation communities include:

9.12.30a: Woodland to open forest of Corymbia leichhardtii (yellowjacket) and Eucalyptus cloeziana (Gympie messmate) +/- E. portuensis (white mahogany) +/- C. citriodora (lemon-scented gum) +/- E. cullenii (Cullen's ironbark) +/- Callitris intratropica (cypress pine). Some canopy species can occur as emergents. The sparse to mid-dense shrub layer is dominated by juvenile canopy species, Persoonia falcata, Grevillea glauca (bushmans clothepeg) and Allocasuarina inophloia (stringybark sheoak) and a lower shrub with Jacksonia thesioides and Xanthorrhoea johnsonii (grass-tree) can occur. The sparse to mid-dense ground layer is dominated by Themeda triandra (kangaroo grass). Rocky rhyolite hills to steep hills.

9.12.30b: Shrubland of Acacia leptostachya (slender wattle) +/- A. umbellata shrubland +/- Callitris intratropica (cypress pine) emergents. There is no mid layer or ground layer. Occurs on shallow soils on rock pavements within 9.12.30a.

Protected areas Evelyn Creek CP

Appendix D2.



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D. FINNEY

Compiled by
J. MIDDLETON

Map Projection
MGAz55

Map Datum
GDA94

File Reference
PR100246-83.mxd

Sheet Number
1 of 1

Client
Transfield Services
Mount Emerald Wind Farm

Title
Amended Regional Ecosystem Mapping

0 0.6 1.2 km

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Appendix E2.

Wildlife Online Search – Flora Mt Emerald Wind Farm

Latitude: 17.1682
Longitude: 145.3805
Distance: 15 km

I: Y indicates that the taxon is introduced to Queensland and has naturalised.
Q: Indicates the Queensland conservation status of each taxon under the Nature Conservation Act 1992. The codes are Presumed Extinct (PE), Endangered (E), Vulnerable (V), Rare (R), Common (C) or Not Protected ( ).
A: Indicates the Australian conservation status of each taxon under the Environment Protection and Biodiversity Conservation Act 1999. The values of EPBC are: Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).
Records: The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens). The second number located after the / indicates the number of specimen records for the taxon.

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Basidiomycota	Amanita			C		5	5
Basidiomycota	Agaricus			C		1	1
Basidiomycota	Inonotus			C		1	1
Basidiomycota	Lactarius			C		1	1
Basidiomycota	Polyporus			C		1	1
Basidiomycota	Stephanospora flava			C		1	1
Basidiomycota	Osmoporus decipiens			C		1	1
Basidiomycota	Lepista sublilacina			C		1	1
Basidiomycota	Coriolus cingulatus			C		1	1
Basidiomycota	Coriolus elongatus			C		1	1
Basidiomycota	Trametes lactinea			C		1	1
Basidiomycota	Trametes friesii			C		1	1
Basidiomycota	Russula foetida			C		1	1
Basidiomycota	Daedalea tenuis			C		1	1
Basidiomycota	Corticium vagum			C		1	1
Basidiomycota	Stereum ostrea			C		2	2
Basidiomycota	Basidiomycota			C		7	7
Basidiomycota	Hymenogaster			C		2	2
Basidiomycota	Scleroderma			C		2	1
Basidiomycota	Psathyrella			C		1	1
Basidiomycota	Pisolithus			C		1	1
Basidiomycota	Microporus			C		2	2
Basidiomycota	Macowanites sp. (Mt Baldy J.Garbaye 1015)			C		1	1
Basidiomycota	Hygrocybe aurantiopallens			C		1	1
Basidiomycota	Armillaria luteobubalina			C		1	1
Basidiomycota	Phellinus rhabarbarinus			C		1	1
Basidiomycota	Hygrocybe chromolimonea			C		2	2
Basidiomycota	Ganoderma williamsianum			C		2	2
Basidiomycota	Ganoderma ochrolaccatum			C		1	1
Basidiomycota	Microporellus obovatus			C		1	1
Basidiomycota	Macrolepiota clelandii			C		1	1
Basidiomycota	Schizophyllum commune			C		1	1
Basidiomycota	Laetiporus sulphureus			C		1	1
Basidiomycota	Clavulinopsis miniata			C		1	1
Basidiomycota	Polyporus sulphureus			C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Basidiomycota	Panaeolus antillarum			C		1	1
Basidiomycota	Microporus xanthopus			C		1	1
Basidiomycota	Phellinus			C		3	3
Basidiomycota	Hygrocybe			C		2	2
Basidiomycota	Calvatia			C		1	1
Basidiomycota	Ramaria			C		1	1
Basidiomycota	Boletus			C		2	2
Basidiomycota	Lepista			C		1	1
Acarosporaceae	Acarospora			C		1	1
Arthoniaceae	Cryptothecia			C		1	1
Parmeliaceae	Parmotrema cooperi			C		1	1
Parmeliaceae	Parmotrema tinctorum			C		1	1
Pertusariaceae	Pertusaria subventosa var. subventosa			C		1	1
Physciaceae	Buellia			C		1	1
Physciaceae	Heterodermia diademata			C		1	1
Physciaceae	Pyxine plumea			C		1	1
Ramalinaceae	Ramalina peruviana			C		2	2
Teloschistaceae	Teloschistes flavicans			C		1	1
Usneaceae	Usnea nidifica			C		2	2
Usneaceae	Usnea rubicunda			C		1	1
Usneaceae	Eumitria pectinata			C		1	1
Ascomycota	Rosellinia			C		1	1
Ascomycota	Rosellinia arcuata			C		1	1
Ascomycota	Bisporella citrina			C		1	1
Glomeromycota	Glomus			C		1	1
Lycopodiaceae	Huperzia phlegmaria	coarse tassel fern		R		1	1
Lycopodiaceae	Lycopodiella cernua			C		1	1
Araucariaceae	Agathis robusta	kauri pine		C		2	2
Araucariaceae	Agathis atropurpurea	blue kauri pine		C		1	1
Araucariaceae	Agathis microstachya	bull kauri		R		2	2
Cupressaceae	Callitris macleayana	stringybark pine		C		2	1
Cupressaceae	Callitris intratropica	coast cypress pine		C		6	1
Podocarpaceae	Sundacarpus amarus			C		4	4
Cycadaceae	Cycas			C		2	0
Cycadaceae	Cycas media - C.platyphylla			C		1	1
Cycadaceae	Cycas media subsp. banksii			C		1	1
Cycadaceae	Cycas media subsp. banksii x C.platyphylla			C		1	1
Cycadaceae	Cycas media subsp. banksii - C.media subsp. media			C		2	2
Adiantaceae	Cheilanthes			C		5	0
Adiantaceae	Pellaea nana			C		3	3
Adiantaceae	Pellaea falcata			C		1	1
Adiantaceae	Cheilanthes nitida			C		2	2
Adiantaceae	Adiantum silvaticum			C		4	4
Adiantaceae	Pityrogramma calomelanos var. calomelanos		Y			1	1
Adiantaceae	Cheilanthes sieberi subsp. sieberi			C		1	1
Adiantaceae	Adiantum hispidulum var. minus			C		2	2
Adiantaceae	Cheilanthes tenuifolia	rock fern		C		1	1
Adiantaceae	Cheilanthes nudiuscula			C		1	1
Adiantaceae	Paraceterach muelleri			C		1	1
Adiantaceae	Doryopteris concolor			C		3	3
Adiantaceae	Adiantum philippense			C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Adiantaceae	Cheilanthes brownii			C		4	4
Adiantaceae	Adiantum atroviride			C		1	1
Adiantaceae	Pellaea paradoxa	heart fern		C		1	1
Aspleniaceae	Asplenium paleaceum	scaly asplenium		C		1	1
Aspleniaceae	Asplenium australasicum			C		1	1
Athyriaceae	Diplazium dilatatum			C		2	2
Athyriaceae	Callipteris prolifera			C		2	2
Azollaceae	Azolla pinnata	ferny azolla		C		1	1
Blechnaceae	Doodia aspera	prickly rasp fern		C		1	1
Blechnaceae	Blechnum cartilagineum	gristle fern		C		1	1
Blechnaceae	Pteridoblechnum neglectum			C		1	1
Blechnaceae	Blechnum wurunuran			C		2	2
Blechnaceae	Doodia caudata			C		2	2
Cyatheaceae	Cyathea celebica			R		2	2
Cyatheaceae	Cyathea baileyana	wig tree fern		R		1	1
Davalliaceae	Davallia pyxidata			C		1	1
Dicksoniaceae	Calochlaena dubia			C		1	1
Dicksoniaceae	Calochlaena villosa			R		1	1
Dicksoniaceae	Dicksonia herbertii			C		2	2
Dryopteridaceae	Lastreopsis tenera			C		1	1
Dryopteridaceae	Lastreopsis rufescens			C		2	2
Dryopteridaceae	Lastreopsis microsora subsp. microsora			C		2	2
Gleicheniaceae	Sticherus flabellatus var. flabellatus			C		1	1
Grammitidaceae	Grammitis wurunuran			C		1	1
Grammitidaceae	Prosaptia fuscopilosa			C		1	1
Hymenophyllaceae	Crepidomanes walleri			C		1	1
Hymenophyllaceae	Cephalomanes obscurum			C		1	1
Hymenophyllaceae	Crepidomanes bipunctatum			C		1	1
Hymenophyllaceae	Hymenophyllum samoense			C		1	1
Lindsaeaceae	Lindsaea brachypoda			C		1	1
Lomariopsidaceae	Teratophyllum brightiae			C		1	1
Lomariopsidaceae	Elaphoglossum callifolium			R		2	2
Lomariopsidaceae	Elaphoglossum queenslandicum	tounge fern		C		2	2
Marattiaceae	Marattia oreades	potato fern		C		1	1
Nephrolepidaceae	Arthropteris tenella	climbing fern		C		3	3
Ophioglossaceae	Ophioglossum gramineum			C		1	1
Platyzomataceae	Platyzoma microphyllum	braid fern		C		10	10
Polypodiaceae	Colysis sayeri			C		3	3
Polypodiaceae	Dictymia brownii	strap fern		C		1	1
Polypodiaceae	Pyrrosia confluens var. dielsii			C		1	1
Pteridaceae	Pteris tremula			C		1	1
Pteridaceae	Acrostichum aureum	golden mangrove fern		C		1	1
Pteridaceae	Pteris tripartita	lacy bracken		C		2	2
Thelypteridaceae	Christella dentata	creek fern		C		1	1
Thelypteridaceae	Christella hispidula			C		1	1
Thelypteridaceae	Cyclosorus interruptus			C		2	2
Thelypteridaceae	Pneumatopteris sogerensis			C		1	1
Thelypteridaceae	Sphaerostephanos unitus var. unitus			C		2	2
Vittariaceae	Monogramma acrocarpa			C		1	1
Acanthaceae	Thunbergia			C		1	1
Acanthaceae	Acanthaceae			C		3	0
Acanthaceae	Brunoniella australis	blue trumpet		C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Acanthaceae	Strobilanthes wallichii		Y			1	1
Acanthaceae	Rostellularia adscendens			C		6	3
Acanthaceae	Rostellularia adscendens subsp. glaucoviolacea			C		2	2
Acanthaceae	Asystasia sp. (Newcastle Bay L.J.Brass 18671)			C		1	1
Acanthaceae	Rostellularia adscendens var. hispida			C		2	2
Acanthaceae	Rostellularia adscendens var. juncea			C		1	1
Acanthaceae	Hypoestes floribunda var. floribunda			C		2	2
Acanthaceae	Stephanophysum longifolium		Y			1	1
Acanthaceae	Harnieria hygrophiloides	white karambal		C		1	1
Acanthaceae	Hypoestes phyllostachya		Y			2	2
Acanthaceae	Brunoniella acaulis			C		1	0
Amaranthaceae	Amaranthus spinosus	needle burr	Y			2	2
Amaranthaceae	Alternanthera ficoidea		Y			1	1
Amaranthaceae	Deeringia amaranthoides	redberry		C		1	1
Anacardiaceae	Euroschinus falcatus var. falcatus			C		1	1
Apiaceae	Platysace valida			C		1	1
Apiaceae	Actinotus gibbonsii	dwarf flannel flower		C		2	2
Apiaceae	Mackinlaya macrosciadea	mackinlaya		C		4	4
Apiaceae	Cyclospermum leptophyllum		Y			1	1
Apocynaceae	Parsonsia			C		1	0
Apocynaceae	Carissa lanceolata			C		3	3
Apocynaceae	Neisosperma poweri			C		4	4
Apocynaceae	Sarcostemma viminale subsp. brunonianum			C		1	1
Apocynaceae	Hoya australis subsp. australis			C		1	1
Apocynaceae	Marsdenia longipedicellata			C		2	2
Apocynaceae	Marsdenia suborbicularis			C		1	1
Apocynaceae	Gomphocarpus physocarpus	balloon cottonbush	Y			3	3
Apocynaceae	Cryptostegia grandiflora	rubber vine	Y			1	0
Apocynaceae	Asclepias curassavica	red-head cottonbush	Y			3	3
Apocynaceae	Alstonia muelleriana	hard milkwood		C		1	1
Apocynaceae	Tylophora benthamii	coast tylophora		C		4	4
Apocynaceae	Parsonsia straminea	monkey rope		C		1	1
Apocynaceae	Melodinus australis	southern melodinus		C		1	1
Apocynaceae	Catharanthus roseus	pink periwinkle	Y			3	2
Apocynaceae	Tylophora colorata			C		3	3
Apocynaceae	Phyllanthera grayi			V		7	7
Apocynaceae	Cascabela thevetia	yellow oleander	Y			1	1
Apocynaceae	Alstonia scholaris	white cheesewood		C		3	2
Apocynaceae	Alyxia spicata			C		2	2
Apocynaceae	Wrightia saligna			C		2	2
Apocynaceae	Parsonsia grayana			C		1	1
Apocynaceae	Alyxia ilicifolia			C		1	1
Apocynaceae	Alyxia grandis			C		1	1
Aquifoliaceae	Ilex arnhemensis subsp. ferdinandi			C		1	1
Araliaceae	Hydrocotyle			C		1	1
Araliaceae	Trachymene montana			C		1	1
Araliaceae	Hydrocotyle acutiloba			C		2	2
Araliaceae	Astrotricha pterocarpa			C		1	1
Araliaceae	Hydrocotyle miranda			C		1	1
Asteraceae	Pterocaulon redolens			C		8	0

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Asteraceae	Synedrella nodiflora		Y			1	1
Asteraceae	Taraxacum officinale	dandelion	Y			1	1
Asteraceae	Podolepis arachnoidea	clustered copper-wire daisy		C		2	2
Asteraceae	Coronidium lanuginosum			C		1	1
Asteraceae	Ozothamnus cassinioides			C		1	1
Asteraceae	Coronidium newcastlianum			C		2	1
Asteraceae	Phacellothrix cladochaeta			C		2	2
Asteraceae	Helichrysum			C		2	0
Asteraceae	Asteraceae			C		1	0
Asteraceae	Centratherum punctatum subsp. punctatum		Y			2	2
Asteraceae	Acmella grandiflora var. brachyglossa			C		5	5
Asteraceae	Emilia sonchifolia var. sonchifolia		Y			1	1
Asteraceae	Conyza canadensis var. pusilla		Y			1	1
Asteraceae	Pseudognaphalium luteoalbum	Jersey cudweed		C		1	1
Asteraceae	Crassocephalum crepidioides	thickhead	Y			2	2
Asteraceae	Dichrocephala integrifolia		Y			1	1
Asteraceae	Peripleura diffusa			C		2	2
Asteraceae	Camptacra gracilis			C		3	3
Asteraceae	Tridax procumbens	tridax daisy	Y			1	0
Asteraceae	Eclipta prostrata	white eclipta		C		1	0
Asteraceae	Ageratina riparia	mistflower	Y			1	1
Asteraceae	Senecio tamoides		Y			2	2
Asteraceae	Cosmos caudatus		Y			2	2
Asteraceae	Cirsium vulgare	spear thistle	Y			2	2
Asteraceae	Bidens pilosa		Y			1	0
Asteraceae	Soliva anthemifolia	dwarf jo jo weed	Y			1	1
Asteraceae	Praxelis clematidea		Y			2	2
Asteraceae	Coronidium rupicola			C		2	2
Asteraceae	Ageratum conyzoides	billygoat weed	Y			1	0
Asteraceae	Parthenium hysterophorus	parthenium weed	Y			2	2
Asteraceae	Bidens alba var. radiata		Y			1	1
Asteraceae	Sigesbeckia orientalis	Indian weed		C		1	0
Asteraceae	Tithonia diversifolia	Japanese sunflower	Y			2	2
Asteraceae	Montanoa hibiscifolia		Y			2	2
Asteraceae	Cyanthillium cinereum			C		9	1
Asteraceae	Ageratum houstonianum	blue billygoat weed	Y			1	0
Balanopaceae	Balanops australiana			C		2	2
Basellaceae	Anredera cordifolia	Madeira vine	Y			1	1
Bignoniaceae	Macfadyena unguis-cati	cat's claw creeper	Y			1	1
Bignoniaceae	Spathodea campanulata subsp. nilotica		Y			1	1
Bignoniaceae	Dolichandrone heterophylla			C		4	1
Boraginaceae	Cordia dichotoma			C		1	0
Boraginaceae	Heliotropium peninsulare			C		1	1
Boraginaceae	Trichodesma zeylanicum			C		2	0
Boraginaceae	Heliotropium tabuliplagae			C		2	2
Boraginaceae	Trichodesma zeylanicum var. zeylanicum			C		1	1
Brassicaceae	Lepidium didymum		Y			1	1
Brassicaceae	Raphanus raphanistrum	wild radish	Y			1	1
Brassicaceae	Lepidium virginicum	Virginian peppercress	Y			3	3
Burseraceae	Canarium australasicum	mango bark		C		2	1
Byttneriaceae	Rulingia dasyphylla	kerrawang		C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Byttneriaceae	Commersonia macrostipulata			C		1	1
Byttneriaceae	Keraudrenia lanceolata			C		1	1
Caesalpiniaceae	Cassia			C		7	0
Caesalpiniaceae	Senna hirsuta		Y			1	1
Caesalpiniaceae	Caesalpinia robusta	giant mother-in-law vine		R		1	1
Caesalpiniaceae	Chamaecrista mimosoides	dwarf cassia		C		3	3
Caesalpiniaceae	Senna pendula var. glabrata	Easter cassia	Y			1	1
Caesalpiniaceae	Chamaecrista rotundifolia var. rotundifolia		Y			1	1
Caesalpiniaceae	Chamaecrista exigua var. exigua			C		3	3
Caesalpiniaceae	Chamaecrista absus var. absus			C		1	1
Caesalpiniaceae	Erythrophleum chlorostachys			C		8	2
Caesalpiniaceae	Senna septemtrionalis		Y			1	1
Caesalpiniaceae	Labichea nitida			C		3	2
Campanulaceae	Lobelia			C		1	0
Campanulaceae	Wahlenbergia			C		2	0
Campanulaceae	Wahlenbergia gracilis	sprawling bluebell		C		1	1
Campanulaceae	Lobelia gibbosa var. gibbosa			C		1	1
Campanulaceae	Wahlenbergia caryophylloides			C		1	1
Campanulaceae	Lobelia membranacea			C		1	1
Capparaceae	Capparis			C		3	0
Carpodetaceae	Abrophyllum ornans var. ornans			C		1	1
Caryophyllaceae	Polycarpaea corymbosa			C		3	0
Caryophyllaceae	Polycarpaea spirostylis subsp. spirostylis			C		2	2
Caryophyllaceae	Polycarpaea corymbosa var. corymbosa			C		2	2
Caryophyllaceae	Polycarpaea spirostylis			C		1	1
Caryophyllaceae	Drymaria cordata subsp. cordata		Y			3	3
Casuarinaceae	Allocasuarina torulosa			C		10	1
Casuarinaceae	Casuarina cunninghamiana			C		1	0
Casuarinaceae	Allocasuarina inophloia			C		2	2
Casuarinaceae	Allocasuarina littoralis			C		6	2
Celastraceae	Celastraceae			C		1	0
Celastraceae	Maytenus bilocularis			C		2	2
Celastraceae	Maytenus cunninghamii	yellow berry bush		C		8	0
Celastraceae	Elaeodendron melanocarpum			C		1	1
Celastraceae	Hedraianthera porphyropetala	hedrianthera		C		1	1
Celastraceae	Euonymus australiana			C		2	2
Celastraceae	Maytenus disperma	orange boxwood		C		4	4
Chrysobalanaceae	Parinari nonda			C		1	0
Clusiaceae	Mammea touriga	brown touriga		R		1	1
Clusiaceae	Hypericum gramineum			C		1	1
Combretaceae	Terminalia sericocarpa	damson		C		1	1
Combretaceae	Terminalia aridicola subsp. aridicola			C		1	1
Convolvulaceae	Ipomoea			C		2	2
Convolvulaceae	Ipomoea indica	blue morning-glory	Y			2	2
Convolvulaceae	Ipomoea polymorpha			C		2	2
Convolvulaceae	Ipomoea eriocarpa			C		2	2
Convolvulaceae	Ipomoea gracilis			C		1	1
Convolvulaceae	Ipomoea hederifolia		Y			1	0
Convolvulaceae	Xenostegia tridentata			C		2	2
Convolvulaceae	Evolvulus alsinoides var. decumbens			C		1	1
Convolvulaceae	Ipomoea polpha subsp. polpha			C		6	6

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Convolvulaceae	Evolvulus alsinoides			C		2	0
Cornaceae	Alangium villosum subsp. polyosmoides			C		3	3
Cucurbitaceae	Diplocyclos palmatus			C		1	1
Cucurbitaceae	Neoachmandra cunninghamii			C		1	1
Cucurbitaceae	Diplocyclos palmatus subsp. affinis			C		1	1
Cucurbitaceae	Cucumis maderaspatanus			C		1	1
Cucurbitaceae	Neoalsomitra clavigera			C		1	1
Cunoniaceae	Pullea stutzeri	hard alder		C		1	1
Cunoniaceae	Gillbeea adenopetala			C		1	1
Cunoniaceae	Geissois biagiana	northern brush mahogany		C		1	1
Dilleniaceae	Hibbertia			C		3	2
Dilleniaceae	Hibbertia melhanioides var. baileyana			C		1	1
Dilleniaceae	Hibbertia aspera subsp. pilosifolia			C		1	1
Dilleniaceae	Hibbertia longifolia			C		3	0
Dilleniaceae	Hibbertia scandens			C		3	2
Droseraceae	Drosera indica			C		1	1
Droseraceae	Drosera angustifolia			C		1	1
Ebenaceae	Diospyros australis	black plum		C		1	1
Ebenaceae	Diospyros pentamera	myrtle ebony		C		1	0
Ebenaceae	Diospyros sp. (Mt Lewis L.S.Smith 10107)			R		1	1
Elaeocarpaceae	Elaeocarpus eumundi	Eumundi quandong		C		2	2
Elaeocarpaceae	Elaeocarpus coorangooloo			R		13	12
Elaeocarpaceae	Elaeocarpus sericopetalus			C		1	1
Elaeocarpaceae	Sloanea australis subsp. parviflora			C		1	1
Elaeocarpaceae	Elaeocarpus largiflorens subsp. largiflorens			C		2	2
Elaeocarpaceae	Elaeocarpus foveolatus			C		1	1
Elaeocarpaceae	Elaeocarpus grandis	blue quandong		C		1	1
Ericaceae	Leucopogon			C		1	0
Ericaceae	Acrotriche baileyana			R		1	1
Ericaceae	Melichrus urceolatus	honey gorse		C		2	2
Ericaceae	Leucopogon ruscifolius			C		1	1
Ericaceae	Astroloma sp. (Baal Gammon B.P.Hyland 10341)			C		1	1
Ericaceae	Acrothamnus spathaceus			C		5	5
Ericaceae	Monotoca scoparia	prickly broom heath		C		2	2
Ericaceae	Acrotriche aggregata	red cluster heath		C		5	5
Erythroxylaceae	Erythroxylum ellipticum			C		1	0
Escalloniaceae	Polyosma hirsuta			C		1	1
Escalloniaceae	Polyosma rhytophloia			C		6	6
Euphorbiaceae	Euphorbia			C		4	0
Euphorbiaceae	Croton minimus			C		1	1
Euphorbiaceae	Bertya polystigma			C		2	2
Euphorbiaceae	Alchornea ilicifolia	native holly		C		3	3
Euphorbiaceae	Baloghia parviflora			C		2	2
Euphorbiaceae	Croton arnhemicus			C		2	0
Euphorbiaceae	Croton insularis	Queensland cascarilla		C		5	4
Euphorbiaceae	Euphorbia pulcherrima		Y			1	1
Euphorbiaceae	Pedilanthus tithymaloides subsp. smallii	zig zag plant	Y			1	1
Euphorbiaceae	Aleurites rockinghamensis			C		3	2
Euphorbiaceae	Chamaesyce hyssopifolia		Y			1	1
Euphorbiaceae	Mallotus philippensis	red kamala		C		2	0

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Fabaceae	Cajanus scarabaeoides var. scarabaeoides			C		3	3
Fabaceae	Austrodolichos errabundus var. (Davies Creek J.R.Clarkson+ 7886B)			C		2	2
Fabaceae	Pultenaea retusa			C		2	2
Fabaceae	Clitoria ternatea	butterfly pea	Y			1	1
Fabaceae	Lotononis bainesii	lotononis	Y			1	1
Fabaceae	Kennedia rubicunda	red Kennedy pea		C		1	1
Fabaceae	Indigofera linnaei	Birdsville indigo		C		1	1
Fabaceae	Indigofera hirsuta	hairy indigo		C		1	1
Fabaceae	Indigofera colutea	sticky indigo		C		1	1
Fabaceae	Hovea densivellosa			C		1	1
Fabaceae	Glycine tomentella	woolly glycine		C		4	2
Fabaceae	Desmodium pullenii			C		2	2
Fabaceae	Crotalaria montana			C		7	0
Fabaceae	Cajanus marmoratus			C		1	1
Fabaceae	Zornia stirlingii			C		1	1
Fabaceae	Tephrosia varians			C		1	1
Fabaceae	Rhynchosia minima			C		2	1
Fabaceae	Glycine syndetika			C		1	1
Fabaceae	Glycine cyrtoloba			C		1	1
Fabaceae	Galactia muelleri			C		2	0
Fabaceae	Crotalaria brevis			C		6	6
Fabaceae	Crotalaria verrucosa			C		1	1
Fabaceae	Crotalaria goreensis	gambia pea	Y			5	3
Fabaceae	Centrosema pascuorum		Y			1	1
Fabaceae	Desmodium triflorum		Y			1	1
Fabaceae	Desmodium filiforme			C		1	1
Fabaceae	Crotalaria humifusa			C		1	1
Fabaceae	Crotalaria calycina			C		5	4
Fabaceae	Cajanus mareebensis			E	E	1	1
Fabaceae	Cajanus acutifolius			C		1	1
Fabaceae	Aeschynomene micranthos			C		1	1
Fabaceae	Crotalaria medicaginea	trefoil rattlepod		C		1	0
Fabaceae	Cajanus confertiflorus			C		1	1
Fabaceae	Tephrosia savannicola			R		1	1
Fabaceae	Indigofera trifoliata			C		1	1
Fabaceae	Indigofera bancroftii			C		2	2
Fabaceae	Erythrina vespertilio			C		4	2
Fabaceae	Uraria lagopodioides			C		5	5
Fabaceae	Tephrosia noctiflora		Y			1	1
Fabaceae	Neonotonia wightii var. wightii		Y			2	2
Fabaceae	Rhynchosia minima var. minima			C		3	3
Fabaceae	Crotalaria retusa var. retusa		Y			1	1
Fabaceae	Vigna radiata var. sublobata			C		6	6
Fabaceae	Macroptilium atropurpureum	siratro	Y			1	1
Fabaceae	Alysicarpus bupleurifolius	sweet alys	Y			1	1
Fabaceae	Austrodolichos errabundus			C		6	6
Fabaceae	Aphyllodium biarticulatum			C		1	1
Fabaceae	Macroptilium lathyroides		Y			1	1
Fabaceae	Derris sp. (Daintree D.E.Boyland+ 469)			C		1	1
Fabaceae	Zornia muelleriana subsp. muelleriana			C		2	2
Fabaceae	Crotalaria incana subsp.		Y			1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
	purpurascens						
Fabaceae	Aeschynomene americana var. americana		Y			1	1
Fabaceae	Macrotyloma uniflorum var. uniflorum		Y			1	1
Fabaceae	Crotalaria montana var. angustifolia			C		2	2
Fabaceae	Cajanus reticulatus var. reticulatus			C		4	4
Fabaceae	Austrosteenisia blackii var. blackii			C		2	2
Fabaceae	Zornia muriculata subsp. muriculata			C		2	2
Fabaceae	Bossiaea armitii			C		2	1
Fabaceae	Glycine curvata			C		1	1
Fabaceae	Hovea longipes	brush hovea		C		1	1
Fabaceae	Cajanus cajan	pigeon pea	Y			1	1
Fabaceae	Uraria picta			C		3	3
Fabaceae	Stylosanthes			C		7	0
Fabaceae	Lamprolobium			C		1	0
Fabaceae	Hovea nana			C		2	2
Fabaceae	Tephrosia			C		1	1
Fabaceae	Desmodium			C		2	0
Fabaceae	Galactia			C		3	3
Fabaceae	Fabaceae			C		1	0
Fabaceae	Glycine			C		2	0
Fabaceae	Cajanus			C		1	0
Fabaceae	Zornia			C		2	1
Fabaceae	Vigna			C		1	1
Fabaceae	Crotalaria medicaginea var. medicaginea			C		2	2
Fabaceae	Crotalaria lanceolata subsp. lanceolata		Y			1	1
Fabaceae	Cajanus scarabaeoides var. pedunculatus			C		1	1
Fabaceae	Zornia muriculata subsp. angustata			C		2	2
Fabaceae	Mirbelia speciosa subsp. ringrosei			C		2	2
Fabaceae	Macrotyloma axillare var. axillare		Y			2	2
Fabaceae	Vigna vexillata var. angustifolia			C		1	1
Fabaceae	Galactia tenuiflora forma sericea			C		4	4
Fabaceae	Tephrosia filipes subsp. filipes			C		2	2
Fabaceae	Pultenaea millarii var. millarii			C		5	5
Fabaceae	Zornia prostrata var. prostrata			C		1	1
Fabaceae	Desmodium rhytidophyllum			C		13	9
Fabaceae	Alysicarpus schomburgkii			C		1	1
Fabaceae	Tephrosia astragaloides			C		1	1
Fabaceae	Stylosanthes guianensis		Y			4	1
Fabaceae	Lamprolobium fruticosum			C		6	3
Fabaceae	Indigofera suffruticosa		Y			1	1
Fabaceae	Castanospermum australe	black bean		C		1	1
Fabaceae	Aeschynomene paniculata		Y			1	1
Fabaceae	Tephrosia leptoclada			C		1	1
Fabaceae	Stylosanthes humilis	Townsville stylo	Y			1	1
Fabaceae	Pycnospora lutescens	pycnospora		C		3	3
Fabaceae	Jacksonia thesioides			C		3	1
Fabaceae	Indigofera pratensis			C		14	2
Fabaceae	Indigofera linifolia			C		5	4
Fabaceae	Gompholobium nitidum			C		1	1
Fabaceae	Flemingia parviflora	flemingia		C		13	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Fabaceae	Tephrosia juncea			C		9	7
Fabaceae	Mirbelia pungens			C		1	1
Fabaceae	Austrodolichos errabundus var. (Mareeba I.B.Staples 070572/9B)			C		1	1
Fabaceae	Derris sp. (Claudie River L.J.Webb+ 8348)			C		1	1
Flacourtiaceae	Casearia dallachii			C		1	1
Flacourtiaceae	Homalium brachybotrys			C		2	2
Flacourtiaceae	Casearia grayi			C		1	1
Flacourtiaceae	Casearia costulata			C		7	7
Gentianaceae	Fagraea fagraeacea			C		6	6
Goodeniaceae	Goodenia rosulata			C		1	1
Goodeniaceae	Scaevola enantophylla			C		1	1
Goodeniaceae	Velleia spathulata	wild pansies		C		1	1
Haloragaceae	Gonocarpus humilis			C		1	1
Haloragaceae	Haloragis heterophylla	rough raspweed		C		1	1
Lamiaceae	Hyptis capitata		Y			1	1
Lamiaceae	Pogostemon stellatus			C		1	1
Lamiaceae	Prostanthera sp. (Dinden P.I.Forster+ PIF17342)			E		1	1
Lamiaceae	Rotheca myricoides cv. Ugandense		Y			1	1
Lamiaceae	Plectranthus scutellarioides			C		1	1
Lamiaceae	Plectranthus glabriflorus			C		1	1
Lamiaceae	Prostanthera clotteniana			E	EX	2	2
Lamiaceae	Clerodendrum floribundum			C		1	1
Lamiaceae	Plectranthus graveolens	flea bush		C		1	1
Lamiaceae	Callicarpa pedunculata	velvet leaf		C		2	2
Lamiaceae	Plectranthus diversus			C		1	1
Lamiaceae	Platostoma longicorne			C		1	1
Lamiaceae	Leucas lavandulifolia		Y			2	2
Lamiaceae	Callicarpa longifolia			C		1	1
Lamiaceae	Anisomeles malabarica			C		1	1
Lamiaceae	Ajuga australis	Australian bugle		C		1	0
Lamiaceae	Salvia misella		Y			3	3
Lamiaceae	Prostanthera			C		2	2
Lamiaceae	Plectranthus amoenus			V		7	7
Lamiaceae	Salvia coccinea	red salvia	Y			1	1
Lamiaceae	Premna acuminata			C		1	1
Lamiaceae	Hyptis suaveolens	hyptis	Y			3	2
Lamiaceae	Vitex queenslandica			C		1	1
Lamiaceae	Tectona grandis		Y			1	1
Lecythidaceae	Planchonia careya	cockatoo apple		C		9	0
Lentibulariaceae	Utricularia			C		1	0
Lentibulariaceae	Utricularia bifida			C		1	1
Leptaulaceae	Citronella smythii			C		1	1
Loganiaceae	Mitrasacme connata			C		2	2
Loranthaceae	Amyema miquelii			C		1	1
Loranthaceae	Amyema bifurcata			C		1	1
Loranthaceae	Dendrophthoe curvata			C		2	2
Loranthaceae	Decaisnina brittenii subsp. brittenii			C		1	1
Loranthaceae	Amylotheca dictyophleba			C		4	4
Loranthaceae	Lysiana filifolia			R		1	1
Lythraceae	Rotala tripartita			C		1	1
Maesaceae	Maesa dependens var. pubescens			C		3	3

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Malvaceae	Sida			C		3	0
Malvaceae	Malvastrum			C		1	0
Malvaceae	Hibiscus meraukensis	Merauke hibiscus		C		1	0
Melastomataceae	Melastoma malabathricum subsp. malabathricum			C		2	2
Meliaceae	Toona ciliata	red cedar		C		1	1
Meliaceae	Dysoxylum mollissimum subsp. molle	miva mahogany		C		1	1
Meliaceae	Dysoxylum papuanum			C		1	1
Meliaceae	Dysoxylum rufum			C		1	1
Meliaceae	Dysoxylum klanderi			C		2	2
Meliaceae	Aglaia sapindina			C		1	1
Menyanthaceae	Nymphoides			C		2	0
Menyanthaceae	Nymphoides indica	water snowflake		C		3	3
Mimosaceae	Acacia			C		4	0
Mimosaceae	Acacia bidwillii			C		8	4
Mimosaceae	Acacia leptoloba			C		1	1
Mimosaceae	Albizia canescens			C		1	1
Mimosaceae	Acacia ulicifolia			C		1	1
Mimosaceae	Acacia leptocarpa	north coast wattle		C		5	1
Mimosaceae	Acacia hemignosta			C		3	2
Mimosaceae	Acacia flavescens	toothed wattle		C		1	1
Mimosaceae	Acacia cincinnata			C		1	1
Mimosaceae	Acacia calyculata			C		1	1
Mimosaceae	Acacia umbellata			C		1	1
Mimosaceae	Acacia nesophila			C		2	2
Mimosaceae	Acacia disparrima subsp. calidestris			C		2	2
Mimosaceae	Acacia holosericea var. holosericea			C		1	1
Mimosaceae	Acacia wickhamii subsp. cassitera			C		2	2
Mimosaceae	Pararchidendron pruinosum			C		2	2
Mimosaceae	Acaciella angustissima		Y			1	1
Mimosaceae	Acacia purpureopetala			V	V	1	1
Mimosaceae	Acacia multisiliqua			C		3	2
Mimosaceae	Acacia polystachya			C		1	1
Mimosaceae	Acacia melanoxylon	blackwood		C		4	1
Mimosaceae	Acacia falciformis	broad-leaved hickory		C		2	2
Mimosaceae	Acacia crassicarpa			C		1	1
Mimosaceae	Acacia aulacocarpa			C		8	2
Mimosaceae	Acacia galioides			C		3	2
Mimosaceae	Acacia humifusa			C		1	1
Mimosaceae	Acacia simsii			C		1	1
Mimosaceae	Acacia whitei			C		4	3
Mimosaceae	Acacia guymeri			V	V	4	3
Mimosaceae	Acacia burrana			C		1	1
Mimosaceae	Acacia decora	pretty wattle		C		1	1
Moraceae	Ficus virens			C		2	2
Moraceae	Ficus rubiginosa forma rubiginosa			C		1	1
Moraceae	Trophis scandens subsp. scandens			C		3	3
Moraceae	Ficus septica var. cauliflora			C		1	1
Moraceae	Ficus congesta var. congesta			C		1	1
Moraceae	Ficus superba var. henneana			C		2	2
Moraceae	Ficus mollior var. mollior			C		2	2
Moraceae	Ficus hispida var. hispida			C		3	3

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Moraceae	Ficus destruens			C		1	1
Moraceae	Ficus leptoclada			C		2	2
Moraceae	Ficus pleurocarpa			C		3	3
Moraceae	Streblus brunonianus	whalebone tree		C		1	1
Moraceae	Ficus watkinsiana	green-leaved Moreton Bay fig		C		1	0
Moraceae	Ficus obliqua			C		7	7
Moraceae	Ficus fraseri	white sandpaper fig		C		2	1
Myodocarpaceae	Delarbrea michieana			C		2	2
Myoporaceae	Eremophila debilis	winter apple		C		1	1
Myrsinaceae	Myrsine achradifolia			C		2	2
Myrsinaceae	Tapeinosperma pallidum			C		1	1
Myrsinaceae	Lysimachia arvensis		Y			1	1
Myrsinaceae	Myrsine subsessilis subsp. cryptostemon			C		1	1
Myrsinaceae	Myrsine variabilis			C		1	1
Myrsinaceae	Ardisia brevipedata			C		2	2
Myrsinaceae	Myrsine smithii			C		1	1
Myrtaceae	Eucalyptus leptophleba	Molloy red box		C		18	6
Myrtaceae	Eucalyptus melanoleuca	Nanango ironbark		C		1	0
Myrtaceae	Leptospermum neglectum			C		2	2
Myrtaceae	Lophostemon suaveolens	swamp box		C		5	0
Myrtaceae	Eucalyptus platyphylla	poplar gum		C		12	4
Myrtaceae	Eucalyptus ochrophloia	yapunyah		C		1	0
Myrtaceae	Melaleuca linariifolia	snow-in summer		C		1	0
Myrtaceae	Rhodamnia sessiliflora			C		2	2
Myrtaceae	Corymbia erythrophloia	variable-barked bloodwood		C		4	2
Myrtaceae	Corymbia confertiflora			C		1	0
Myrtaceae	Rhodomyrtus pervagata			C		2	2
Myrtaceae	Rhodomyrtus canescens			C		11	11
Myrtaceae	Melaleuca viridiflora			C		12	0
Myrtaceae	Melaleuca leucadendra	broad-leaved tea-tree		C		4	2
Myrtaceae	Lophostemon confertus	brush box		C		1	1
Myrtaceae	Eucalyptus tetrodonta	Darwin stringybark		C		2	2
Myrtaceae	Eucalyptus resinifera	red mahogany		C		3	2
Myrtaceae	Eucalyptus chartaboma			C		2	2
Myrtaceae	Eucalyptus acmenoides			C		2	0
Myrtaceae	Corymbia leichhardtii	rustyjacket		C		4	2
Myrtaceae	Corymbia clarksoniana			C		31	12
Myrtaceae	Syzygium cormiflorum	bumpy satinash		C		1	1
Myrtaceae	Eucalyptus granitica	granite ironbark		C		5	5
Myrtaceae	Eucalyptus cloeziana	Gympie messmate		C		1	0
Myrtaceae	Corymbia tessellaris	Moreton Bay ash		C		7	3
Myrtaceae	Corymbia ellipsoidea			C		1	1
Myrtaceae	Corymbia dallachiana			C		5	1
Myrtaceae	Syzygium luehmannii			C		2	2
Myrtaceae	Syzygium canicortex	yellow satinash		C		2	2
Myrtaceae	Melaleuca viminalis			C		3	2
Myrtaceae	Homoranthus porteri			V	V	3	3
Myrtaceae	Gossia myrsinocarpa			C		2	2
Myrtaceae	Eucalyptus shirleyi			C		1	0
Myrtaceae	Eucalyptus populnea	poplar box		C		3	0
Myrtaceae	Eucalyptus cullenii	Cullen's ironbark		C		10	4
Myrtaceae	Corymbia intermedia	pink bloodwood		C		10	2

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Myrtaceae	Lophostemon grandiflorus			C		1	1
Myrtaceae	Eucalyptus drepanophylla			C		1	1
Myrtaceae	Acmenosperma claviflorum	grey satinash		C		2	2
Myrtaceae	Waterhousea unipunctata			C		1	1
Myrtaceae	Melaleuca trichostachya			C		2	2
Myrtaceae	Leptospermum amboinense			C		1	1
Myrtaceae	Eucalyptus tereticornis			C		9	0
Myrtaceae	Syzygium trachyphloium			C		1	1
Myrtaceae	Rhodomyrtus macrocarpa	finger cherry		C		1	1
Myrtaceae	Gossia bidwillii			C		3	3
Myrtaceae	Acmena smithii	lillypilly satinash		C		2	2
Myrtaceae	Syzygium wesa			C		3	3
Myrtaceae	Gossia hillii			C		2	2
Myrtaceae	Leptospermum			C		2	0
Myrtaceae	Acmena resa	red Eungella satinash		C		1	1
Myrtaceae	Eucalyptus			C		6	0
Myrtaceae	Melaleuca			C		5	3
Myrtaceae	Melaleuca viridiflora var. viridiflora			C		3	3
Myrtaceae	Uromyrtus tenella			C		2	2
Myrtaceae	Syzygium australe	scrub cherry		C		4	4
Myrtaceae	Melaleuca recurva			C		1	1
Myrtaceae	Melaleuca nervosa			C		7	0
Myrtaceae	Gossia floribunda			C		1	1
Myrtaceae	Eucalyptus crebra	narrow-leaved red ironbark		C		8	1
Myrtaceae	Eucalyptus atrata	Herberton ironbark		C		1	1
Myrtaceae	Syzygium oleosum	blue cherry		C		8	8
Myrtaceae	Melaleuca uxorum			E		2	2
Myrtaceae	Corymbia citriodora	spotted gum		C		3	0
Myrtaceae	Syzygium johnsonii	Johnson's satinash		C		2	2
Myrtaceae	Melaleuca monantha			C		3	3
Myrtaceae	Gossia dallachiana			C		3	3
Myrtaceae	Eucalyptus reducta			C		6	2
Myrtaceae	Eucalyptus grandis	flooded gum		C		2	2
Myrtaceae	Eucalyptus exserta	Queensland peppermint		C		1	0
Myrtaceae	Decaspermum humile	silky myrtle		C		2	2
Myrtaceae	Corymbia abergiana	range bloodwood		C		2	2
Myrtaceae	Corymbia citriodora subsp. citriodora			C		3	3
Myrtaceae	Psidium cattleianum var. cattleianum		Y			1	1
Myrtaceae	Corymbia stockeri subsp. stockeri			C		5	4
Myrtaceae	Melaleuca nervosa subsp. nervosa			C		1	1
Myrtaceae	Leptospermum polygalifolium	tantoon		C		5	5
Myrtaceae	Archirhodomyrtus beckleri	rose myrtle		C		5	5
Myrtaceae	Tristaniopsis exiliflora	kanuka box		C		1	1
Myrtaceae	Thaleropia queenslandica	pink myrtle		R		4	4
Myrtaceae	Melaleuca sp. (Ropers Peak P.I.Forster PIF7208)			C		1	1
Myrtaceae	Eucalyptus tereticornis subsp. tereticornis			C		2	2
Myrtaceae	Syncarpia glomulifera subsp. glomulifera			C		5	1
Myrtaceae	Lophostemon grandiflorus subsp. riparius			C		2	2
Myrtaceae	Eucalyptus pachycalyx subsp. pachycalyx			C		1	1
Myrtaceae	Melaleuca stenostachya			C		8	3

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Nyctaginaceae	Mirabilis jalapa	four o'clock	Y			1	1
Nyctaginaceae	Pisonia aculeata	thorny Pisonia		C		1	1
Ochnaceae	Brackenridgea australiana			C		3	3
Oleaceae	Olea paniculata			C		1	1
Oleaceae	Ligustrum sinense	small-leaved privet	Y			1	1
Oleaceae	Ligustrum lucidum	large-leaved privet	Y			2	2
Oleaceae	Notelaea punctata			C		1	1
Oleaceae	Ligustrum australianum			C		1	1
Oleaceae	Notelaea sp. (Barakula A.R.Bean 7553)			C		1	1
Oleaceae	Jasminum didymum subsp. didymum			C		1	1
Oleaceae	Jasminum dallachii	soft jasmine		C		2	2
Onagraceae	Ludwigia octovalvis	willow primrose		C		3	1
Opiliaceae	Opilia amentacea			C		1	1
Oxalidaceae	Oxalis			C		1	1
Passifloraceae	Passiflora edulis		Y			1	1
Passifloraceae	Passiflora aurantia var. aurantia			C		1	1
Passifloraceae	Passiflora herbertiana subsp. herbertiana	native passionfruit		C		1	1
Pentaphylacaceae	Ternstroemia cherryi	cherry beech		C		1	1
Phyllanthaceae	Breynia			C		1	0
Phyllanthaceae	Phyllanthus			C		3	0
Phyllanthaceae	Breynia cernua			C		5	2
Phyllanthaceae	Antidesma bunius	currantwood		C		2	2
Phyllanthaceae	Antidesma erostre			C		1	1
Phyllanthaceae	Sauropus aphyllus			C		1	1
Phyllanthaceae	Glochidion hylandii			C		1	1
Phyllanthaceae	Sauropus macranthus			V	V	7	7
Phyllanthaceae	Phyllanthus virgatus			C		1	0
Phyllanthaceae	Antidesma parvifolium			C		1	1
Phyllanthaceae	Glochidion harveyanum			C		3	3
Phyllanthaceae	Glochidion sumatranum	umbrella cheese tree		C		1	1
Phyllanthaceae	Poranthera microphylla	small poranthera		C		3	2
Phyllanthaceae	Sauropus elachophyllus			C		1	1
Phyllanthaceae	Glochidion benthamianum			C		1	1
Phyllanthaceae	Phyllanthus carpentariae			C		1	1
Phyllanthaceae	Margaritaria dubium-traceyi			C		3	3
Phyllanthaceae	Flueggea virosa subsp. melanthesoides			C		1	1
Phyllanthaceae	Glochidion harveyanum var. harveyanum			C		2	2
Phytolaccaceae	Phytolacca octandra	inkweed	Y			1	1
Picrodendraceae	Petalostigma			C		1	0
Picrodendraceae	Petalostigma pubescens	quinine tree		C		10	0
Picrodendraceae	Pseudanthus ligulatus subsp. ligulatus			C		2	2
Picrodendraceae	Petalostigma banksii			C		4	2
Pittosporaceae	Bursaria incana			C		2	1
Pittosporaceae	Pittosporum wingii			C		1	1
Pittosporaceae	Bursaria tenuifolia			C		1	1
Pittosporaceae	Pittosporum revolutum	yellow pittosporum		C		1	1
Pittosporaceae	Pittosporum ferrugineum subsp. linifolium			C		2	2
Polygalaceae	Comesperma			C		2	2
Polygalaceae	Polygala persicariifolia			C		1	1
Polygalaceae	Polygala sp. (Portland Roads L.Pedley 2757)			C		1	1

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Polygalaceae	Polygala paniculata		Y			1	1
Polygalaceae	Salomonia ciliata			C		1	1
Polygonaceae	Persicaria			C		2	0
Polygonaceae	Persicaria barbata			C		2	2
Polygonaceae	Persicaria decipiens	slender knotweed		C		3	3
Polygonaceae	Muehlenbeckia zippelii			C		2	2
Proteaceae	Grevillea glauca	bushy's clothes peg		C		15	4
Proteaceae	Persoonia tropica			C		4	4
Proteaceae	Grevillea coriacea			C		3	1
Proteaceae	Grevillea dryandri subsp. dryandri			C		1	1
Proteaceae	Banksia spinulosa var. spinulosa			C		3	3
Proteaceae	Stenocarpus angustifolius			C		2	2
Proteaceae	Buckinghamia celsissima	spotted silky oak		C		1	1
Proteaceae	Grevillea pteridifolia	golden parrot tree		C		5	3
Proteaceae	Grevillea glossadenia			V	V	3	3
Proteaceae	Darlingia darlingiana			C		1	1
Proteaceae	Xylomelum scottianum			C		4	1
Proteaceae	Stenocarpus sinuatus	wheel of fire		C		2	2
Proteaceae	Lomatia fraxinifolia			C		3	3
Proteaceae	Helicia australasica			C		2	2
Proteaceae	Grevillea mimosoides			C		1	0
Proteaceae	Darlingia ferruginea			C		2	2
Proteaceae	Grevillea parallela			C		14	2
Proteaceae	Grevillea baileyana			C		1	1
Proteaceae	Cardwellia sublimis			C		1	1
Proteaceae	Alloxylon wickhamii			C		2	2
Proteaceae	Alloxylon flammeum			V	V	4	4
Proteaceae	Persoonia falcata			C		13	2
Proteaceae	Hakea persiehana			C		5	1
Proteaceae	Grevillea striata	beefwood		C		1	0
Proteaceae	Hakea plurinervia			C		3	2
Putranjivaceae	Drypetes acuminata			C		1	1
Putranjivaceae	Drypetes deplanchei	grey boxwood		C		2	2
Rhamnaceae	Alphitonia whitei	red ash		C		1	1
Rhamnaceae	Alphitonia			C		3	0
Rhamnaceae	Emmenosperma alphitonioides	yellow ash		C		1	1
Rhamnaceae	Alphitonia petriei	pink ash		C		1	1
Rhamnaceae	Cryptandra debilis			C		2	2
Rhamnaceae	Rhamnus nipalensis			C		1	1
Rhamnaceae	Alphitonia pomaderroides			C		13	4
Rhamnaceae	Pomaderris argyrophylla			C		1	1
Rhamnaceae	Alphitonia excelsa	soap tree		C		3	2
Rosaceae	Prunus turneriana	almondbark		C		1	1
Rosaceae	Rubus moluccanus var. trilobus			C		4	4
Rubiaceae	Rubiaceae			C		1	0
Rubiaceae	Coffea arabica	Arabian coffee	Y			1	1
Rubiaceae	Ixora oreogena			C		2	2
Rubiaceae	Morinda umbellata			C		1	1
Rubiaceae	Spermacoce remota		Y			1	1
Rubiaceae	Nauclea orientalis	Leichhardt tree		C		2	2
Rubiaceae	Randia tuberculosa			C		1	1
Rubiaceae	Gynochthodes oresbia			C		1	1
Rubiaceae	Spermacoce sp. (Lorim Point A.Morton AM1237)			C		1	1

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Rubiaceae	Atractocarpus fitzalanii subsp. fitzalanii			C		1	1
Rubiaceae	Psychotria sp. (Danbulla S.T.Blake 15262)			C		2	2
Rubiaceae	Timonius timon var. timon			C		1	1
Rubiaceae	Cyclophyllum multiflorum			C		1	1
Rubiaceae	Pogonolobus reticulatus			C		3	1
Rubiaceae	Hodgkinsonia frutescens			C	V	1	1
Rubiaceae	Richardia brasiliensis	white eye	Y			1	1
Rubiaceae	Psychotria dallachiana			C		1	1
Rubiaceae	Psychotria interstans			C		1	1
Rubiaceae	Opercularia diphylla			C		1	1
Rubiaceae	Larsenaikia ochreata			C		2	2
Rubiaceae	Psydrax laxiflorens			C		2	2
Rubiaceae	Oldenlandia laceyi			C		1	1
Rubiaceae	Mitracarpus hirtus		Y			9	2
Rubiaceae	Psydrax attenuata			C		2	2
Rubiaceae	Ixora timorensis			C		1	1
Rubiaceae	Spermacoce			C		5	0
Rutaceae	Zieria			C		1	1
Rutaceae	Zieria cytisoides	downy Zieria		C		1	1
Rutaceae	Sarcomelicope simplicifolia subsp. simplicifolia	yellow aspen		C		2	2
Rutaceae	Zieria minutiflora subsp. trichocarpa			C		1	1
Rutaceae	Phebalium longifolium			C		3	3
Rutaceae	Flindersia schottiana	bumpy ash		C		5	5
Rutaceae	Flindersia brayleyana	Queensland maple		C		1	1
Rutaceae	Acronychia pauciflora	soft acronychia		C		1	1
Rutaceae	Micromelum minutum	clusterberry		C		1	1
Rutaceae	Melicope vitiflora	northern evodia		C		1	1
Rutaceae	Melicope elleryana			C		2	1
Rutaceae	Melicope bonwickii			C		1	1
Rutaceae	Acronychia vestita			C		1	1
Rutaceae	Clausena brevistyla var. brevistyla			C		1	1
Rutaceae	Acronychia acronychioides			C		1	1
Rutaceae	Pitaviaster haplophyllus			C		6	6
Rutaceae	Zanthoxylum ovalifolium			C		3	3
Rutaceae	Flindersia pimenteliana	maple silkwood		C		1	1
Rutaceae	Acronychia crassipetala			C		2	2
Rutaceae	Melicope broadbentiana			C		5	5
Rutaceae	Flindersia bourjotiana			C		3	3
Rutaceae	Zanthoxylum veneficum			C		3	3
Rutaceae	Halfordia kendack	saffron heart		C		2	2
Rutaceae	Zieria whitei			C		4	4
Rutaceae	Zieria smithii			C		3	3
Rutaceae	Acronychia laevis	glossy acronychia		C		4	4
Rutaceae	Boronia bipinnata	rock boronia		C		1	1
Rutaceae	Melicope rubra			C		2	2
Sambucaceae	Sambucus australasica	native elderberry		C		1	1
Santalaceae	Exocarpos latifolius			C		2	2
Santalaceae	Santalum lanceolatum			C		3	1
Sapindaceae	Dodonaea			C		1	0
Sapindaceae	Arytera divaricata	coogera		C		5	5
Sapindaceae	Synima cordierorum			C		1	1

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Sapindaceae	Alectryon coriaceus	beach alectryon		C		2	2
Sapindaceae	Alectryon tomentosus			C		4	4
Sapindaceae	Alectryon semicinereus			R		2	2
Sapindaceae	Diploglottis bernieana			C		1	1
Sapindaceae	Dodonaea lanceolata var. subsessilifolia			C		2	2
Sapindaceae	Diploglottis diphyllostegia			C		1	1
Sapindaceae	Distichostemon dodecandrus			C		5	2
Sapindaceae	Cardiospermum grandiflorum	heart seed vine	Y			1	1
Sapindaceae	Mischocarpus grandissimus			C		1	1
Sapindaceae	Mischarytera lautereriana	corduroy tamarind		C		4	4
Sapindaceae	Mischocarpus macrocarpus			C		1	1
Sapindaceae	Mischocarpus stipitatus			C		1	1
Sapindaceae	Toechima erythrocarpum			C		1	1
Sapindaceae	Castanospora alphandii	brown tamarind		C		1	1
Sapindaceae	Cupaniopsis foveolata	narrow-leaved tuckeroo		C		2	2
Sapindaceae	Dodonaea tenuifolia			C		2	2
Sapindaceae	Synima reynoldsiae			C		3	3
Sapindaceae	Atalaya variifolia			C		2	1
Sapindaceae	Guioa montana			C		3	3
Sapindaceae	Guioa acutifolia	northern guioa		C		5	5
Sapotaceae	Pouteria papyracea			C		2	2
Sapotaceae	Niemeyera prunifera			C		1	1
Sapotaceae	Vanroyena castanosperma			C		1	1
Sapotaceae	Planchonella asterocarpon			C		5	5
Sapotaceae	Sersalisia sericea			C		3	2
Sapotaceae	Pouteria xerocarpa			C		1	1
Scrophulariaceae	Orobanche minor	lesser broomrape	Y			1	1
Scrophulariaceae	Rhamphicarpa australiensis			R		1	1
Scrophulariaceae	Buchnera linearis			C		1	1
Scrophulariaceae	Limnophila brownii			C		1	1
Scrophulariaceae	Limnophila fragrans			C		1	1
Scrophulariaceae	Limnophila aromatica			C		2	2
Scrophulariaceae	Striga parviflora			C		3	3
Scrophulariaceae	Veronica plebeia	trailing speedwell		C		1	1
Solanaceae	Datura inoxia		Y			1	1
Solanaceae	Solanum parvifolium subsp. tropicum			C		1	1
Solanaceae	Solanum pseudocapsicum	Madeira winter cherry	Y			1	1
Solanaceae	Solanum seaforthianum	Brazilian nightshade	Y			3	3
Solanaceae	Solanum viridifolium			C		5	5
Solanaceae	Solanum mauritianum	wild tobacco	Y			1	1
Solanaceae	Solanum capsicoides	devil's apple	Y			1	1
Solanaceae	Nicandra physalodes	apple of Peru	Y			5	5
Solanaceae	Solanum villosum		Y			1	1
Solanaceae	Cestrum nocturnum		Y			4	4
Solanaceae	Nicotiana tabacum		Y			2	2
Solanaceae	Solanum nodiflorum		Y			6	6
Solanaceae	Physalis peruviana		Y			1	1
Solanaceae	Solanum macoorai			C		5	5
Solanaceae	Solanum torvum	devil's fig	Y			1	1
Sparrmanniaceae	Grewia			C		1	0
Sparrmanniaceae	Grewia latifolia	dysentery plant		C		1	0
Sparrmanniaceae	Grewia retusifolia			C		17	3

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Sparrmanniaceae	Triumfetta rhomboidea	chinese burr	Y			1	1
Sparrmanniaceae	Trichospermum pleiostigma			C		1	1
Sparrmanniaceae	Triumfetta pilosa		Y			1	1
Sphenostemonaceae	Sphenostemon lobosporus			C		1	1
Stackhousiaceae	Stackhousia intermedia			C		1	1
Sterculiaceae	Brachychiton			C		4	0
Sterculiaceae	Brachychiton diversifolius subsp. orientalis			C		1	1
Sterculiaceae	Franciscodendron laurifolium			C		1	1
Sterculiaceae	Firmiana papuana	lacewood		R		1	1
Sterculiaceae	Argyrodendron peralatum	red tulip oak		C		2	2
Stylidiaceae	Stylidium			C		1	0
Stylidiaceae	Stylidium cordifolium			C		2	2
Stylidiaceae	Stylidium eriorhizum			C		1	1
Surianaceae	Guilfoylia monostylis	guilfoylia		C		3	3
Symplocaceae	Symplocos cochinchinensis var. pilosiuscula			C		3	3
Thymelaeaceae	Pimelea			C		1	0
Thymelaeaceae	Pimelea linifolia			C		1	1
Thymelaeaceae	Wikstroemia indica	tie bush		C		8	3
Thymelaeaceae	Phaleria clerodendron	scented daphne		C		1	1
Thymelaeaceae	Thecanthes cornucopiae			C		1	1
Thymelaeaceae	Pimelea sericostachya subsp. sericostachya			C		2	2
Thymelaeaceae	Pimelea trichostachya	flaxweed		C		1	0
Thymelaeaceae	Phaleria chermsideana	scrub daphne		C		1	1
Thymelaeaceae	Phaleria octandra	phaleria		C		1	1
Ulmaceae	Trema			C		2	0
Ulmaceae	Aphananthe philippinensis			C		1	0
Urticaceae	Urtica incisa	stinging nettle		C		1	1
Urticaceae	Dendrocnide photinophylla	shiny-leaved stinging tree		C		2	1
Verbenaceae	Lantana camara		Y			1	1
Verbenaceae	Lantana camara cv. Gol Gol		Y			3	0
Violaceae	Hybanthus enneaspermus			C		5	1
Violaceae	Hybanthus stellarioides			C		1	1
Viscaceae	Viscum articulatum	flat mistletoe		C		1	1
Viscaceae	Notothixos subaureus	golden mistletoe		C		1	1
Vitaceae	Cissus			C		1	0
Vitaceae	Cissus vinosa			C		1	1
Vitaceae	Cayratia trifolia			C		7	2
Vitaceae	Cissus penninervis			C		1	1
Vitaceae	Clematicissus opaca			C		4	4
Vitaceae	Tetrastigma petraeum			C		3	3
Vitaceae	Cissus cardiophylla			C		1	1
Vitaceae	Cissus hypoglauca			C		2	2
Vitaceae	Cayratia japonica			C		1	1
Vitaceae	Cissus adnata			C		1	1
Zygophyllaceae	Tribulus terrestris	caltrop		C		1	1
Annonaceae	Cananga odorata	Ylang-ylang		C		1	1
Annonaceae	Desmos goezeanus			C		1	1
Annonaceae	Polyalthia nitidissima	polyalthia		C		2	2
Aristolochiaceae	Aristolochia holtzei			C		1	1
Aristolochiaceae	Pararistolochia deltantha			C		1	1
Aristolochiaceae	Aristolochia thozetii			C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Aristolochiaceae	Aristolochia pubera var. pubera			C		1	1
Cabombaceae	Brasenia schreberi			R		2	2
Hernandiaceae	Gyrocarpus americanus subsp. americanus			C		1	1
Himantandraceae	Galbulimima baccata			C		4	4
Lauraceae	Litsea leefeana			C		3	3
Lauraceae	Endiandra insignis			C		1	1
Lauraceae	Cryptocarya cocosoides			C		9	9
Lauraceae	Cryptocarya corrugata			C		2	2
Lauraceae	Cinnamomum baileyanum	candlewood		C		1	1
Lauraceae	Beilschmiedia recurva			C		1	1
Lauraceae	Beilschmiedia collina			C		3	3
Lauraceae	Beilschmiedia brunnea			C		5	5
Lauraceae	Endiandra bessaphila			C		5	5
Lauraceae	Cryptocarya angulata	ivory laurel		C		2	2
Lauraceae	Endiandra sankeyana	Sankey's walnut		C		2	2
Lauraceae	Endiandra monothyra subsp. monothyra			C		1	1
Lauraceae	Cryptocarya triplinervis var. pubens			C		2	2
Lauraceae	Cryptocarya onoprienkoana			C		2	2
Lauraceae	Cryptocarya triplinervis			C		3	3
Lauraceae	Cryptocarya saccharata			C		1	1
Lauraceae	Cryptocarya hypospodia	north Queensland purple laurel		C		3	3
Lauraceae	Cryptocarya densiflora			C		4	4
Lauraceae	Endiandra monothyra			C		1	1
Lauraceae	Endiandra dielsiana			C		1	1
Lauraceae	Cryptocarya grandis			C		1	1
Lauraceae	Cinnamomum laubatii			C		2	2
Lauraceae	Cinnamomum camphora	camphor laurel	Y			2	2
Lauraceae	Cassytha filiformis	dodder laurel		C		5	5
Lauraceae	Neolitsea dealbata	white bolly gum		C		1	1
Lauraceae	Litsea fawcettiana			C		9	9
Lauraceae	Cryptocarya putida			C		1	1
Lauraceae	Litsea connorsii			C		2	2
Lauraceae	Neolitsea brassii			C		3	3
Menispermaceae	Legnephora moorei			C		1	1
Menispermaceae	Hypserpa smilacifolia			R		1	1
Monimiaceae	Wilkiea pubescens			C		1	1
Monimiaceae	Levieria acuminata			C		1	1
Monimiaceae	Hedycarya loxocarya			C		1	1
Monimiaceae	Steganthera macooraia			C		2	2
Monimiaceae	Wilkiea angustifolia			C		3	3
Myristicaceae	Myristica globosa subsp. muelleri	native nugmeg		C		1	1
Nymphaeaceae	Nymphaea			C		1	0
Nymphaeaceae	Nymphaea immutabilis subsp. immutabilis			C		1	1
Piperaceae	Peperomia enervis			C		1	1
Ranunculaceae	Clematis pickeringii			C		2	2
Winteraceae	Tasmannia membranea			C		4	4
Winteraceae	Bubbia semecarpoides			C		1	1
Alismataceae	Caldesia parnassifolia			C		1	1
Araceae	Spirodela punctata	thin duckweed		C		3	3
Arecaceae	Calamus australis	hairy mary		C		1	1
Arecaceae	Laccospadix australasica	Atherton palm		C		2	2

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Asparagaceae	Asparagus racemosus	native asparagus		C		1	1
Boryaceae	Borya septentrionalis			C		1	1
Colchicaceae	Iphigenia indica			C		1	1
Colchicaceae	Kuntheria pedunculata			C		1	1
Colchicaceae	Schelhammera multiflora			C		3	2
Commelinaceae	Commelina			C		1	0
Commelinaceae	Cartonema spicatum var. humile			C		2	2
Commelinaceae	Murdannia graminea	murdannia		C		1	1
Commelinaceae	Murdannia vaginata		Y			2	2
Commelinaceae	Tradescantia fluminensis		Y			1	1
Commelinaceae	Cartonema spicatum			C		3	3
Cyperaceae	Tetraria capillaris			C		1	1
Cyperaceae	Fimbristylis macrantha			C		1	1
Cyperaceae	Fimbristylis dichotoma	common fringe-rush		C		1	1
Cyperaceae	Schoenoplectus laevis			C		1	1
Cyperaceae	Lepidosperma laterale			C		1	0
Cyperaceae	Eleocharis geniculata			C		2	2
Cyperaceae	Eleocharis equisetina			C		1	1
Cyperaceae	Lipocarpha chinensis			C		2	2
Cyperaceae	Lepironia articulata			C		3	1
Cyperaceae	Cyperus tetraphyllus			C		2	2
Cyperaceae	Cyperus polystachyos var. polystachyos			C		1	1
Cyperaceae	Cyperus nutans var. eleusinoides	flatsedge		C		1	1
Cyperaceae	Cyperus haspan subsp. haspan			C		1	1
Cyperaceae	Cyperus conicus var. conicus			C		1	1
Cyperaceae	Rhynchospora subtenuifolia			C		1	1
Cyperaceae	Schoenoplectus mucronatus			C		6	4
Cyperaceae	Eleocharis atropurpurea			C		2	2
Cyperaceae	Cyperus holoschoenus			C		1	1
Cyperaceae	Fimbristylis nutans			C		1	1
Cyperaceae	Fimbristylis cymosa			C		1	1
Cyperaceae	Exocarya scleroides			C		2	2
Cyperaceae	Bulbostylis barbata			C		1	1
Cyperaceae	Cyperus unioloides			C		1	1
Cyperaceae	Schoenus falcatus			C		1	1
Cyperaceae	Fuirena umbellata			C		1	1
Cyperaceae	Eleocharis minuta		Y			1	1
Cyperaceae	Eleocharis dulcis			C		1	1
Cyperaceae	Cyperus trinervis			C		1	1
Cyperaceae	Cyperus aquatilis			C		3	3
Cyperaceae	Carex breviculmis			C		1	1
Cyperaceae	Fuirena ciliaris			C		1	1
Cyperaceae	Cyperus flavidus			C		1	1
Cyperaceae	Scleria brownii			C		2	2
Cyperaceae	Cyperus enervis			C		1	1
Cyperaceae	Cyperus distans			C		1	1
Cyperaceae	Cyperus fulvus			C		2	2
Cyperaceae	Gahnia aspera			C		3	2
Cyperaceae	Eleocharis			C		3	0
Cyperaceae	Scleria			C		5	0
Cyperaceae	Cyperus			C		3	0
Cyperaceae	Cyperus polystachyos			C		2	2
Cyperaceae	Cyperus involucratus		Y			3	3

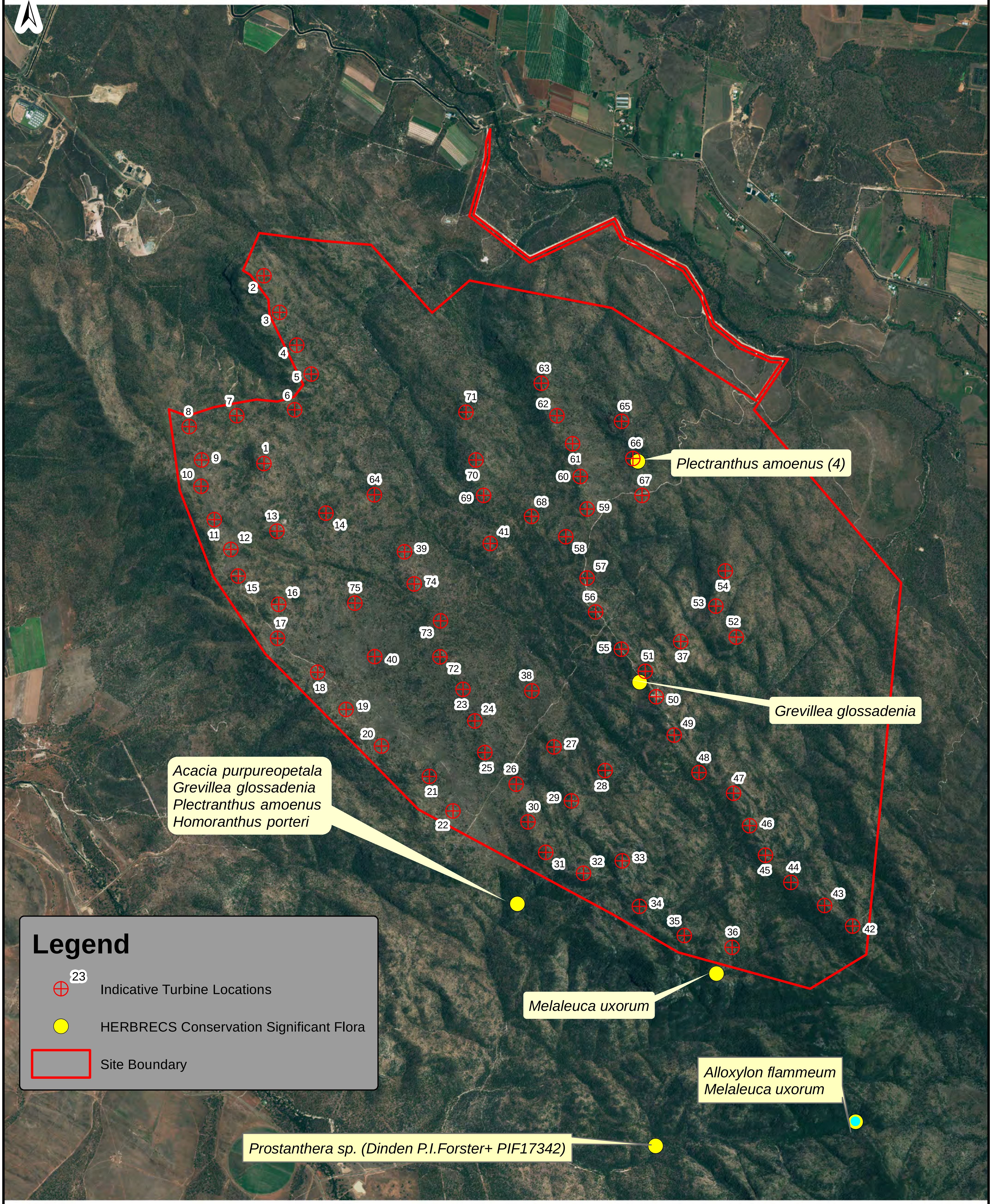
Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Dioscoreaceae	Dioscorea bulbifera var. bulbifera			C		1	1
Eriocaulaceae	Eriocaulaceae			C		1	0
Eriocaulaceae	Eriocaulon nanum			C		1	1
Eriocaulaceae	Eriocaulon scariosum			C		1	1
Eriocaulaceae	Eriocaulon australe			C		1	1
Haemodoraceae	Haemodorum coccineum			C		2	0
Hemerocallidaceae	Dianella			C		6	0
Hemerocallidaceae	Dianella atraxis			C		1	1
Hemerocallidaceae	Dianella caerulea var. vannata			C		3	2
Hydrocharitaceae	Ottelia alismoides			C		1	1
Hypoxidaceae	Molineria capitulata			C		1	1
Hypoxidaceae	Curculigo ensifolia var. ensifolia			C		1	1
Johnsoniaceae	Tricoryne anceps			C		3	0
Johnsoniaceae	Tricoryne elatior	yellow autumn lily		C		1	1
Johnsoniaceae	Tricoryne anceps subsp. anceps			C		2	1
Juncaceae	Juncus usitatus			C		2	2
Laxmanniaceae	Lomandra			C		9	2
Laxmanniaceae	Lomandra filiformis subsp. filiformis			C		1	1
Laxmanniaceae	Thysanotus tuberosus subsp. tuberosus			C		1	1
Laxmanniaceae	Lomandra multiflora subsp. multiflora			C		1	1
Laxmanniaceae	Lomandra filiformis			C		1	1
Orchidaceae	Diuris oporina	northern white donkeys tails		R		1	1
Orchidaceae	Cheirostylis ovata	caterpillar orchid		C		1	1
Orchidaceae	Cymbidium canaliculatum			C		1	0
Orchidaceae	Arthrochilus oreophilus			C		1	1
Orchidaceae	Spathoglottis paulinae			R		1	1
Orchidaceae	Pterostylis parviflora	tiny greenhood		C		1	1
Orchidaceae	Bulbophyllum johnsonii			C		1	1
Orchidaceae	Peristylus banfieldii			R		1	1
Orchidaceae	Corybas aconitiflorus			C		1	1
Orchidaceae	Sarcochilus falcatus	orange blossom orchid		C		1	1
Orchidaceae	Dipodium elegantulum			C		1	1
Orchidaceae	Thelymitra sp. (Toy Creek P.I.Forster+ PIF21217)			C		1	1
Orchidaceae	Caladenia carnea var. carnea			C		1	1
Orchidaceae	Dendrobium canaliculatum			C		1	0
Orchidaceae	Arthrochilus irritabilis	leafy elbow orchid		C		1	1
Orchidaceae	Pterostylis depauperata			C		1	1
Orchidaceae	Dendrobium gracilicaule	slender orchid		C		1	1
Orchidaceae	Acianthus fornicatus	pixie caps		C		1	1
Orchidaceae	Pterostylis stricta			C		3	3
Orchidaceae	Drymoanthus minutus			C		1	1
Orchidaceae	Dipodium ensifolium	leafy hyacinth orchid		C		1	1
Orchidaceae	Calochilus ammobius			C		1	1
Orchidaceae	Octarrhena pusilla			C		1	1
Orchidaceae	Dendrobium aemulum	ironbark orchid		C		1	1
Orchidaceae	Corybas fimbriatus	fringed helmet orchid		C		1	1
Orchidaceae	Acianthus borealis			C		1	1
Orchidaceae	Nervilia plicata			C		2	2
Orchidaceae	Corybas cerasinus			R		1	1
Orchidaceae	Cymbidium madidum			C		1	0
Orchidaceae	Empusa habenarina			C		1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Orchidaceae	Phaius australis			E	E	1	1
Orchidaceae	Zeuxine oblonga	hairy jewel orchid		C		1	1
Pandanaceae	Pandanus			C		5	0
Pandanaceae	Freycinetia excelsa	climbing pandanus		C		1	1
Pandanaceae	Pandanus cookii			C		1	1
Philydraceae	Philydrum lanuginosum	frogsmouth		C		1	1
Poaceae	Panicum mitchellii			C		1	1
Poaceae	Aristida perniciosa			C		1	1
Poaceae	Eragrostis cumingii			C		1	1
Poaceae	Megathyrsus maximus		Y			2	2
Poaceae	Paspalum conjugatum	sourgrass	Y			1	1
Poaceae	Oplismenus compositus			C		1	1
Poaceae	Heteropogon triticeus	giant speargrass		C		19	3
Poaceae	Heteropogon contortus	black speargrass		C		19	2
Poaceae	Eremochloa bimaculata	poverty grass		C		1	0
Poaceae	Echinochloa oryzoides		Y			1	1
Poaceae	Cymbopogon bombycinus	silky oilgrass		C		2	1
Poaceae	Aristida superpendens			C		1	1
Poaceae	Whiteochloa airoides			C		2	2
Poaceae	Tripogon loliiformis	five minute grass		C		1	1
Poaceae	Digitaria nematostachya			C		1	1
Poaceae	Urochloa subquadripara		Y			2	2
Poaceae	Enneapogon lindleyanus			C		1	1
Poaceae	Cyrtococcum deltoideum		Y			1	1
Poaceae	Cleistochloa subjuncea			C		1	0
Poaceae	Bothriochloa ewartiana	desert bluegrass		C		1	1
Poaceae	Alloteropsis semialata	cockatoo grass		C		1	0
Poaceae	Schizachyrium fragile	firegrass		C		8	2
Poaceae	Panicum lachnophyllum	don't panic		C		1	1
Poaceae	Cymbopogon queenslandicus			C		1	1
Poaceae	Capillipedium parviflorum	scented top		C		2	2
Poaceae	Thaumastochloa pubescens			C		1	1
Poaceae	Echinochloa dietrichiana			C		1	1
Poaceae	Dactyloctenium aegyptium	coast button grass	Y			2	2
Poaceae	Capillipedium spicigerum	spicytop		C		1	1
Poaceae	Stenotaphrum secundatum	buffalo grass	Y			1	1
Poaceae	Sporobolus jacquemontii		Y			2	2
Poaceae	Pseudoraphis spinescens	spiny mudgrass		C		1	0
Poaceae	Dichanthium sericeum subsp. polystachyum			C		1	1
Poaceae	Urochloa holosericea subsp. holosericea			C		2	2
Poaceae	Bothriochloa bladhii subsp. bladhii			C		1	1
Poaceae	Setaria pumila subsp. pallidefusca		Y			2	2
Poaceae	Panicum seminudum var. cairnsianum			C		2	2
Poaceae	Chloris divaricata var. divaricata	slender chloris		C		1	1
Poaceae	Megathyrsus maximus var. maximus		Y			2	2
Poaceae	Ischaemum australe var. australe			C		1	1
Poaceae	Sorghum nitidum forma aristatum			C		2	2
Poaceae	Aristida calycina var. calycina			C		1	1
Poaceae	Ischaemum rugosum var. segetum			C		1	1
Poaceae	Cynodon dactylon var. dactylon		Y			1	1
Poaceae	Setaria pumila subsp. pumila		Y			1	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Poaceae	Pseudopogonatherum contortum			C		1	0
Poaceae	Aristida utilis var. utilis			C		1	1
Poaceae	Mnesithea rottboellioides			C		9	1
Poaceae	Melinis repens	red natal grass	Y			4	0
Poaceae	Chloris gayana	rhodes grass	Y			1	1
Poaceae	Eriachne rara			C		2	2
Poaceae	Eragrostiella			C		1	0
Poaceae	Arundinella			C		3	0
Poaceae	Digitaria			C		1	0
Poaceae	Aristida			C		17	0
Poaceae	Poaceae			C		3	0
Poaceae	Panicum			C		8	0
Poaceae	Panicum incomtum			C		1	1
Poaceae	Leersia hexandra	swamp rice grass		C		4	1
Poaceae	Eriachne triseta			C		1	1
Poaceae	Urochloa mutica		Y			2	0
Poaceae	Themeda arguens			C		1	1
Poaceae	Sorghum bicolor	forage sorghum	Y			1	1
Poaceae	Setaria surgens			C		1	1
Poaceae	Sehima nervosum			C		1	1
Poaceae	Panicum effusum			C		1	1
Poaceae	Panicum antidotale	giant panic	Y			1	1
Poaceae	Oryza meridionalis			C		1	1
Poaceae	Digitaria bicornis			C		2	2
Poaceae	Chrysopogon fallax			C		1	0
Poaceae	Arundinella setosa			C		9	2
Poaceae	Aristida warburgii			C		3	2
Poaceae	Urochloa pubigera			C		4	4
Poaceae	Urochloa piligera			C		1	1
Poaceae	Setaria apiculata			C		1	0
Poaceae	Panicum coloratum		Y			1	1
Poaceae	Mnesithea formosa			C		1	1
Poaceae	Ectrosia leporina			C		3	2
Poaceae	Themeda triandra	kangaroo grass		C		25	1
Poaceae	Paspalum notatum	bahia grass	Y			1	1
Poaceae	Hordeum vulgare		Y			1	1
Poaceae	Eriachne obtusa			C		1	1
Poaceae	Eleusine indica	crowsfoot grass	Y			1	1
Poaceae	Chloris virgata	feathertop rhodes grass	Y			1	1
Poaceae	Bambusa balcooa		Y			1	1
Poaceae	Thaumastochloa			C		1	0
Poaceae	Sarga plumosum			C		11	2
Poaceae	Panicum simile			C		1	1
Poaceae	Themeda quadrivalvis	grader grass	Y			4	2
Poaceae	Paspalum paniculatum	Russell River grass	Y			3	3
Poaceae	Eragrostis pubescens			C		2	2
Poaceae	Echinochloa inundata	marsh millet		C		1	1
Poaceae	Cymbopogon refractus	barbed-wire grass		C		5	1
Poaceae	Cenchrus caliculatus	hillside burrgrass		C		1	1
Poaceae	Urochloa polyphylla			C		1	1
Poaceae	Paspalum plicatulum	plicatulum	Y			1	1
Poaceae	Melinis minutiflora	molasses grass	Y			3	1
Poaceae	Imperata cylindrica	blady grass		C		3	1

Family	Scientific Name	Common Name	I	Q	A	Sighting Records	Specimen Records
Poaceae	Cymbopogon ambiguus	lemon grass		C		3	2
Poaceae	Urochloa distachya		Y			1	1
Poaceae	Setaria sphacelata		Y			3	1
Poaceae	Urochloa decumbens		Y			2	2
Poaceae	Urochloa brizantha		Y			2	2
Pontederiaceae	Monochoria cyanea			C		1	1
Potamogetonaceae	Potamogeton			C		1	1
Potamogetonaceae	Potamogeton crispus	curly pondweed		C		1	1
Smilacaceae	Smilax			C		1	0
Smilacaceae	Smilax glyciphylla	sweet sarsaparilla		C		2	2
Typhaceae	Typha domingensis			C		1	1
Xanthorrhoeaceae	Xanthorrhoea			C		1	0
Xanthorrhoeaceae	Xanthorrhoea johnsonii			C		3	0
Xyridaceae	Xyris complanata	yellow-eye		C		9	8
Xyridaceae	Xyris pauciflora			C		1	1
Zingiberaceae	Alpinia caerulea	wild ginger		C		1	1
Zingiberaceae	Alpinia arctiflora			C		1	1
Amblystegiaceae	Leptodictyum riparium			C		1	1
Bryaceae	Bryum argenteum			C		2	2
Bryaceae	Brachymenium nepalense			C		1	1
Dicnemonaceae	Eucamptodon muelleri			C		1	1
Dicranaceae	Campylopus robillardei			C		1	1
Hypnaceae	Taxiphyllum taxirameum			C		1	1
Leucomiaceae	Leucomium strumosum			C		2	2
Meteoriaceae	Aerobryopsis longissima			C		1	1
Orthotrichaceae	Macromitrium aurescens			C		1	1
Polytrichaceae	Pogonatum			C		1	1
Sematophyllaceae	Sematophyllum subpinnatum			C		2	2
Indet.	Indet.			C		10	0
Psilotaceae	Psilotum nudum	skeleton fork fern		C		2	2
Atherospermataceae	Doryphora aromatica			C		2	2
Atherospermataceae	Daphnandra repandula			C		1	1

Appendix F2.



DIGITAL CADASTRAL DATA BASE - BOUNDARY INFORMATION.
REGIONAL ECOSYSTEM VERSION 6 DATA
DERM AERIAL PHOTOGRAPHY.

Regional ecosystem linework compiled at scale greater than 1:100,000, except in designated areas, where a compilation scale of 1:50,000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100,000 is +/-100 metres.

The aerial photography used in this plan has not been rectified. The image has been overlaid as a best fit on the boundaries shown and position is approximate only.

Date of Capture: August 2006.

Project Manager	D. Finney
Compiled by	Jeff Middleton
Map Projection	MGAz55
Map Datum	GDA94
File Reference	PR100246-7.mxd
Sheet Number	1 of 1

Client

Transfield Services

Title

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SCALE (A3)	DATE	DRAWING NO.	ISSUE
1:29,112	12/8/2010	PR100246-7	

Appendix G2.

Part P: Requirements for clearing for public safety and infrastructure

Public safety and infrastructure includes clearing that is:

a) for establishing a necessary fence, firebreak, road or vehicular track, or for constructing necessary built infrastructure, if there is no suitable alternative site for the fence, firebreak, road, track or infrastructure; or

b) a natural and ordinary consequence of other assessable development for which a development approval as defined under the *Integrated Planning Act 1997* (IPA) was given, or a development application as defined under IPA was made, before 16 May 2003; or

c) to ensure public safety.

Performance Requirement
PR P.1: Limits to clearing for public safety and infrastructure To regulate the clearing of vegetation in a way that conserves remnant vegetation that are regional ecosystems, does not cause land degradation, prevents the loss of biodiversity and maintains ecological processes—subject to the limitations required to meet PR P.2 to PR P.10—clearing is limited to the extent that is necessary— a) for establishing a necessary fence, firebreak, road or vehicular track, or for constructing necessary built infrastructure, if there is no suitable alternative site for the fence, firebreak, road, track or infrastructure; or b) as a natural and ordinary consequence of other assessable development for which a development approval as defined under the IPA was given, or a development application as defined under IPA was made, before 16 May 2003; or c) to ensure public safety.
Comment The application is relevant to Item a of the Performance Requirement as the clearing will be required to establish access track and associated infrastructure, such as wind turbines, associated cabling and substation as shown on **Appendix A1** attached to this report. a) for establishing a necessary fence, firebreak, road or vehicular track, or for constructing necessary built infrastructure, if there is no suitable alternative site for the fence, firebreak, road, track or infrastructure;

Performance Requirement	Acceptable Solution
PR P.2: Wetlands To regulate the clearing of vegetation in a way that prevents the loss of biodiversity and maintains ecological processes—assessable vegetation associated with any natural significant wetland and/or natural wetland is protected to maintain— a) water quality by filtering sediments, nutrients and other pollutants; and b) aquatic habitat; and c) terrestrial habitat.	**AS P.2** Clearing does not occur— a) in any natural wetland; and b) within 100 metres from any natural wetland; and c) in any natural significant wetland; and d) within 200 metres from any natural significant wetland. AND P.2.2 Where clearing is for a significant community project, maintain the current extent of assessable vegetation associated with any natural significant wetland and/or natural wetland to provide— a) water quality by filtering sediments, nutrients and other pollutants; and b) aquatic habitat; and c) terrestrial habitat.
Comment Granite Creek, which occurs adjacent to the site and generally parallel to the access leg of Lot 7 on SP235244 is	

mapped as a Wetland Management Area. However, no wetlands occur (or are shown on mapping) within the project area. The project area is characterised by ridges, and the land's topography is not conducive to supporting wetland environments. As such, compliance is achieved as no clearing is proposed within or adjacent to any mapped wetland.

Performance Requirement	Acceptable Solution
PR P.3: Watercourses To regulate the clearing of vegetation in a way that does not cause land degradation, prevents the loss of biodiversity and maintains ecological processes—assessable vegetation associated with any watercourse is protected to maintain— a) bank stability by protecting against bank erosion; and b) water quality by filtering sediments, nutrients and other pollutants; and c) aquatic habitat; and d) terrestrial habitat.	**AS P.3** P.3.1 Clearing does not occur— a) in any watercourse; and b) within the relevant distance stipulated in Table 1, of each high bank of each watercourse. AND P.3.2 Where clearing is for a significant community project, maintain the current extent of assessable vegetation associated with any watercourse to provide— a) bank stability by protecting against bank erosion; and b) water quality by filtering sediments, nutrients and other pollutants; and c) aquatic habitat; and d) terrestrial habitat.

Comment

A number of lower order seasonally flowing stream features will be traversed, as shown on **Appendix H2** attached to this report.. The existing powerline service track already crosses the most significant of these features, and therefore no further clearing is required at these points. The creation of new stream crossings has therefore been avoided.

In other areas of the project, the road and cabling network is configured so that it follows ridgelines or high ground above watercourses.

If other stream features are encountered (these are expected to be intermittently flowing drainage lines with no defined riparian vegetation), clearing is expected to be minor (maximum 10 m wide) and appropriate erosion and sediment control measures will be designed and implemented.

<table>
<tr><th>Performance Requirement</th><th>Acceptable Solution</th></tr>
<tr><td>PR P.4: Connectivity
To regulate the clearing of vegetation in a way that prevents the loss of biodiversity and maintains ecological processes—areas of mapped remnant vegetation are retained that are—
a) of sufficient size and configured in a way to maintain ecosystem functioning; and
b) of sufficient size and configured in a way to remain in the landscape in spite of any threatening processes; and
c) located on the lot(s) that are the subject of the application to maintain connectivity to mapped remnant vegetation on adjacent properties.</td><td>AS P.4
P.4.1
Where clearing is less than—
a) 10 metres wide; or
b) 2 hectares;
clearing does not—
i)) reduce the width of mapped remnant vegetation to less than 200 metres; and
ii) occur where the width of mapped remnant vegetation is less than 200 metres;
AND
P.4.2
Clearing does not—
a) reduce areas of contiguous mapped remnant vegetation to less than 10 hectares; and
b) occur in areas of contiguous mapped remnant vegetation that are less than 10 hectares; and
c) reduce the width of mapped remnant vegetation to less than 200 metres; and
d) occur where the width of mapped remnant vegetation is less than 200 metres; and
e) reduce the total extent of mapped remnant vegetation to less than 30%; and
f) occur where the total extent of mapped remnant vegetation is less than 30%.
AND
P.4.3
Where clearing is for a significant community project, maintain the current extent of mapped remnant vegetation where the vegetation is—
a) of sufficient size and configured in a way to maintain ecosystem functioning; and
b) of sufficient size and configured in a way to remain in the landscape in spite of any threatening processes; and
c) located on the lot(s) that are the subject of the application to maintain connectivity to mapped remnant vegetation on adjacent properties.</td></tr>
<tr><td colspan="2">Comment
Initial clearing for the road and cabling network will be limited to a width of 10 metres or less. Following the construction phase, these tracks will be allowed to regenerate naturally to a reduced width of 5 m.

The clearing required for each wind turbine construction site will not exceed 2 hectares and is generally expected to be an area of 40 m x 40 m.

Each turbine site stands in isolation from others and therefore vegetation connectivity will not be affected. Allowing the initial construction tracks to regenerate to 5 m width will also reinstate connectivity between sites. No clearing will occur that will isolate remnant vegetation strips less than 200 m wide. Vegetation contiguity will be maintained due to the small footprint of each turbine.</td></tr>
</table>

<table>
<tr><th>Performance Requirement</th><th>Acceptable Solution</th></tr>
<tr><td>PR P.5: Soil erosion
To regulate the clearing of vegetation in a way that does not cause land degradation and maintains ecological processes—the effect of clearing does not result in—
a) mass movement, gully erosion, rill erosion, sheet erosion, tunnel erosion, stream bank erosion, wind erosion, or scalding; and
b) any associated loss of chemical, physical or biological fertility—including, but not limited to water holding capacity, soil structure, organic matter, soil biology, and nutrients, within and/or outside the lot(s) that are the subject of the application.</td><td>AS P.5
P.5.1
Mechanical clearing only occurs on—
a) stable soils on a slope less than 30%; and
b) unstable soils on a slope less than 10%; and
c) very unstable soils on a slope less than 1%.</td></tr>
<tr><td colspan="2">Comment
Mechanical clearing for the purposes of track establishment and construction pads for wind turbine sites will be on stable soils and generally following ridge topography, subject to geo-technical investigations prior to construction. Field investigations of the project area did not detect any unstable soils that could be evidenced by slumps, erosion gullies or tunnel and rill erosion. No evidence was seen of mass soil movement even on sloping land with slopes greater than 30%.

The PR can be adequately met by implementing a range of erosion and sediment control measures as well as by selective routing of the road and cable network to take advantage of least sloping land.</td></tr>
</table>

<table>
<tr><th>Performance Requirement</th><th>Acceptable Solution</th></tr>
<tr><td>PR P.6: Salinity
To regulate the clearing of vegetation in a way that does not cause land degradation and maintains ecological processes—clearing does not contribute to—
a) waterlogging; or
b) the salinisation of groundwater, surface water or soil.</td><td>AS P.6
P.6.1
Where clearing is less than—
a) 2 hectares; or
b) 10 metres wide;
clearing does not occur in any discharge area.
AND
P.6.2
Where clearing is less than—
a) 5 hectares; or
b) 50 metres wide—
clearing does not occur—
i) in any discharge area; and
ii) within 200 metres of any discharge area.
AND
P.6.3
Clearing does not occur in areas greater than 5 hectares</td></tr>
<tr><td colspan="2">Comment
The project area is not identified as a region of salinity hazard. Further, given the elevation above sea level and the hilly topography it is unlikely that salinity in any form will be an issue. Clearing will not occur in any discharge area, or within 200 m of a discharge area.</td></tr>
</table>

Performance Requirement	Acceptable Solution
PR P.7: Conserving remnant vegetation that are *endangered* regional ecosystems and *of concern* regional ecosystems To regulate the clearing of vegetation in a way that conserves remnant vegetation that are *endangered* regional ecosystems and *of concern* regional ecosystems—maintain the current extent of *endangered* regional ecosystems and *of concern* regional ecosystems.	**AS P.7** P.7.1 Clearing— a) does not occur in an *endangered* regional ecosystem or an *of concern* regional ecosystem that is listed in Table 2; and b) in an *endangered* regional ecosystem or an *of concern* regional ecosystem that is not listed in Table 2 only occurs where the clearing is less than 10 metres wide or 0.5 hectares.

Comment

No *endangered* remnant regional ecosystems occur in the study area where the wind turbines are to be located. Further, no regional ecosystems listed in Table 2 of the Code will be cleared or affected by the project.

Wind turbines are proposed to be located in zones of greatest wind capture capability. This position coincides with the currently mapped *of concern* vegetation community RE 7.12.57 and is characterised by its landscape occurrence along ridge topography. RE 7.12.57 is not listed in Table 2 of the Code and the clearing will comply with AS S.7.

In regard to the conservation status of remnant vegetation however, the current RE mapping incorrectly indicates that RE 7.12.57 (Of Concern) is present along a majority of the ridges south of the existing powerline, and where a number of turbines are proposed to be located. Field surveys identified that RE 7.12.57 is not present in any of the areas mapped. Amended mapping showing the presence of a heterogeneous polygons of RE 7.12.30b/ 7.12.65k (Least Concern) is provided with this report (see attached **Appendix D2**). Polygons containing the RE 7.12.57 label will therefore be relabelled as RE 7.12.30b / 7.12.65k with a respective proportional representation of each community of 80 / 20 percent.

As a result, the proposed clearing complies with relevant outcomes by ensuring that no endangered or of concern regional ecosystems are cleared as a result of the proposal.

Performance Requirement	Acceptable Solution
PR P.8: Essential habitat To regulate the clearing of vegetation in a way that prevents the loss of biodiversity—maintain the current extent of essential habitat.	**AS P.8** P.8.1 Clearing does not occur in an area shown as essential habitat on the essential habitat map.

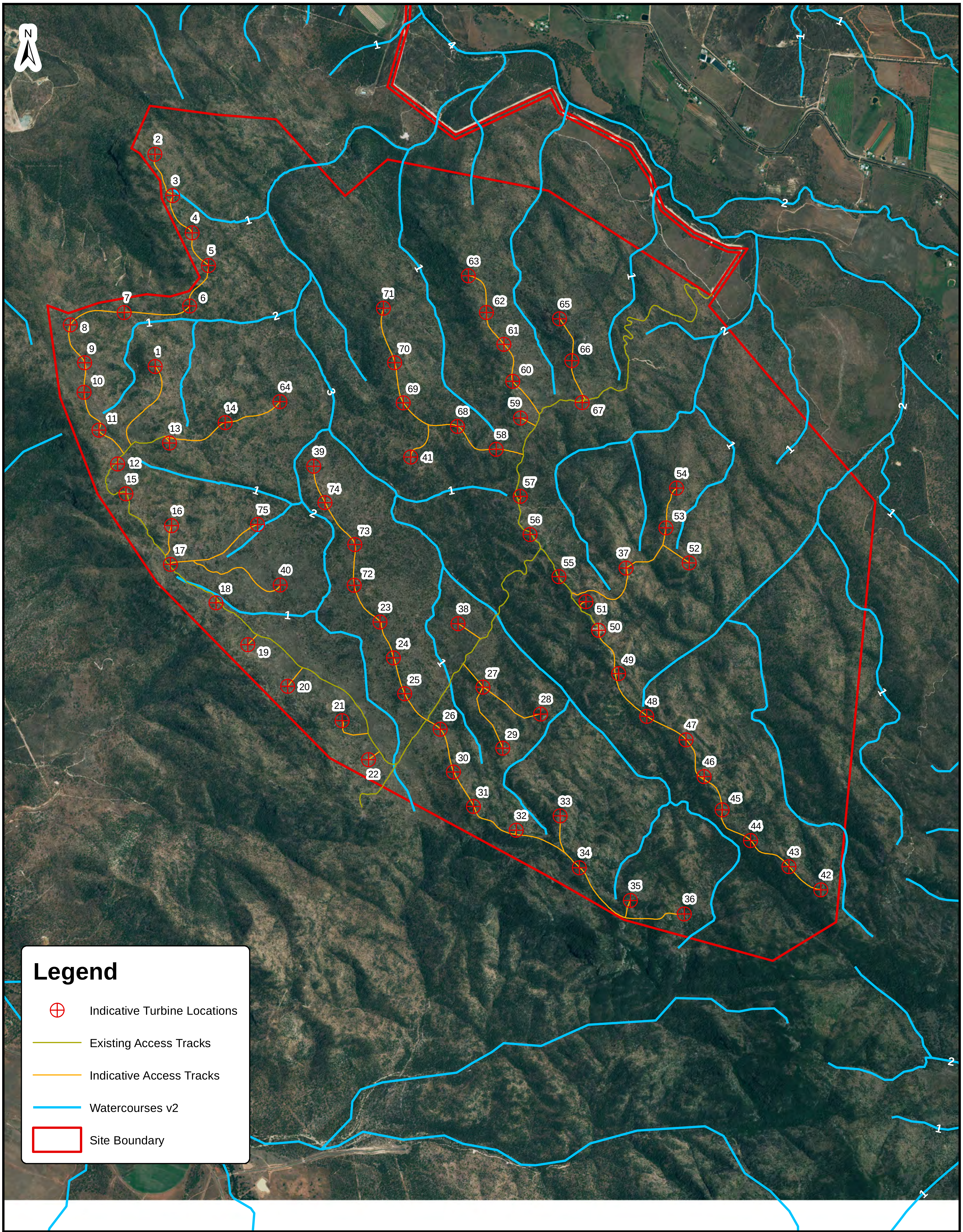
Comment

Essential habitat for the southern cassowary (*Casuarius casuarius johnsonii*), and four species of plants is mapped for an area within the southern portion of the project area. Nine turbines are proposed to be established in this habitat zone. Although the habitat zoning for the southern cassowary in this particular area is an ecological anomaly, there is reasonable probability that the four species of plants could occur. It is therefore recommended, that intensive ground searches are made of the proposed turbine sites in this area to detect the presence of conservation significant plants. There may be options to micro-site the turbines in question to similar landscape situations just outside of the area mapped as essential habitat.

Performance Requirement	Acceptable Solution
PR P.9: Conservation status thresholds To regulate the clearing of vegetation in a way that conserves remnant vegetation that are regional ecosystems and prevents the loss of biodiversity—maintain the current extent of regional ecosystems listed in Table 3.	**AS P.9** P.9.1 Clearing in a regional ecosystem listed in Table 3, does not occur unless the clearing is less than— a) 10 metres wide; or b) 2 hectares.
Comment No regional ecosystems listed in Table 3 of the Code occur in the project area.	

Performance Requirement	Acceptable Solution
PR P.10: Acid sulfate soils To regulate the clearing of vegetation in a way that does not cause land degradation and maintains ecological processes—clearing activities do not result in disturbance of acid sulfate soils or changes to the hydrology of the location that will either— a) aerate horizons containing iron sulfides; or b) mobilise acid and/or metals.	**AS P.10** P.10.1 Clearing in land zone 1, land zone 2 or land zone 3 in areas below 5 metre Australian Height Datum— a) is carried out in accordance with an acid sulfate soils environmental management plan as outlined in the *State Planning Policy 2/02 Guideline: Planning and Managing Development involving Acid Sulfate Soils;* and b) follows management principles in accordance with the Soil Management Guidelines in the *Queensland Acid Sulfate Soil Technical Manual*.
Comment Acid Sulfate Soils do not occur in the project area, as the region is at an elevation above sea level of greater than 800 m. The ridge topography and granite / rhyolite geology is not conducive to the development of Acid Sulphate Soils.	

Appendix H2.



0 250 500 750 1,000
Meters (A3)

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The aerial photography used in this plan has not been rectified. The image has been overlaid as a best fit on the boundaries shown and position is approximate only.

Date of Capture: August 2006.

Project Manager	D. Finney
Compiled by	Jeff Middleton
Map Projection	MGAz55
Map Datum	GDA94
File Reference	PR100246-10.mxd
Sheet Number	1 of 1

Client
Transfield Services

Title
Watercourses

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SCALE (A3)	DATE	DRAWING NO.	ISSUE
1:25,000	10/08/2011	PR100246-9	

Appendix 12.

Provisional Checklist of Flora – Mt Emerald Wind Farm

Scientific Name	Common Name	Form	NCA[1]	EPBC[2]
ADIANTACEAE				
Cheilanthes sp. (grey, hirsute pinnae)	Rock Fern	Fern	-	-
Cheilanthes tenuifolia	Rock Fern	Fern	-	-
APOCYNACEAE				
Alyxia spicata	Chain Fruit Vine	Vine	-	-
Hoya australis	Wax Flower	Vine	-	-
ASPARAGACEAE				
Asparagus racemosus	Asparagus Vine	Vine	-	-
ASTERACEAE				
Helichrysum sp.	Bright yellow waxy flowers	Forb	-	-
**Ageratum conyzoides*	Bluetop	Forb	-	-
**Crassocephalum crepidioides*	Thickhead	Forb	-	-
Cyanthillium cinereum	In report as *Vernonia cinerea*	Forb		
Glossocardia bidens	Native Cobblers Pegs	Forb	-	-
Helichrysum newcastlianum	Strawflower	Forb	-	-
**Praxelis clematidea*	Praxelis	Forb	-	-
Pterocaulon sphacelatum	Ragweed	Forb	-	-
BIGNONIACEAE				
Dolichandrone heterophylla	Lemon Wood	Shrub	-	-
Pandorea pandorana	Wonga Wonga Vine	Vine	-	-
BORYACEAE				
Borya septentrionalis	Resurrection Plant	Forb	-	-
CAPPARACEAE				
Capparis canescens	Wild Orange	Vine	-	-
CARYOPHYLLACEAE				
Polycarpaea spirostylis	Copper Plant	Forb	-	-
CASUARINACEAE				
Allocasuarina inophloia	Woolly-barked Oak	Tree	-	-
Allocasuarina littoralis	Black She-oak	Tree	-	-
CELASTRACEAE				
Maytenus cunninghamii	Yellow-berry Bush	Shrub	-	-
Maytenus disperma		Tree	-	-
COMMELINACEAE				
Cartonema spicatum	-	Forb	-	-
Commelina ensifolia	Wandering Jew	Forb	-	-
CONVOLVULACEAE				
Evolvulus alsinoides	Tropical Speedwell	Vine	-	-
Polymeria ambigua	Creeping Polymeria	Vine	-	-
CUPRESSACEAE				
Callitris intratropica	Cypress Pine	Tree	-	-
CYPERACEAE				
Rhynchospora subtenuifolia	Beak Rush	Sedge	-	-

Scientific Name	Common Name	Form	NCA[1]	EPBC[2]
Gahnia aspera	Saw Sedge	Sedge	-	-
Scleria brownii	Sedge	Sedge	-	-
DILLENIACEAE				
Hibbertia stirlingii	Guinea Flower	Subshrub	-	-
ERICACEAE				
Monotoca scoparia	Prickly Broom-heath	Shrub	-	-
ERYTHROXYLACEAE				
Erythroxylon ellipticum	Brown Plum	Shrub	-	-
FABACEAE				
Aeschynomene micranthos	-	Forb	-	-
Crotalaria brevis	Rattlepod	Forb	-	-
Crotalaria medicaginea	Trefoil rattlepod	Forb	-	-
Hovea nana	Hovea	Forb	-	-
Indigofera pratensis	Forest Indigo	Subshrub	-	-
Jacksonia thesioides	Dogwood	Shrub	-	-
**Stylosanthes scabra*	Stylo	Shrub	-	-
Tephrosia juncea	-	Subshrub	-	-
Tephrosia sp.	-	Subshrub	-	-
HAEMODORACEAE				
Haemodorum coccineum	Blood Root	Forb	-	-
JOHNSONIACEAE				
Tricoryne anceps	Yellow Rush Lily	Forb	-	-
LAMIACEAE				
Clerodendrum floribundum	Lolly Bush	Shrub	-	-
Plectranthus amoenus	-	Forb	V	-
Plectranthus sp.	-	Forb	-	-
LAURACEAE				
Cassytha filiformis	Dodder Laurel	Vine	-	-
LAXMANNIACEAE				
Eustrephus latifolius	Wombat Berry	Vine	-	-
Lomandra filiformis	Mat Rush	Graminoid	-	-
Lomandra sp.	Mat Rush	Graminoid	-	-
Thysanotus tuberosus	Fringe Lily	Forb	-	-
LECYTHIDACEAE				
Planchonia careya	Cocky Apple	Tree	-	-
MALVACEAE				
Hibiscus meraukensis	Wild Rosella	Shrub	-	-
MIMOSACEAE				
Acacia calyculata	Wattle	Shrub	-	-
Acacia flavescens	Red Wattle	Shrub	-	-
Acacia humifusa	Wattle	Shrub	-	-
Acacia leptostachya	Townsville Wattle	Shrub	-	-
Acacia simsii	Sim’s Wattle	Shrub	-	-

Scientific Name	Common Name	Form	NCA[1]	EPBC[2]
Acacia umbellata	Umbellata wattle	Shrub	-	-
MORACEAE				
Ficus opposita	Sandpaper Fig	Tree	-	-
MYRTACEAE				
Corymbia abergiana	Range Bloodwood	Tree	-	-
Corymbia citriodora	Lemon-scented Gum	Tree	-	-
Corymbia clarksoniana	Clarkson's Bloodwood	Tree	-	-
Corymbia leichhardtii	Leichhardt's Rusty Jacket	Tree	-	-
Eucalyptus cloeziana	Dead Finish	Tree	-	-
Eucalyptus crebra	Narrow-leaf ironbark	Tree	-	-
Eucalyptus granitica	Granite Ironbark	Tree	-	-
Eucalyptus leptophleba	Molly Box	Tree	-	-
Eucalyptus lockyeri subsp. *lockyeri*	-	Tree	-	-
Eucalyptus pachycalyx	Pumpkin Gum	Tree	-	-
Eucalyptus portuensis	Yellow Stringybark	Tree	-	-
Eucalyptus reducta	Grey Stringybark	Tree	-	-
Eucalyptus shirleyi	Shirley's Silver-leafed Ironbark	Tree	-	-
Homoranthus porteri	-	Shrub	V	V
Lophostemon grandiflorus var. *riparia*	Northern Swamp Box	Tree	-	-
Melaleuca monantha	Small-leaved Tea Tree	Tree	-	-
Melaleuca nervosa	Paperbark	Tree	-	-
Melaleuca sp.	Hirsute, narrow leaves.	Shrub	-	-
Melaleuca viridiflora	Broad-leaved Paperbark	Tree	-	-
NYMPHAEACEAE				
Nymphoides crenata	Wavy Marshwort	Aquatic	-	-
ORCHIDACEAE				
Dendrobium canaliculatum	Onion Orchid	Orchid	-	-
Thelymitra fragrans	Sun Orchid	Orchid	-	-
PHYLLANTHACEAE				
Breynia oblongifolia	Coffee Bush	Shrub	-	-
Euphorbia mitchellii	-	Forb	-	-
PICRODENDRACEAE				
Petalostigma pubescens	Quinine Bush	Tree		
PITTOSPORACEAE				
Bursaria incana	Australian Blackthorn	Shrub	-	-
POACEAE				
Aristida sp.	Wire Grass	Grass	-	-
Aristida utilis	Wire Grass	Grass	-	-
Arundinella setosa		Grass	-	-
**Chloris virgata*	Feathertop Rhodes Grass	Grass	-	-
Cymbopogon bombycinus	Silky Oilgrass	Grass	-	-
Dichanthium sericeum	Queensland Bluegrass	Grass	-	-
Eragrostis schultzii	-	Grass	-	-

Scientific Name	Common Name	Form	NCA[1]	EPBC[2]
Eragrostis sp.	-	Grass	-	-
Eriachne obtusa	Northern Wanderrie Grass	Grass	-	-
Eriachne rara	Wanderrie Grass	Grass	-	-
Heteropogon contortus	Black Speargrass	Grass	-	-
Heteropogon triticeus	Giant Speargrass	Grass	-	-
**Hyparrhenia rufa*	Thatch Grass	Grass		
**Melinis minutiflora*	Molasses Grass	Grass		
**Melinis repens*	Red Natal Grass	Grass	-	-
Panicum effusum	Hairy Panic	Grass	-	-
Panicum seminudum var. *cairnsianum*	Panic	Grass	-	-
Panicum trichoides	Tropical Panic Grass	Grass	-	-
Perotis rara	Comet Grass	Grass	-	-
Poaceae sp. (similar to *Sarga*)	-	Grass	-	-
Pseudopogonatherum contortum	-	Grass	-	-
**Setaria* sp. (*pumila*?)	Pigeon Grass	Grass	-	-
Setaria surgens	Pigeon Grass	Grass	-	-
Schizachyrium pseudeulalia	Firegrass	Grass	-	-
Schizachyrium sp. (10 cm)	Firegrass	Grass	-	-
**Themeda quadrivalvis*	Grader Grass	Grass	-	-
Themeda triandra	Kangaroo Grass	Grass	-	-
POLYPODIACEAE				
Drynaria rigidula	Basket Fern	Fern	-	-
PROTEACEAE				
Grevillea dryandri	Dryander's Grevillea	Shrub	-	-
Grevillea glauca	Bushman's clothes-peg	Tree	-	-
Grevillea glossadenia	-	Shrub	V	V
Grevillea mimosoides	Grevillea	Shrub	-	-
Grevillea parallela	Beefwood	Tree	-	-
Hakea lorea	Bootlace Hakea	Tree	-	-
Persoonia falcata	Geebung	Shrub	-	-
Xylomelum scottianum	Woody Pear	Tree	-	-
RHAMNACEAE				
Alphitonia excelsa	Red Ash	Tree	-	-
RUBIACEAE				
Larsenaikia ochreata	Native Gardenia	Shrub	-	-
Pogonolobus reticulatus	Medicine Bush	Shrub	-	-
SAPINDACEAE				
Dodonaea lanceolata	Hop Bush	Shrub	-	-
Dodonaea sp. (hirsute leaves)	Hop Bush	Shrub	-	-
SCROPHULARIACEAE				
Lindernia sp.	-	Forb	-	-
SPARRMANNIACEAE				
Grewia retusifolia	Dog's Balls	Shrub	-	-

Scientific Name	Common Name	Form	NCA[1]	EPBC[2]
TACCACEAE				
Tacca leontopetaloides	Arrowroot		-	-
THYMELAEACEAE				
Wikstroemia indica	Tie Bush	Shrub	-	-
VERBENACEAE				
**Lantana camara*	Lantana (Class 3 weed)	Shrub	-	-
XANTHORRHOEACEAE				
Xanthorrhoea johnsonii	Grass Tree		-	-

[1] Conservation status as listed under the *Nature Conservation Act 1992*:
E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern, NT – Near Threatened

[2] Conservation status as listed under the *Environment Protection and Biodiversity Conservation Act 1999*:
E – Endangered, V - Vulnerable

Appendix J2.

Summary of Vegetation Survey Sites – Mt Emerald Wind Farm

Site	X	Y	Structural Description (field)
1	327347	8099806	Open woodland to woodland 8-15 m of *Callitris intratropica* and *Corymbia leichhardtii* interspersed with ± bare rock pavements.
2	327647	8099786	Woodland to open woodland 8-12 m of *Eucalyptus shirleyi* and *Callitris intratropica* with *E. cloeziana* on rolling hills.
3	326509	8100269	Woodland of *Eucalyptus crebra* and *Corymbia citriodora* to 10 – 12 m on relatively uniform surface.
4	326318	8100418	Low woodland to open woodland of *Eucalyptus shirleyi* to 4 – 5 m on stony rises.
5	325995	8100652	Woodland of *Eucalyptus crebra* to 8 – 10 m on rocky surfaces of brow of hill.
6	325837	8100892	Woodland of *Eucalyptus cloeziana* and *Corymbia citriodora* to 8 – 10 m on uneven ground with rocky soils.
7	327767	8099522	Low woodland of *Eucalyptus lockyeri* subsp. *exuta* to 5 m on rocky, uneven surfaces.
8	327898	8099717	Woodland of *Callitris intratropica* to 8 m on stony and rocky soils.
9	328075	8099984	Woodland of *Corymbia leichhardtii* and *Eucalyptus lockyeri* subsp. *exuta* to 10 m on very rocky surfaces.
10	328242	8100193	Woodland of *Eucalyptus shirleyi* to 5 m on rocky surfaces.
11	328302	8100280	Woodland of *Eucalyptus crebra* to 12 m on sloping ground.
12	328385	8100444	Woodland of *Corymbia leichhardtii* and *Eucalyptus granitica* to 10 – 12 m on sloping ground with rocky surfaces.
13	328370	8100603	Woodland to open forest of *Eucalyptus cloeziana* and *Corymbia citriodora* to 15 m on side of rocky hill.
14	328570	8100763	Woodland of *Eucalyptus portuensis* to 8 m on rocky hill slope approaching ridge.
15	328589	8100961	Mixed woodland of *Corymbia abergiana*, *Eucalyptus lockyeri* subsp. *exuta*, *Corymbia citriodora* and *Eucalyptus shirleyi* on ridge with pale soils and scattered surface rocks (with small areas of rock pavement).
16	328478	8101240	Woodland of *Eucalyptus cloeziana* and *E. portuensis* with *Callitris intratropica* to 8 m on ridge with pale, rocky soils.
17	329787	8099439	Low open woodland to woodland of *Eucalyptus portuensis* and *Allocasuarina littoralis* to 4 m.
18	329906	8099181	Low woodland of *Corymbia abergiana* and *Eucalyptus portuensis* to 5-6 m on broad ridge with pale, sandy soil.
19	330038	8098936	Low woodland of *Corymbia abergiana* and *Eucalyptus portuensis* to 4-5 m on broad ridge.
20	330283	8098692	Open forest of *Callitris intratropica* to 8 – 10 m on ridge.
21	330541	8098500	Woodland to open forest to 14 m of *Eucalyptus reducta* and *Corymbia citriodora* on flat top ridge.
22	330819	8098275	Rock pavement at terminus of ridge with sparse vegetation cover limited to scattered trees of *Corymbia citriodora* and single *Eucalyptus* sp. to 4 m.
23	327477	8098833	Shrubland to low woodland 4-8 m of *Acacia leptostachya* (thickets), *Eucalyptus portuensis* and *E. cloeziana* on western edge of ridge.
24	327148	8099089	Open woodland to 8 m of *Eucalyptus portuensis* with *Allocasuarina inophloia* on colluvial slope.
25	327148	8099347	Small rock pavement surrounded by low woodland of *Eucalyptus portuensis* to 6 m.
26	327062	8099605	Rock pavement fringed by shrubland of *Acacia leptostachya* to 4-5 m.
27	328342	8100388	Woodland 12 m of *Eucalyptus portuensis*, *Callitris intratropica* adjacent to ephemeral watercourse.
28	327968	8099949	Open woodland 6 m of *Lophostemon grandiflorus*, *Callitris intratropica* with grassy understorey on rocky, ephemeral stream.

Site	X	Y	Structural Description (field)
29	330878	8099138	Open woodland to 4 m of *Corymbia abergiana*, *Eucalyptus portuensis*, *E. lockyeri* subsp. *exuta* on outcropping rhyolite – many bare rock areas and fissures.
30	330732	8099400	Woodland to 6 m of *Eucalyptus portuensis*, *Corymbia citriodora*, *C. abergiana*.
31	330708	8099679	Woodland to 14 m of *Eucalyptus portuensis*, *E. crebra* (sens. lat.), *Corymbia citriodora*.
32	330302	8099941	Fringing open woodland to 14 m of *Lophostemon grandiflorus*, *Callitris intratropica*, (*Corymbia dallachiana*) along rocky ephemeral creek in ravine.
33	330362	8099490	Fringing open woodland to 10 m of *Lophostemon grandiflorus*, *Callitris intratropica* along rocky ephemeral creek at upper reaches of ravine.
34	330476	8098995	Woodland to 15 m of *Callitris intratropica* with *Lophostemon grandiflorus* lining rocky banks of ephemeral creek in ravine.
35	327680	8099056	Sparse, open woodland to 5 m of *Lophostemon grandiflorus*, *Eucalyptus shirleyi* along shallow, rocky ephemeral stream.
36	329980	8098454	Open woodland to 10 m of *Lophostemon grandiflorus*, *Melaleuca viridiflora*, *Eucalyptus lockyeri* subsp. *exuta*, (*E. portuensis*), *E. cloeziana* lining rocky, lower order ephemeral stream.
37	330738	8098294	Very sparse, low open woodland (scattered trees) to 4 m of *Corymbia citriodora*, (*C. abergiana*), *Eucalyptus granitica*, *E. lockyeri* subsp. *exuta* on rock pavement.
38	330492	8098502	Woodland to 12 m of *Eucalyptus reducta* and *E. portuensis* on narrow ridge.
39	330212	8098691	Woodland to 12 m of *Eucalyptus cloeziana*, *Corymbia citriodora*, *Eucalyptus granitica* on rounded (broad) ridge.
40	329982	8098921	Sparse low open woodland to 5 m of *Eucalyptus lockyeri* subsp. *exuta*, *E. portuensis*, *Callitris intratropica* on skeletal soils in mosaic of rock pavements and outcropping rhyolite.
41	329821	8099168	Low woodland to 5 m of *Corymbia abergiana*, *Eucalyptus portuensis* on rocky ridge.
42	329730	8099436	Low woodland to 3.5 m of *Corymbia abergiana*, *Allocasuarina littoralis* on outcropping rhyolite on narrow ridge.
43	329402	8099648	Woodland to 10 m of *Eucalyptus cloeziana*, *Corymbia citriodora*, *E. portuensis* on broad ridge.
44	329199	8099948	Low open woodland to 4 m of *Corymbia abergiana*, *Eucalyptus portuensis*, *E. shirleyi*, *E. granitica* on skeletal soil with much surface rock with small areas of rock pavement.
45	328958	8101923	Open woodland to 6 m of *Corymbia citriodora*, *Corymbia leichhardtii*, *Eucalyptus portuensis*, (*E. shirleyi*) on stony soil.
46	329250	8102478	Woodland to 12 m of *Eucalyptus portuensis* around outcropping rhyolite on rocky soils.
47	329481	8102556	Woodland to 10 m of *Eucalyptus portuensis*, *E. granitica*, *E. crebra* (sens lat.) around outcropping rhyolite.
48	328888	8102236	Rock pavement fringed by low woodland to 4-5 m. *Eucalyptus portuensis*, (*Callitris intratropica*: 6-8 m), *Jacksonia thesioides*, *Acacia flavescens*, *Xanthorrhoea johnsonii*, *Allocasuarina littoralis*.
49	328495	8101250	Woodland 6-10 m, *Eucalyptus portuensis*, *Callitris intratropica*, *Xanthorrhoea johnsonii*, *Themeda triandra*, *Jacksonia thesioides*, *Grevillea glauca*, *Eucalyptus shirleyi*, *Grevillea glossadenia* (1 specimen), *Corymbia abergiana*.
50	328574	8100955	Sparse low woodland/rock pavement. *Callitris intratropica* to 5 m, (*Corymbia leichhardtii*), *Xanthorrhoea johnsonii*, *Acacia umbellata*, *Grevillea glossadenia* alongside track, *E. shirleyi*, *Grevillea striata*, *Melaleuca viridiflora* (narrow leaf).
51	328775	8100683	Woodland 6-8 m. *Eucalyptus portuensis*, *Corymbia abergiana*, *C. citriodora*, *Xanthorrhoea johnsonii*, *Jacksonia thesioides*, *Persoonia falcata*, *Themeda triandra*, *Capparis* sp., *Acacia calyculata*, *Grevillea glossadenia* (several specimens on edge of track).
52	329045	8100451	Woodland 6-8m (10m max *Corymbia citriodora*), *Eucalyptus portuensis*, *Heteropogon triticeus*, *Arundinella setosa*, *Themeda triandra*, *Persoonia falcata*, *Grevillea glossadenia* (nearby), *Xanthorrhoea johnsonii*, (*Corymbia abergiana*), *Mnesithea rottboellioides*.
53	329102	8100252	*Grevillia glossadenia* seedlings responding to disturbance at cleared pad for wind monitoring tower. Surrounding low, open woodland of *Eucalyptus portuensis* to 3 m.

Site	X	Y	Structural Description (field)
54	328548	8101660	Woodland 10-12 m. *Eucalyptus cloeziana*, *Corymbia citriodora* sub-dominant, *Heteropogon triticeus*, *Arundinella setosa*, *Themeda triandra*. Shrub layer very sparse to absent.
55	328512	8101484	Woodland 8-12 m. *Eucalyptus cloeziana*, *Corymbia citriodora*, *E. portuensis*, (*Callitris intratropica*), *Xanthorrhoea johnsonii*, *Grevillea dryandri*, *Themeda triandra*, (E. *shirleyi*) - near ecotone of previous survey, *Persoonia falcata*, *Jacksonia thesioides*.
56	328449	8101263	Woodland 10-12 m. *Eucalyptus cloeziana*, *Corymbia citriodora*, *Heteropogon triticeus*, *Arundinella setosa*, *Themeda triandra*. Shrub layer very sparse to absent.
57	329076	8100278	Cleared wind monitoring tower with two species of introduced *Senna* at cleared pad for wind monitoring tower near turbine 50. Other species of weeds recently introduced and forming dominant ground cover.
58	328385	8100606	Woodland 10-14 m on brow of steep slope. *Corymbia citriodora*, (*Eucalyptus granitica*), *Eucalyptus cloeziana*, *Corymbia* sp. (*clarksoniana*?), (*C. abergiana*), *Xanthorrhoea johnsonii*, *Themeda triandra*, *Panicum* sp. *Eucalyptus portuensis*.
59	328267	8100215	Open woodland to 6m with emergent *Callitris intratropica* 8-10 m. Sparse *Eucalyptus shirleyi*, *Callitris intratropica*, *Xanthorrhoea johnsonii*, *Corymbia leichhardtii*, *Persoonia falcata*.
60	328142	8100081	Woodland to 6 m. *Eucalyptus shirleyi*, *Corymbia leichhardtii*, (*E. lockyeri* subsp. *exuta*), *Acacia umbellata* forming dominant shrub layer/thicket to 1.5 m - thicket dead. Rat's Tail Grass (*Sporobolus* sp.) - 1.8 m tall ~12 individuals on edge of track.
61	327931	8099910	Low open woodland to 2-4 m. (*Callitris intratropica*), *Eucalyptus shirleyi*, *Acacia umbellata* (dead), *Melaleuca monantha*, *Xanthorrhoea johnsonii*, *Corymbia leichhardtii*, *Themeda triandra*, *Schizachyrium* sp., mosaic of rock pavement.
62	329524	8098132	Rock pavement with low shrubland to 1.5-2 m of ±*Eucalyptus lockyeri* subsp. *exuta*, ±*E. portuensis*, ±*Corymbia abergiana*.
63	329486	8098125	Woodland to 15-18 m of *Eucalyptus portuensis*, *E. granitica*.
64	329079	8098280	Broad drainage depression with open forest to 15-18 m of *Corymbia intermedia*, *Eucalyptus portuensis*, +/- *Allocasuarina littoralis*, +/- *E. drepanophylla*.
65	329121	8098281	Thicket of *Homoranthus porteri* (in flower) on areas of bare rock. Scattered *Grevillea glossadenia*.
66	329104	8098298	Rock pavement in shallow saddle of relatively narrow ridge. *Homoranthus porteri* and *Grevillea glossadenia* nearby. Precipitous near vertical drop off immediately to north. Low shrubland to 1.8m. The vegetation on the south side of saddle grades into shallow valley.
67	328972	8098531	Woodland to open forest to 10-15 m on sheltered side of large rocky knoll of *Eucalyptus portuensis*, *Allocasuarina littoralis*, +/- *Corymbia abergiana*.
68	328990	8098552	Rocky knoll of outcropping rhyolite with shrubland to 2 m of *Eucalyptus lockyeri* subsp. *exuta*, *E. granitica*.
69	330870	8099131	Low woodland to 5 m on ridge *Eucalyptus portuensis*, *Corymbia abergiana*, *Acacia calyculata*, *Allocasuarina littoralis*, +/-*Eucalyptus granitica*, +/- *Corymbia citriodora*.
70	330821	8099124	Woodland to open forest on sheltered western side of ridge to 15 m of *Corymbia citriodora*, *Eucalyptus cloeziana*.
71	330741	8099385	Ridge approximately 20-30 m wide. Woodland to 8-10 m of *Corymbia citriodora*, *Eucalyptus portuensis*, *E. shirleyi*, *Lophostemon suaveolens*, *E. granitica*, *C. abergiana*, *E. drepanophylla*.
72	330723	8099676	Sloping rock pavement with short grasses. Broad ridge half way up the hill. Northerly aspect. Outside of pad - surrounding woodland to 8 m of *E. drepanophylla*, *Corymbia leichhardtii*, *E. shirleyi*, *C. intermedia*, *C. citriodora*, *E. granitica*, *E. lockyeri* subsp. *exuta*.
73	329659	8101299	Outcropping rhyolite with surrounding low open woodland to 4-6 m of *E. portuensis*, *E. shirleyi*, *Corymbia leichhardtii*, Melaleuca monantha (poorly defined fringe around outer edge of knoll), +/- *E. lockyeri* subsp. *exuta*.
74	329619	8101299	Pouteria sericea, *Alyxia spicata*, *Antidesma* sp. *Asparagus racemosus*, *Scleria brownii*. *Hibiscus meraukensis*, **Melinis repens*, *Euroschinus falcata*, *Larsenaikia ochreata*, *Callitris intratropica*.
75	329657	8101352	Cleared open area surrounded by open woodland to woodland to 8 m of *Callitris*

Site	X	Y	Structural Description (field)
			intratropica, *Corymbia leichhardtii*, *Melaleuca monantha*.
76	329581	8101006	Open woodland to 5-8 m of *E. cloeziana*, *Callitris intratropica*, *Corymbia leichhardtii*, *C. abergiana*, *E. shirleyi*.
77	329738	8100745	Rock pavement with knoll with surrounding low woodland to 4-5 m of *Eucalyptus lockyeri* subsp. *exuta*, *Corymbia abergiana*, *Callitris intratropica*, *C. leichhardtii*, *E. shirleyi*, *E. portuensis*, *Alphitonia excelsa*.
78	328964	8101930	Woodland to 4-5 m of <u>*Corymbia leichhardtii*</u> in mosaic of rhyolite rock pavements and exposed rock. (*Corymbia citriodora*), *Eucalyptus lockyeri* subsp. *exuta*. T2 (*Callitris intratropica*), *Corymbia leichhardtii*.
79	328506	8101239	Woodland to 6 m of <u>*Eucalyptus portuensis*</u>. T2 (*Callitris intratropica*), *E. portuensis*, *Corymbia abergiana*, (*Petalostigma pubescens*), (*E. lockyeri* subsp. *exuta*).
80	328773	8100681	Low woodland to 4-6 m of <u>*Corymbia abergiana*</u> (50% PFC). S1 *Xanthorrhoea johnsonii*. G: *Grevillea glossadenia*, *Jacksonia thesioides*.
81	328507	8101817	Open woodland to 4-5 m of *Eucalyptus granitica*, *Corymbia leichhardtii*. T2 *C. leichhardtii*, *Callitris intratropica*, *Allocasuarina littoralis*, *Grevillea glauca*, *Maytenus disperma*.
82	328492	8101845	Woodland to 8 m of *Callitris intratropica* on rock pavement. S1 & G not recorded.
83	327600	8099074	Low open woodland to 3 m of *Eucalyptus shirleyi* on uniform surface with patchy rock pavements. (*Callitris intratropica*), (*Corymbia leichhardtii*)
84	327915	8099518	Low open woodland to 5 m on rhyolite rock pavement of *Callitris intratropica*. T1 *Callitris intratropica*, *Corymbia leichhardtii*, (*Eucalyptus lockyeri* subsp. *exuta*), (*E. granitica*).
85	328029	8099220	Low woodland to 3-4 m of *Eucalyptus portuensis*, (*Corymbia abergiana*), *Eucalyptus granitica*, *E. lockyeri* subsp. *exuta*, *E. shirleyi*.
86	328146	8098962	Low woodland to 4-5 m of *Eucalyptus portuensis* and *Corymbia abergiana* on rollover of broad ridge with stony soils.
87	328166	8098970	Low sparse shrubland/scattered trees to 2.5 m of *Eucalyptus lockyeri* subsp. *exuta*, *Melaleuca* sp. (fine leaves), *Acacia calyculata*, *Xanthorrhoea johnsonii*. *Homoranthus porteri* and *Grevillea glossadenia* (poss. eastern limit of *H. porteri*).
88	328247	8098844	Woodland to 15 m of *Eucalyptus cloeziana* in west running broad gully.
89	328425	8098766	Low open woodland to 3-4 m of <u>*Eucalyptus portuensis*</u>, (*Corymbia abergiana*) on ridge with outcropping rhyolite.
90	328562	8098721	Woodland to open forest to 14 m of <u>*Eucalyptus reducta*</u> on wide ridge.
91	328450	8102087	Open woodland to 6-8 m of *Eucalyptus lockyeri* subsp. *exuta*, *Corymbia abergiana*, *C. citriodora*, (*Callitris intratropica*). T2 *E. granitica*, *Allocasuarina littoralis*, *Grevillea glauca*, *Callitris intratropica*, (*E. shirleyi*).
92	328367	8102383	Rock pavement with fringing woodland to 10 m of *Callitris intratropica*.
93	328384	8102361	Low open woodland to 5-6 m of *Corymbia leichhardtii* and *Callitris intratropica* on pale rocky soil. G: *Acacia calyculata*.
94	328250	8102610	Rock pavement with surrounding open woodland to 6-8 m of *Callitris intratropica*, *Corymbia leichhardtii*, (*Eucalyptus lockyeri* subsp. *exuta*).
95	328123	8102866	Woodland to 8-10 m of *Eucalyptus portuensis*, *Corymbia leichhardtii* and *Callitris intratropica* on saddle.
96	326730	8101936	Woodland to 15 m of *Eucalyptus portuensis* and *Corymbia citriodora*, (*E. cloeziana*). T2: *E. granitica*, *Hakea lorea*, *Callitris intratropica*, *Cycas media*, *E. portuensis*.
97	328030	8103067	Rock pavement with very sparse low woodland to 3-4 m of *Eucalyptus shirleyi*, *Callitris intratropica*, *Maytenus disperma*, *Larsenaikia ochreata*, *Eucalyptus portuensis*. G: *Arundinella setosa*, *Themeda triandra*, *Jacksonia thesioides*.
98	328501	8101480	Woodland to 15 m of *Eucalyptus cloeziana* and *Corymbia citriodora*, (*Eucalyptus portuensis*), (*Callitris intratropica*).
99	328368	8101559	Woodland to 10-12 m of *Eucalyptus cloeziana*, *E. crebra*, *E. granitica*, *E. reducta*, *Corymbia leichhardtii*, (*Callitris intratropica*).

Site	X	Y	Structural Description (field)
100	328383	8101589	Rock pavement with very sparse woodland to 8 m of *Eucalyptus crebra*, *E. granitica* and *Corymbia citriodora*.
101	328335	8101612	Rock pavement with sparse woodland to 7 m of *Callitris intratropica*.
102	328019	8101756	Series of elevated rock pavements with isolated trees to 2-3 m of *Eucalyptus lockyeri* subsp. *exuta*, *Callitris intratropica* and thickets of *Homoranthus porteri*.
103	327829	8101815	Woodland to 15-18 m of *Eucalyptus cloeziana* and *Corymbia citriodora*. Low shrublayer of *Jacksonia thesioides*.
104	327636	8101937	Woodland to 8-10 m of *Eucalyptus cloeziana*, *Corymbia leichhardtii*, *E. portuensis*, *Callitris intratropica*, (*E. crebra*), (*C. intermedia*)
105	327628	8101956	Rock pavement with possible *Plectranthus* amoenus. Trees more or less absent.
106	327578	8102225	Rock pavement mosaic with isolated and widely scattered trees of *Callitris intratropica*.
107	327508	8102611	Rhyolite monolith with no woody vegetation community. Scattered occurrences of *Arundinella setosa*, *Themeda triandra* and stunted *Callitris intratropica* in cracks and on small ledges.
108	327374	8102874	Open woodland to 6 m of *Eucalyptus shirleyi*, *Callitris intratropica*, *E. portuensis*, *Corymbia leichhardtii*, E. *granitica*.
109	327150	8103108	Open woodland to 10-12 m of *Callitris intratropica*, *Corymbia leichhardtii*, *Eucalyptus crebra*, *E. shirleyi*.
110	327096	8103393	Woodland to 12 m of *Callitris intratropica*, *Eucalyptus crebra*, (*E. portuensis*).
111	328773	8100681	Woodland to 4-6 m of *Corymbia abergiana*, (*C. citriodora*), *Eucalyptus granitica*, *E. portuensis*.
112	328841	8100679	Rock pavement with isolated low shrubs to 1.2 m of *Eucalyptus granitica* and *Acacia umbellata*.
113	329015	8100299	Woodland to open forest to 18-20 m of *Eucalyptus reducta* and *Corymbia citriodora*.
114	329036	8100415	Woodland to open forest to 18-20 m of *Eucalyptus reducta* and *Corymbia citriodora*.
115	329040	8100460	Woodland to 6-8 m of *Eucalyptus portuensis*, (*E. reducta*), (*Corymbia citriodora*).
116	329091	8100198	Rock pavement with scattered low shrubs to 1.8 m and surrounded by woodland of *Eucalyptus reducta* to 12 m.
117	329091	8100198	Rock pavement mosaic and outcropping rhyolite with very sparse, low woodland to 3 m of scattered trees of *Eucalyptus shirleyi*, *Corymbia abergiana*, *E. portuensis*, *E. granitica*, *Maytenus disperma*. S1: *Grevillea glossadenia*, *Xanthorrhoea johnsonii*.
118	329182	8099995	Rock pavement with very sparse, low shrubland of scattered shrubs of *Eucalyptus portuensis*, *Acacia calyculata*, *Grevillea glossadenia*, *E. shirleyi*, *Xanthorrhoea johnsonii*, *Persoonia falcata*.
119	325803	8103785	Low woodland to 5 m of *Corymbia citriodora* and *Eucalyptus reducta*. S1: *Xanthorrhoea johnsonii*, *Eucalyptus reducta*, *E. shirleyi*. G: *Themeda triandra*.
120	325956	8103457	Low shrubland to 1.2 m of *Eucalyptus reducta* with *Xanthorrhoea johnsonii*. Scattered juvenile regrowth of *E. shirleyi* on ridge. Adjacent slopes with woodland to 6 m of *E. crebra*, *Corymbia citriodora*. Scattered *Xanthorrhoea johnsonii*. G: *Themeda triandra*.

Appendix 21

Dasyurus hallucatus Population Genetics: Final Report September 2013

Prepared by University of the Sunshine Coast

University of the Sunshine Coast

Dasyurus hallucatus

Population Genetics:

Final Report

September 2013

Report compiled by Dr Gabriel Conroy and Dr Robert Lamont

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The genetic structure of Northern Quoll (*Dasyurus hallucatus*) populations centred around Mt. Emerald, Atherton Tablelands.

Introduction

Dasyurus hallucatus is the largest extant marsupial carnivore in northern Australia, with a range spanning northern Queensland, the Northern Territory and Western Australia. Although listed as being of Least Concern in Queensland (*Nature Conservation Act 1992), D. hallucatus* is listed as Endangered nationally (*Environment and Biodiversity Conservation Act 199*9). Key threatening processes include habitat destruction, fragmentation and degradation stemming from agricultural and urban development (DSEWPC 2013).

When anthropogenic pressures lead to habitat loss, fragmentation or modification, the persistence of a species may become compromised at either a local or regional level. On the Atherton Tablelands, the negative effects of habitat fragmentation are well documented for a number of taxa (Laurance 1994; Cunningham & Moritz 1998; Bowyer *et al.* 2002; Sumner *et al*. 2004). Due to the proposed wind-farm on Mt Emerald, the University of the Sunshine Coast has been commissioned to undertake a population genetic analysis of *D. hallucatus* to determine population relationships between the development site and surrounding areas. While previous research exists on the population genetics and phylogenetic structure (Firestone 2000) of the northern Quoll, these studies have been restricted to Western Australia (How *et al.* 2009) and the Northern Territory (Cardoso *et al.* 2009).

The quantification of genetic diversity facilitates an interpretation of the manner in which diversity is partitioned within and among remnant populations of threatened species (England *et al.* 2002; Frankham 2002). Establishing these patterns can also lead to an understanding of the effects of inbreeding, gene flow, selection, mutation and genetic drift (Frankham 2002). The population genetic structure of a species can provide insights into historical patterns of landscape level processes such as gene flow, and in turn, can detect how a species may be affected by interruptions to these processes (Frankham 2005; Lowe *et al.* 2009). Familiarity with the amount and distribution of genetic variability within a species prior to the impacts of threatening processes will therefore increase the precision and effectiveness with which the main priorities for conservation management are identified and executed (England *et al.* 2002; Frankham 2005; How *et al.* 2009).

In contemporary population genetics analysis, codominant microsatellites, or simple sequence repeats (SSRs) are the marker of choice, due to a high level of polymorphism among individuals (Bhargava & Fuentes 2010). This study used SSRs to investigate the genetic importance of the *D. hallucatus* population on Mt Emerald in relation to proximate populations, particularly with regard to its contribution to regional genetic diversity and its potential status as a source or linkage for the movement of genes through associated subpopulations comprising the area's broader metapopulation.

This is the final USC report on the population genetic structure of *D. hallucatus* subpopulations in the vicinity of Mt. Emerald, and will cover DNA extraction, PCR amplification of microsatellites, genotyping, and data analysis. Implications for the future of the Mt Emerald quoll population and potential avenues of conservation in light of the proposed development are discussed.

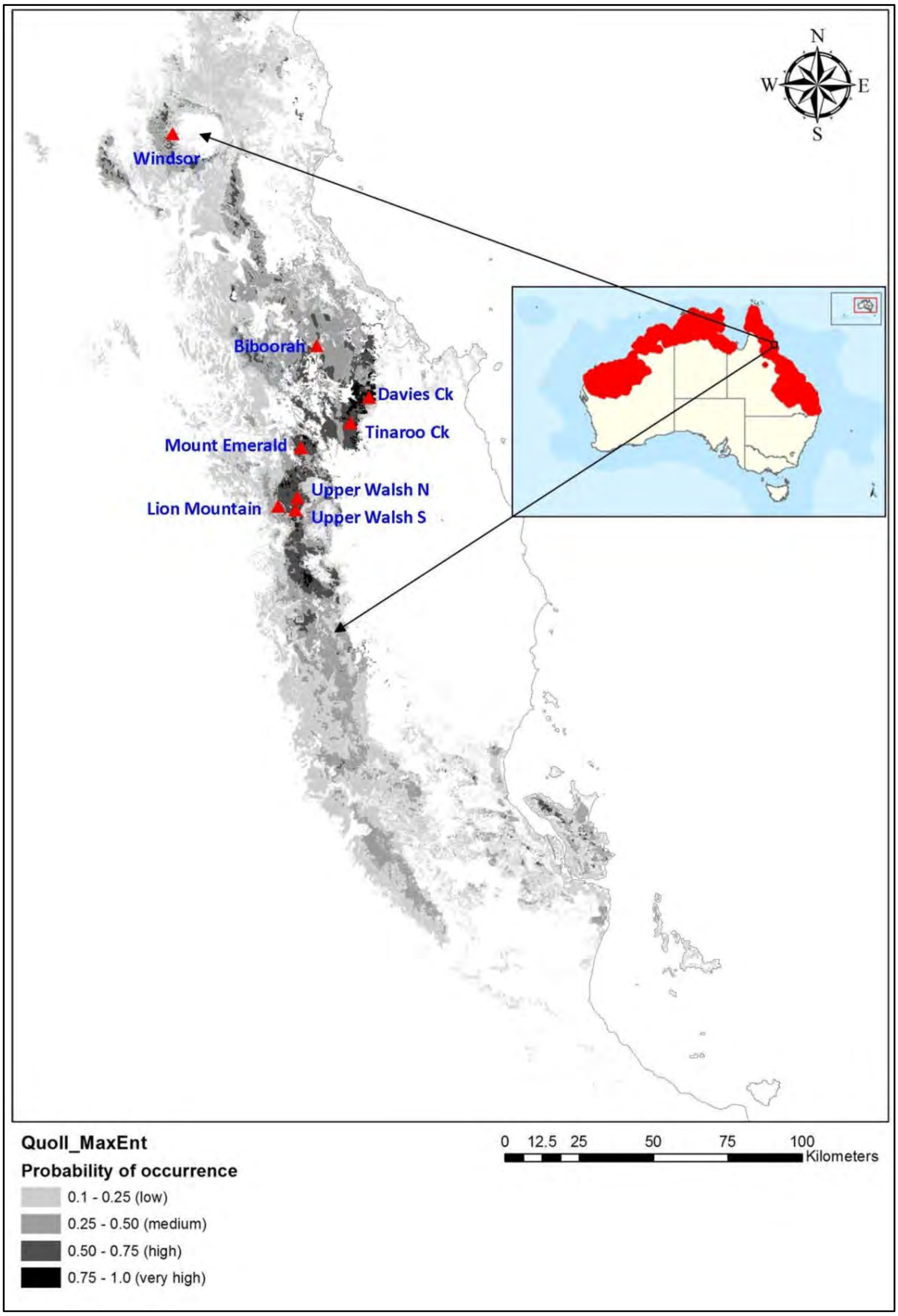


Figure 1: Sampling locations (▲) and modelled probability of *Dasyurus hallucatus* occurrence as a function of suitable habitat within an approximate 200km radius of Mt Emerald. Probability of occurrence as modelled by Shimizu and Burnett (2013) is indicated by the degree of shading as per legend. Inset: Geographic distribution of *D. hallucatus* across northern Australia (DSEWPC, 2013).

Methods

Field Methods

A total of 379 sticky traps were set on Mt Emerald and surrounds to collect hairs from foraging *D. hallucatus*, however only 34 of these were successful in obtaining hair samples. Initial extraction trials focussed on ascertaining the most appropriate method for extracting DNA from sticky-trap samples, most of which consisted of a single hair, or hairs without follicles. Two extraction techniques, Qiagen's DNeasy Blood and Tissue Kit and the Chelex method were tested. The Qiagen kit was unsuccessful due to insufficient quantities of DNA, and although some extractions were successful using Chelex, DNA yield from these samples was very low. During subsequent PCR and genotyping, many of the genetic markers employed were found to amplify inconsistently, suggesting that the integrity of the DNA had been compromised by the length of time spent in the field under tropical conditions prior to trap retrieval.

As a result, the study proceeded with directly-plucked hair samples from 81 trapped individuals, sourced from nine 'populations' (Table 1). Although sufficient samples (n-33) were collected from Mt Emerald, samples from proximate localities were pooled in order to achieve a more statistically-robust dataset (Table 1). Individuals from Upper Walsh North (12), Upper Walsh South (10) and Lion Mountain (1) were combined to create a subpopulation of 23 samples, and individuals from Tinaroo Creek (11), Davies Creek (6), and Biboohra (1) were pooled to create a sample size of 18 (Table 1; Figure 1). Two distant populations, Windsor (2; ~250km) and Weipa (5; ~650km), were included as outgroups for genetic comparison and treated as distinct entities (Table 1).

Table 1: Sampling location, population code for combined sites, number of individual quolls sampled per site (*n*), and number of individuals per combined population (*N*) for the five demes.

Location	Popn Code	*n*	*N*
Mt Emerald	**MTE**	**33**	**33**
Upper Walsh N	**UWL**	**12**	
Upper Walsh S	**UWL**	**10**	**23**
Lion Mtn	**UWL**	**1**	
Tinaroo Crk	**DTB**	**11**	
Davies Crk	**DTB**	**6**	**18**
Biboohra	**DTB**	**1**	
Windsor	**WIN**	**2**	**2**
Weipa	**WEI**	**5**	**5**
Total			**81**

Laboratory Methods

DNA Extraction

Total genomic DNA was isolated from the hair follicles of captured quolls using the DNeasy Blood and Tissue Kit (Qiagen) according to the manufacturer’s instructions. Ten hairs from each individual were trimmed to approximately 1cm in length from the follicle, placed in 1.7mL microcentrifuge tubes and lysed overnight in 180μl of ATL lysis buffer and 20μl of 10 mg/mL Proteinase-K at 56°C. DNA was eluted in 100μl of AE buffer and compared with known concentrations (5ng/μl, 10ng/μl, and 20ng/μl) of Lambda EcoR1/*Hind*III digest molecular-weight marker (Fisher-Biotec) to estimate yields using agarose gel electrophoresis.

Microsatellite analysis

Eleven Dasyurid microsatellite primers (Firestone 1999; Jones *et al.* 2003; Spencer *et al.* 2007) were selected for use and end-labelled with either VIC, NED, PET or FAM fluorescent dyes (Applied Biosystems; Table 2). PCR amplification was performed using reaction volumes of 12.5µl containing ~20ng of template DNA, 1 x reaction buffer (67mM Tris-HCl (pH 8.8), 16.6mM (NH4)2 SO4, 0.45% Triton X-100, 0.2mg/mL gelatine), 200µM of each dNTP, 1.5mM $MgCl_2$, 0.4µM of each primer and 0.5U *Taq* F1 DNA polymerase (Fisher Biotech). Initial gradient trials using a Mastercycler® gradient thermocycler (Eppendorf) were conducted to establish the most appropriate annealing temperature for each primer pair, resulting in an optimised annealing temperature of 55°C for all primers except Q4.4.2 (59°C). PCR was performed using an initial denaturation at 95°C for 3 min, followed by 40 cycles of 94°C for 30s, annealing at either 55°C or 59°C for 30s, extension at 72 °C for 45s; with a final extension at 72 °C for 10 min. Prior to genotyping, PCR products were run on 1.5% agarose 0.6xTBE check gels at 140V for 40min, and visualised using ethidium bromide and UV light. Amplification products were separated by capillary electrophoresis on an AB 3500 Genetic Analyser (Applied Biosystems) with fragment sizes determined relative to an internal lane standard (GS-600 LIZ; Applied Biosystems) using GENEMARKER V1.95 software (SoftGenetics) and double-checked manually to ensure accuracy.

Data Analysis

Allelic frequencies were calculated for each population using GenAlEx v6.4 (Peakall & Smouse 2006) to derive standard genetic diversity and inbreeding measures including the mean number of alleles per locus (A), the number of private alleles (A_P) unique to a particular population, observed heterozygosity (H_O), expected heterozygosity (H_E), and the allelic fixation index (F) as a measure of inbreeding (Wright 1965). Polymorphism information content (PIC) was computed in CERVUS v3.0 (Kalinowski *et al*. 2007). To account for differences in sampling intensity, FSTAT Version 2.9.3 (Goudet 2001) was used to calibrate allelic richness (A_R) among populations.

Nei's standard genetic distance measures (Nei 1972; 1978) were calculated to examine patterns of genetic differentiation among individuals and populations and used to perform frequency based population assignment tests to designate a percentage 'self' or 'other' assignment by assigning samples to sites with the highest likelihood of genetic similarity using GenAlEx v6.4 (Peakall & Smouse 2006). A pairwise squared genetic distance matrix was generated in GenAlEx v6.4 (Peakall & Smouse 2006) prior to carrying out an hierarchical cluster analysis (UPGMA - unweighted pair group method with arithmetic averaging) using 1000 permutations in PRIMER 5 software (Clarke & Gorley 2001). The matrix was then used to conduct a principal coordinates analysis (PCoA) to look for genetic relationships between individuals, both within and among populations, while the hierarchical partitioning of genetic variation among sampled populations (*PhiPT* - the correlation between individuals within a population relative to all individuals within a species) was tested for statistical significance using an analysis of molecular variance (AMOVA; Excoffier *et al.* 1992). Measures of gene flow (*Nm*) based on *PhiPT* values were used to construct a pairwise population *PhiPT* matrix with associated estimates of N_m using GenAlEx v6.4 (Peakall & Smouse 2006). Tests for correlations between pairwise geographic and genetic distance matrices (Mantel 1976) were performed in PRIMER v6.1.5 (Clarke & Gorley 2001) using 1000 permutations.

To determine the likelihood of recent bottlenecks, Wilcoxon's sign rank tests and sign tests for mutation-drift equilibrium were applied to the allelic frequency data using BOTTLENECK v1.2.02 (Piry *et al.* 1999). These tests were conducted under the assumptions of the infinite alleles model (IAM), the stepwise mutation model (SMM), and the intermediate two-phased model (TPM), with results reported for the latter, due to its suitability for microsatellite data.

Table 2: Characteristics of the 11 microsatellite loci used to quantify genetic diversity in *Dasyurus hallucatus* populations in the vicinity of Mt. Emerald. *PIC*, polymorphic information content; N_A, number of alleles per locus; H_O, observed and H_E, expected heterozygosities; primers *pDG1A1*, *pDG1H3*, *pDG5G4*, and *pDG6D5* from Spencer *et al.* (2007); *3.1.2*, *3.3.1*, *3.3.2*, *4.4.2*, and *4.4.10* from Firestone (1999); Sh3o and Sh6e from Jones *et al*. (2003).

Locus GenBank	Repeat motif	Primer sequences (5'-3')	Size range (bp)	*PIC*	N_A	H_O	H_E
pDG1A1	$(AC)_{20}$	F: **NED**-ATTTGCTTCTTGCTCCCTACAGC	208-220	0.465	7	0.432	0.488
EF077168		R: TTTCACTCCTTCTGAGTTTATCACC					
pDG1H3	$(TG)_{17}$	F: **VIC**-GTGGATTGACACAATCAGAGTGG	184-200	0.801	9	0.827	0.828
EF077169		R: GCAATTCCATCTTTATTGCATGC					
pDg5G4	$(AC)_{24}$	F: **PET**-TAGATTCCTTCAATGGCTATCCC	109-111	0.348	2	0.481	0.451
EF077170		R: GCTCCTGACATAGAGTGATGATGG					
pDG6D5	$(AC)_{22}$	F: **NED**-CCTCCAGACAAATGCAACC	133-151	0.576	7	0.630	0.640
EF077171		R: TCTCTGAATTTACTGATAGTATCTTTGG					
3.1.2	$(CA)_{18}$	F: **FAM**-AGGAAACTTCACAAGTGTCGA	177-189	0.760	7	0.741	0.794
AF124212		R: ATTAATGACTCATCTGTTGTTGG					
3.3.1	$(CA)_{20}$	F: **NED**-CAGCCCTTGAGTCTTGAGATT	128-157	0.822	10	0.864	0.846
AF124213		R: CATACCACCCCAGGAGTTTC					
3.3.2	$(CA)_{21}$	F: **FAM**-GCATATTGGAGATTAAAACAGAGC	152-184	0.721	11	0.580	0.762
AF124214		R: CTCCGCGCACTCAGATCTAT					
4.4.2	$(CA)_{19}$	F: **VIC**-GAAATCCAAGCTCATTTTAG	117-133	0.751	8	0.580	0.786
AF124215		R: AATCAACTCTGGAATGCATC					
4.4.10	$(CA)_{29}$	F: **FAM**-AATGCTAGATTTCACTCCC	216-220	0.111	3	0.123	0.117
AF124216		R: CCTCACATTTCTGGAACTG					
Sh3o	$(CA)_{22}$	F: **PET**-CTCAATGCCAAAGGTATCTTT	203-223	0.729	10	0.728	0.767
AJ515733		R: CATAGTTCCAAATCACTCTCCAG					
Sh6e	$(CA)_{18}$	F: **PET**-GATTCTAGAAGGGATAGCAAGC	169-183	0.691	8	0.790	0.731
AJ515737		R: GACACTCCATAGAAATGCACTG					

Results and Discussion

A total of 82 alleles were resolved using 11 microsatellite loci in 81 *D. hallucatus* individuals (Table 2), although not all alleles were present in every population (Table 3). The most intensively sampled population, Mt Emerald (MTE), displayed a comparable level of allelic diversity to individuals from the Upper Walsh (UWL, ~16km to the southwest), particularly after rarefaction to account for differences in sampling effort. However, a higher diversity of alleles many of which were unique, were detected within the much smaller sample size obtained from the Davies/Tinaroo Creeks area (DTB, ~19km to the northeast; Figure 1, Table 3). Estimates of observed and expected heterozygosity (Table 3) in the main study populations (UWL, MTE, DTB) were almost identical and similar to those found in previous studies of *D. hallucatus* populations in Western Australia (How *et al.* 2009) and the Northern Territory (Cardoso *et al.* 2009). Inbreeding was minimal with neglible values showing a slight excess of either homozygotes (+*F*) or heterozygotes (-*F*, Table 3), with populations close to conditions of Hardy-Weinberg equilibrium.

Table 3: Summary of genetic measures for the 81 *D. hallucatus* individuals sampled: *N***,** number of animals sampled per population; N_A, number of alleles per population resolved across 11 loci ; *A*, mean number of alleles per locus; A_P, number of private alleles per population; A_R, mean allelic richness across populations; H_O, observed heterozygosity; H_E , mean expected heterozygosity, and *F*, inbreeding coefficient. Standard deviations are shown in parentheses. Population codes are given in Table 2.

Population	N	N_A	A	A_P	A_R	H_O	H_E	F
MTE	33	57	5.18	1	1.73	0.63	0.61	-0.06
			(0.69)			(0.08)	(0.08)	(0.05)
UWL	23	52	4.73	2	2.26	0.64	0.62	-0.03
			(0.57)			(0.07)	(0.05)	(0.05)
DTB	18	60	5.46	7	3.33	0.61	0.63	0.03
			(0.71)			(0.07)	(0.07)	(0.05)
WIN	2	30	2.72	4	n/a	0.64	0.53	-0.17
			(0.27)			(0.12)	(0.07)	(0.15)
WEI	5	32	2.91	3	n/a	0.46	0.46	-0.05
			(0.37)			(0.09)	(0.08)	(0.09)

While the low sample sizes from the Windsor (~250km) and Weipa (~650km) populations have been included for comparison, the limited number of samples must necessarily preclude these sites from meaningful genetic analysis of the populations under review. Perhaps the main inference which can be drawn from their inclusion can be derived from the considerable number of private alleles (A_P) detected in only seven individuals, suggesting that the geographic partitioning of genetic diversity among *D. hallucatus* populations will be more apparent over a scale of hundreds of kilometres rather than over the distances (~20km) relevant to this study.

A high level of historical gene flow (N_m) between the MTE/UWL and the DTB populations to the northeast was detected (Table 4), as would be anticipated from a species known to travel distances of up to 10km overnight, although it is unknown to what extent connectivity has been affected by the significant fragmentation of valley habitat along the Walkamin corridor since settlement (Figure 2). The resolution of a relatively large number of private alleles in the northeast populations (DTB), not present in the Mt Emerald or Upper Walsh populations suggests that this barrier has had some effect in restricting gene flow already however, to date, this appears insufficient to be totally excluding genetic exchange.

Table 4: Estimated mean number of migrants per generation (N_m) based on *PhiPT* values of population differentiation for the three Atherton Tablelands populations of *D. hallucatus*. N_m values >1 (migrant per generation) are considered necessary to avoid inbreeding and/or genetic drift. Population codes are given in Table 2. **UWL,** Upper Walsh River population; **MTE,** Mt Emerald population; **DTB**, Lamb Range population.

	UWL	MTE	DTB
UWL	0.00		
MTE	7.28	0.00	
DTB	5.96	8.64	0.00

Both the UPGMA (Figure 3) and principle coordinates analysis (Figure 4) demonstrated the high genetic similarity of individuals within these populations and no correlation (r^2=0.045, p>0.05) was found between genetic and geographic distance matrices using Mantels tests.

Figure 2: Aerial view of the now heavily fragmented valley habitat separating the Mt Emerald/Upper Walsh (MTE, UWL) and Davies/Tinaroo Creek (DTB) populations. **Image courtesy of Google Earth.**

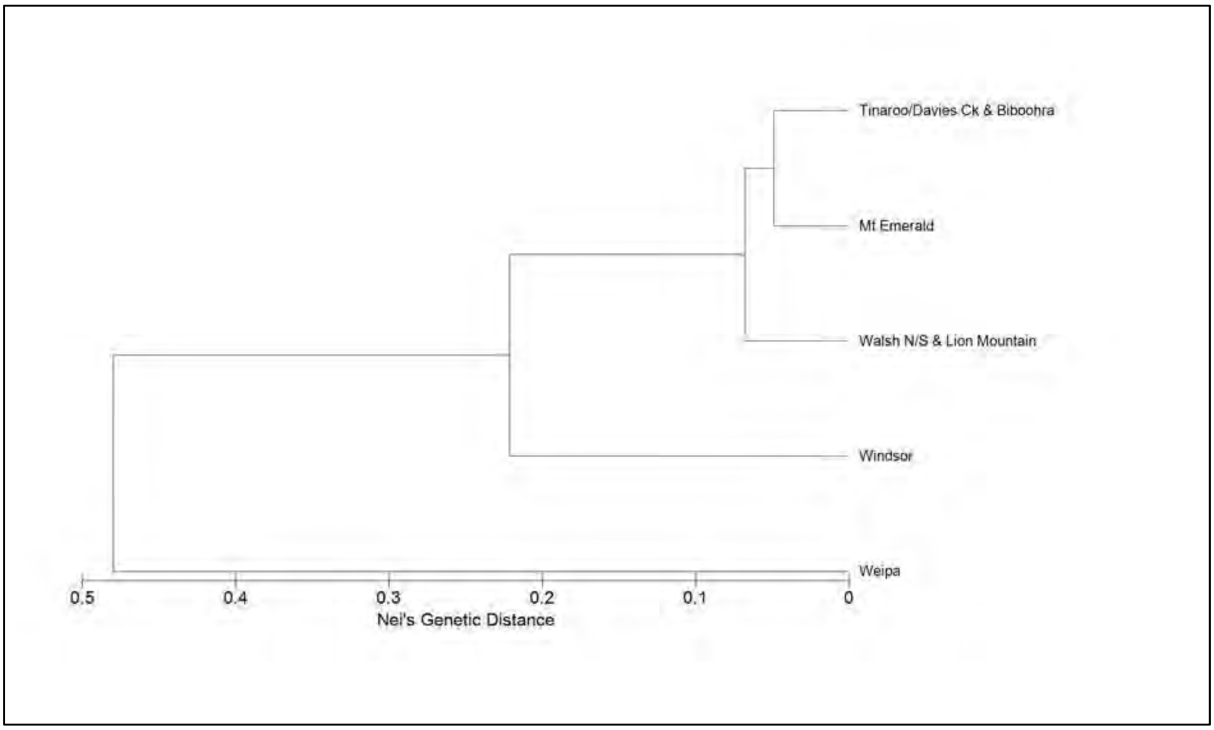


Figure 3: UPGMA cluster analysis of the five populations of *D. hallucatus* sampled, using Nei's standard (1972) genetic distance, showing >90% similarity among the Atherton Tablelands populations.

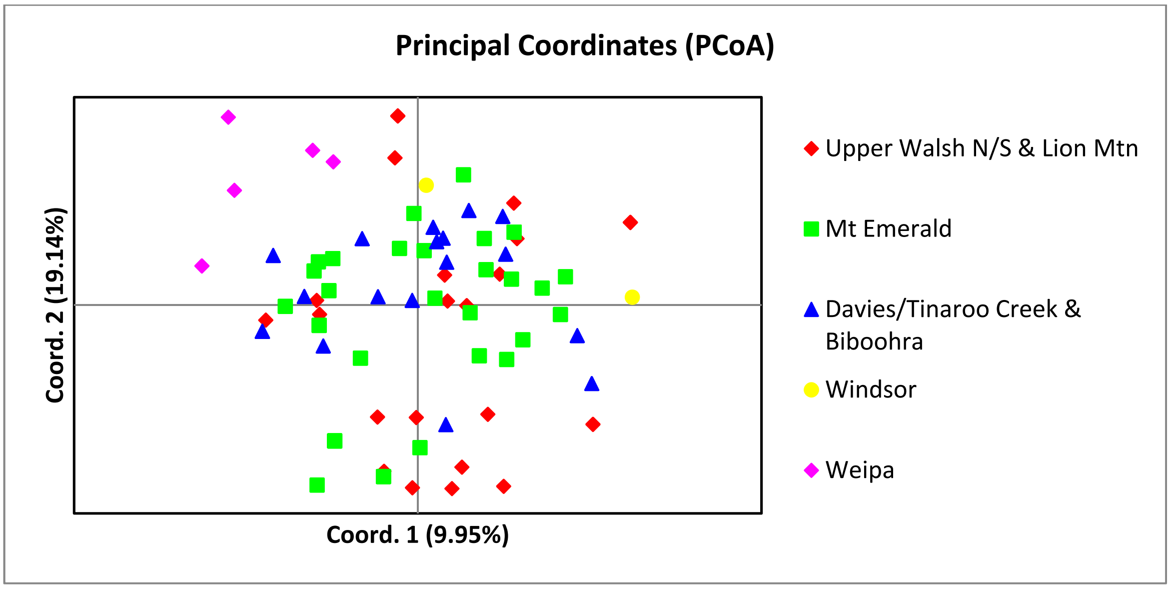


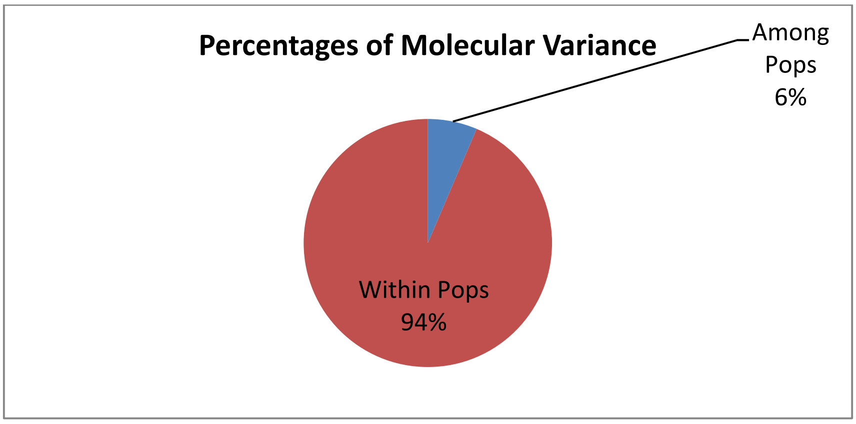
Figure 4: Principal coordinates analysis (PCoA) using genetic distance matrices with data standardisation showing the genetic relationships among *D. hallucatus* populations sampled for this assessment. Individuals from the five populations are indicated by the colours and symbols shown. Combined, the first three axes account for only 26.46% of the variation in the data.

However, assignment analysis using multilocus genotypes were able to be assign the majority of individuals to their correct population of origin, with only 15% of randomly selected samples being assigned to a population other than their own (Table 5).

Table 5: Frequency-based population assignment analysis outcomes for *D. hallucatus* study populations from the Atherton Tablelands region. The percentage of samples per population assigned correctly (Self) or incorrectly (Other) using highest log likelihoods are given. **UWL,** Upper Walsh River population; **MTE,** Mt Emerald population; **DTB**, Lamb Range population.

Population	Self	Other
MTE	95.65	4.35
UWL	81.82	18.18
DTB	77.78	22.22
Total %	85	15

a)



b)

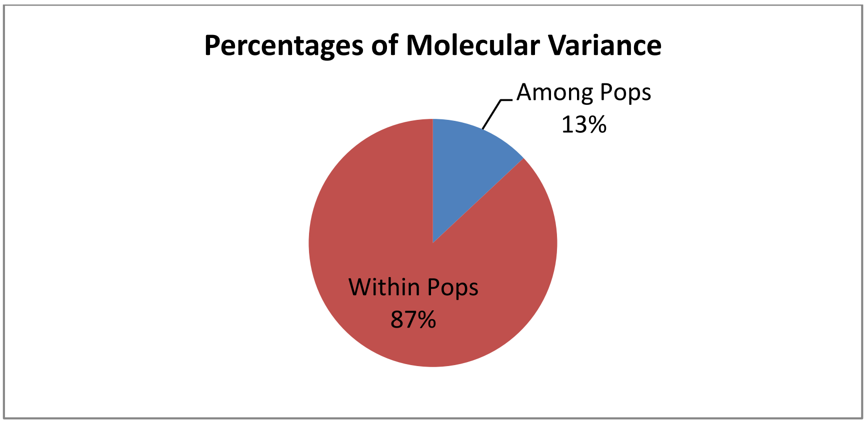


Figure 5: Partitioning of genetic diversity both within and among populations of *D. hallucatus* - a) at the Atherton Tablelands sites (UWL, MTE, DTB) only, and b) including Windsor Tableland and Weipa samples.

The majority of genetic variation was due to variation among individuals within populations, rather than differences among populations (*PhiPT* = 0.06; Figure 5). This is most likely a product of strong historical gene flow, as evidenced by the high number of migrants per generation (N_m; Table 4) and is again supported by the results of the principle coordinates analysis (Figure 4) which does not indicate clearly definable patterns between individuals from populations in the Atherton Tablelands region based on allelic composition.

Population genetic theory predicts that small isolated populations may suffer a loss of genetic diversity over time (Frankham 2002) and previous research has demonstrated genetic erosion to be an issue for isolated populations of *D. hallucatus* in the Northern Territory (Cardoso *et al.* 2009) and Western Australia (How *et al.* 2009). Cardoso *et al.*

(2009) found reduced genetic variation after just three generations in small, translocated populations. The effect was also shown to be more pronounced in island populations isolated from the mainland, although genetic bottlenecks indicating recent reductions in abundance were detected in both island and mainland *D. hallucatus* populations (Cardoso *et al.* 2009). In contrast, no evidence was found in this study to indicate recent bottlenecks in any of the Atherton Tablelands populations. There were no statistically significant (p>0.05) instances of heterozygosity-excess under the two-phase model (TPM) for any of the populations, and thus no mode-shifts that would reflect a disproportionate loss of rare alleles relative to those that occur at intermediate frequency (Luikart & Cornuet 1998; Piry *et al.* 1999). This is most likely due to the strong levels of historical gene flow detected among the three Atherton Tablelands subpopulations. Genetic bottlenecks are therefore unlikely to occur unless these populations become isolated from established avenues of gene flow, or suffer a significant reduction in population size.

Conclusions

Fragmentation has been highlighted as a key threatening process for *D. hallucatus (DSEWPC* 2013*)* and substantial anthropogenic disturbance has already occurred in the region (Cunningham & Moritz 1998; Sumner *et al*. 2004) and adjacent to the study site (Figure 2). It is unknown whether the effects of the proposed wind farm and associated infrastructure will further contribute to complete isolation of either the Mt Emerald population, or of the other populations in the immediate vicinity. However, the results of this study strongly suggest that the Mt Emerald population site spans a narrow corridor of high-value habitat, and is currently serving as an important linkage for the movement of genes between proximate *D. hallucatus* aggregations to the northeast and southwest.

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Appendix 22

Preliminary detection dog survey for Northern Quoll *Dasyurus hallucatus* on Mt Emerald, Mareeba Queensland

Prepared by Saddler Springs Education Centre Pty Ltd

Report
2012



Report prepared by Amanda Hancock
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Preliminary detection dog survey for northern quoll *Dasyurus hallucatus* on Mt Emerald, Mareeba Queensland

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Front page photographs: (Bottom left to right)
'Sparky' and Amanda Hancock search Boulder pile on ridgeline; northern quoll (photo taken by Dr Scott Burnett); Amanda Hancock & 'Sparky'; Ridgeline B site Mt Emerald and Amanda Hancock & 'Kuna' find quoll odour in creekline

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1. SUMMARY

Between 22nd to 25th October 2012, a northern quoll *Dasyurus hallucatus* (Endangered nationally, *Environment Protection and Biodiversity Conservation Act 1999*), preliminary survey using detection dog methodology was completed by Amanda and Lloyd Hancock and detection dogs 'Sparky' and 'Kuna' (Carnarvon Canines) of Saddler Springs Education Centre (SSEC) Pty Ltd (Injune) for RPS Group and University of Sunshine Coast (USC) at the Mt Emerald Turbine study area, Mareeba, Queensland.

Systematic surveys completed previously by RPS Group and USC have located quolls within the Mt Emerald Turbine study area, however some of the ridgeline and creekline areas targeted within the previous studies were inconclusive to determining quoll presence or absence. Therefore, the SSEC detection dog surveys were implemented as a preliminary search for the following outcomes:

(i) a comparative study of positive quoll indication sites between ridgelines and creeklines, with the site selection consisting of one ridgeline and creekline within an area of no quoll records and one ridgeline and associated creekline within an area of known quoll records.

(ii) to identify presence or absence of northern quoll odour in these areas, especially likely den sites, which may assist to streamline the placement of remote cameras and future intensive fauna trapping programs within the Mt Emerald study area.

The quoll detection dog is trained to locate the target odour of northern quoll scat (faeces) and live odour. The methodology with the detection dog consisted of searches by dog and handler/ecologist along the stratified critical quoll habitat areas of the selected creek lines and ridgelines at the Mt Emerald turbine study area (*Appendix A*), with the defined areas divided into search transects (sites) where required for larger areas.

Target searches within each transect were, potential den/refuge sites such as hollow logs, trees with hollows, termite mounds, rock boulders with crevices and caves. Visual observations by both handler/ecologists for quoll scats were completed.

During all searches at the Mt Emerald turbine study area, SSEC 'Carnarvon Canines' quoll detection dogs showed 'positive indications for quoll target odour at 47 different locations'. At some of these locations scats were identified and collected for further analysis.

On the basis of the detection dog results and visual ecological assessment during the survey, it is evident that the Mt Emerald study area contains critical quoll habitat, evidence of quoll presence by odour detection dog results, and evidence of likely dens and active den use, especially in the ridgeline sites surveyed with good quoll den habitat and the strongest dog indications (Appendix A).

2. PROJECT BRIEF AND CONTEXT

Between 22nd to 25th October 2012, a northern quoll *Dasyurus hallucatus* (Endangered nationally, *Environment Protection and Biodiversity Conservation Act 1999*), preliminary survey using detection dog methodology was completed by Amanda and Lloyd Hancock and detection dogs 'Sparky' and 'Kuna' (Carnarvon Canines) of Saddler Springs Education Centre (SSEC) Pty Ltd (Injune) for RPS Group and University of Sunshine Coast (USC) at the Mt Emerald Turbine study area, Mareeba, Queensland.

Saddler Springs Education Centre Pty Ltd was contracted to implement the use of quoll odour detection dogs as a new fauna survey methodology to assist to determine presence or absence of northern quoll within the environs of the Mt Emerald study area.

This survey forms only one part of a broader environmental impact assessment by RPS Group and USC for a proposed wind turbine development project on Mt Emerald. The detection dog methodology implemented by SSEC is considered a preliminary survey of an area for presence/absence of the target species (northern quoll), which allows ecologists to then concentrate further fauna survey effort such as, camera and cage traps to sites of positive target odour indication, within the study area.

The results of this survey will provide the basis for development of more targeted surveys, where presence is identified. Where survey results show an absence of quolls, this may be considered inconclusive due to limitations of time and extent of survey within the Mt Emerald study area.

The northern quoll, *Dasyurus hallucatus*, is the smallest of this family of Australian native carnivorous marsupial and are listed nationally as *Endangered* under the *Environment Protection and Biodiversity Conservation Act 1999*. Northern quolls are solitary with home ranges of up to 1000ha. Female home ranges are generally much smaller than this, though still several hundred hectares in size.

Habitat critical to the survival of the northern quoll as defined by the EPBC Act policy statement 3.25, relevant to the Mt Emerald study area includes:

- Rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creek lines.
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds and/or hollow logs and/or with rocky areas nearby.

The northern quoll species distribution has declined nationally with a number of threats, either directly or in combination with each other, thought to contribute to the species decline. These threats include mortality caused by poisoning by cane toads, predation by feral predators, inappropriate fire regimes and removal, degradation and fragmentation of critical habitat to the survival of the species as well as foraging/dispersal habitat, as a result of development, mining and pastoralism.

However, ecological studies to date on Mt Emerald, indicate this may be a strong northern quoll population, with further research continuing into 2013 to determine population dynamics and extent of home ranges and foraging areas.

3. METHODOLOGY

The fauna survey techniques implemented are in accordance with Queensland Government Animal Ethics requirements and the code of practice for the use of animals, as well as QPWS scientific purposes permit requirements and the Regulation of Animal Care during Wildlife Surveys.

The quoll detection dog survey was completed following the recommended guidelines of the '*Environment Protection and Biodiversity Conservation Act 1999 (EPBC) Survey guidelines for Australia's threatened mammals'*. That is:

(i) Characterise the study area

Habitat features of significance to the northern quoll within the Mt Emerald Turbine study area, were identified by GIS mapping provided by RPS & University of the Sunshine Coast, as well as from on-site visual inspection.

Habitat critical to the survival of the northern quoll relevant to the Mt Emerald study area, as defined by the Department of Environment and Heritage (*EPBC Act policy statement 3.25*):

- Rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields
- Major drainage lines or treed creek lines and/or with rocky areas nearby
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds and/or hollow logs

Therefore, the search areas were defined as the treed and rocky creek lines with rocky areas nearby, hills with boulders, large boulder outcrops and large rocky ridgelines (Appendix A).

(ii) Identify those threatened mammals that are known to, likely or may occur in the region

The focus of this survey was on the northern quoll *Dasyurus hallucatus* which is listed as *Vulnerable* in Queensland (*Nature Conservation Act 1992*) and is *Endangered* nationally (*Environment Protection and Biodiversity Conservation (EPBC)Act 1999*).

- The EPBC Protected matters search tool identifies that northern quolls are known/likely to occur on Mt Emerald.
- Previous ecological research completed by RPS and University of the Sunshine Coast have confirmed records of Northern quoll within the Mt Emerald study area

Figure 1. Edited map of the modelled distribution of Northern quoll *Dasyurus hallucatus* for Queensland as @ February 2009 www.environment.gov.au.

(iii) Determine optimal location of surveys

Habitat stratification was completed at the study area with the following defined search areas:

- A comparative study was requested to review quoll detection results between ridgelines and creeklines. Due to inconclusive quoll records in some sites previously surveyed, it was agreed to define the the search areas as Ridgeline A & Creekline A (sites with known quoll records), and Ridgeline B and Creekline B (sites with no quoll records to date).
- Due to the extent and quoll den habitat to survey on Ridgeline B, the search area was was stratified (divided) into 4 different transect search sites (Appendix A) with focus on sections with good quoll den habitat defined previously.

All landscape assessment data relevant to the transect search site area was recorded on the Carnarvon Canines – Quoll Detection Dog Proforma (*Appendix D*)

Figure 2. Examples of areas defined by critical quoll habitat features and positive dog indications within the 6 sites (transect search areas) surveyed.

Site 1 – Ridgeline A (wpt102)

Site 2 – Creekline A (wpt 113)

Site 3 – Ridgeline B (wpt 117)

Site 4 – Ridgeline B (wpt 125)

Figure 2. Continued. Examples of areas defined by critical quoll habitat features and positive dog indications within the 6 sites (transect search areas) surveyed.

Site 5 – Ridgeline B (wpt 136)

Site 6 – Creekline B (wpt 156)

(iv) Target searches

During all detection dog searches, any potential quoll den/refuge sites such as rocky boulders with crevices, caves, hollow logs, termite mounds, trees with hollows, or large burrows in creek banks were targeted (*Figure 3*). Visual observations for quoll scats or tracks were completed by the detection dog handler/ecologist.

iv.1. Scat voucher specimens

Where evidence of quolls, such as scats were detected during target searches, these were collected as voucher specimens and coded and recorded on the *Carnarvon Canines – Quoll Detection Dog Proforma* (Attachment A). These records matched the duplicate coding on the voucher specimen bag.

Figure 3. Examples of target searches with quoll detection dog of boulder piles (left) on ridgeline and rocky areas (right) along creek lines

(v) Direct detections survey methods

v.1. Odour detection dogs

Although the use of odour detection dogs is currently outside the scope of the EPBC survey guidelines for Australia's threatened mammals, SSEC is working towards a review of these guidelines - results of further tentatively proposed comparative field studies with GPS collared quolls in research in 2013 conducted by Dr Scott Burnett (Quoll expert) will be critical to this end.

Methods used for the Mt Emerald study area involved daytime searches with an odour detection dog which is trained to locate both northern quoll scat (faeces) and live odour. Daytime searches eliminated potential disturbance to live quolls, as the quolls are nocturnal and most likely within dens during daytime searches. On a rare occasion that a quoll is outside a den and detected by the dog, SSEC dogs are under the management of the handler at all times and are trained not to disturb any wildlife. Their focus is on the reward (tennis ball) once the target odour is located.

SSEC have completed full Animal Ethics approval for 'the use of odour detection dogs to locate target fauna'. SSEC have Qld Government scientific permits for non-protected areas Queensland and specified protected areas, as well a letter of approval for dogs on park for research purposes.

Positive indication by our detection dogs is a sit and bark response on the target odour with reward of a tennis ball play. Through previous field studies and during this survey, it is evident that the detection dogs natural prey behaviour and trained indication response becomes more highly animated when a den site is active with live quoll odour. Future studies with GPS collared quolls will confirm detection dog response and accuracy to active den location.

All positive dog indications were GPS recorded and visual observations completed by field staff for evidence of scat, track, den, fur or live quoll. Photo records and voucher specimens of quoll evidence were completed. All detection dog search data, quoll evidence, photo numbers, voucher specimens and GPS locations were recorded on the *Carnarvon Canines – Quoll Detection Dog Proforma* (*Appendix D*).

Location details of positive dog indications were in Google Earth file to RPS Group and University of the Sunshine Coast to be used to review further targeted quoll survey effort to these locations.

v.2. Remote camera trapping

Camera trapping for the Mt Emerald study area is being completed by University of the Sunshine Coast, with methodologies and approvals by Dr Scott Burnett. SSEC were not involved with camera trapping at this time. Key hotspots for quoll indication by the dogs were provided which may assist future camera trapping locations.

4. LIMITATIONS

(i) Optimal timing for surveys of 'target' taxa

A limitation to this survey was the timing of the searches being potentially affected by seasonal changes in abundance and detectability of the quoll. The Mt Emerald survey due to project requirements was delayed and completed in Mid-October, which is outside the time recommended by Dr Scott Burnett (Quoll Expert) for quoll activity during their breeding season May – July.

An important note on detectability regarding the use of odour detection dogs which may assist addressing this survey limitation is that SSEC's detection dogs have been tested in both simulated training and in-situ field survey results, with the dogs recorded finding quoll scats from the previous breeding season (previous year). Therefore confirming the timing may not be a limitation to the presence and absence of quoll odour.

However, the timing may determine if quolls are still in the den sites identified by the dogs or have retreated or died after the breeding season. The timing therefore is a potential limitation to the camera trapping, especially if the population is in low numbers across an extensive area. Future GPS collar research will assist confirmation of accuracy of detection dog indications to active quoll dens.

(ii) Further Limitations

<u>Survey Time</u> – SSEC were contracted for five days only, and handlers have to work within the ability of the dog and conditions during surveys. Daytime temperatures also affected the timing and extent of searches.

Detection Dogs can become fatigued quickly (nasal fatigue) due to the concentrated effort of scenting over long periods as well as physical fatigue over large areas. Surveys during the cooler months of the quoll breeding season, May – July would assist daytime searches.

And more time to active search for quoll scats and further time to explore the large rocky ridgelines more extensively with the dogs may have been beneficial for the survey.

5. FINDINGS

(i) <u>Primary Findings</u>

The detection dog survey consisted of 6 sites (Transects) (*Figure 2* & *Appendix A*) that met the key quoll habitat criteria. The results were 47 positive quoll odour indications by the dogs, with the highest concentration of positive indications, good quoll den habitat and likely active dens being at Ridgeline B.

The comparison of ridgeline transects surveyed versus creek lines, identified the ridgelines had the higher quoll detection results and a higher number of likely quoll den habitat. With the sections of creek line surveyed still providing results of positive dog indications for quoll odour, however, they had minimal quoll den/refuge habitat features, within the extent surveyed and dog behaviour and indications did not suggest active quoll dens.

Six voucher specimens of scat were collected at some of the sites of positive indication visually identified as Northern quoll scat, however they will be sent for further ID analysis by Dr Scott Burnett, University of the Sunshine Coast.

The dogs and ecologists did locate a range of non-target animal evidence including dog scats, scent trails of dog, macropods, bird kill carcass. However, the detection dog gave no false indication response for quoll.

During all searches at the Mt Emerald study area, SSEC 'Carnarvon Canines' quoll detection dogs showed 'positive indications for quoll target odour at 47 different locations'.
A table of the Primary findings - positive dog indications is presented in Appendix A. At some of these locations scats were identified as quoll scat and collected.

On the basis of the detection dog results and visual ecological assessment on the survey, it is evident that the search areas defined in this report, within the Mt Emerald Turbine study area have the following:

- northern quoll habitat critical to the survival of the species, as defined by the EPBC guidelines.
- evidence of quoll odour presence, from the preliminary detection dog survey results.
- Very likely active quoll den sites, from the detection dog strong indications and behaviours
- evidence of quoll scats

The voucher specimens will be sent to Dr Scott Burnett, University of the Sunshine Coast for further analysis.

(ii) Secondary Observations

During this preliminary survey day, other ecological observations of note and details of scat voucher specimens were recorded and are presented in Appendix B.

Figure 4. Examples of incidental observations recorded

Site 5: 8 x Sarrus Cranes flying over

Site 6: Carlia jarnoldae

Site 6: unidentified beetles

Site 6: Nobbi Dragon

6. RECOMMENDATIONS

Based on evidence from this preliminary survey, the key recommendations to be reviewed by Dr Scott Burnett (USC) and Jeff Middleton (RPS Group), which may assist the Mt Emerald Turbine study area, regarding impacts to the northern quoll and habitat critical to the survival of the species are the following:

A. To implement some of the camera trapping program to the locations of high quoll odour indications by the detection dogs during the October survey.

B. Address the implementation of further surveys of the Mt Emerald stud area with more than one survey methodology, as per EPBC guidelines, including the use of odour detection dogs, early in the quoll breeding season (May) 2013.

C. To have a trapping program compliment closely the detection dog positive indication sites early in the breeding season (May) 2013.

D. Further benefit to active quoll den location, would be testing the dog indication response to dens with GPS collared quolls (tentatively proposed research for 2013). This will provide behavioural response and accuracy confirmation of the detection dogs to active quoll dens, which will be beneficial to future quoll research, and may also indicate active dens of potential uncollared quolls at the Mt Emerald study area.

7. ACKNOWLEDGEMENTS

Thanks to Dr Scott Burnett, University of the Sunshine Coast and Jeff Middleton, RPS Group for actioning the use of odour detection dogs within the quoll survey, as well as their local knowledge and advice during the field work.

And we are very grateful to our Carnarvon Canines 'Sparky' and 'Kuna' for their enthusiasm and hard work and for teaching us all more about quolls.

8. REFERENCES

Australian Government, 2011. '*Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered northern quoll, Dasyurus hallucatus*', EPBC Act policy statement 3.25.

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9. **APPENDIX A - Primary findings: Quoll detection dog results - positive indication at each Site (Transect search area).**

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
Ridgeline A Site 1 Start: 17° 9'39.20"S 145°23'29.30"E End: 17° 9'17.60"S 145°23'21.40"E											
1	23/10	095	Scattered boulders, rocky outcrop on hill of dense grass and grass trees.	17° 9'36.40"S 145°23'29.70"E	Strong	Sparky	Rocks, boulders, crevices. Good refuge. Positive dog behaviour to odour all over rocks.	Dog indication & quoll den habitat			2865-2866
2	23/10	096	Medium rock outcrop.	17° 9'34.10"S 145°23'30.05"E	Strong	Sparky	Boulders, crevices. Strong dog indication to crevices.	No scats found. Dog indication & quoll den habitat only			2867-2868
3	23/10	097	Medium rock outcrop.	17° 9'34.80"S 145°23'30.20"E	Strong	Sparky	Boulders, crevices. Very strong dog indication. Dog showed indication at site of scats, then zig zagged to a crevice and very strong indication into crevice.	Scats collected. Dog indication & quoll den habitat only.		CC001	2870-2869
4	23/10	099	Large rocky outcrop with small boulder patches/crevices.	17° 9'31.80"S 145°23'29.40"E	Strong	Sparky	There appears saturated with quoll odour. boulders, crevices. Strong dog indication.	Dog indication & quoll den habitat only			2871
5	23/10	100	Medium boulder pile.	17° 9'31.20"S 145°23'31.30"E	Strong	Sparky	Boulders, crevices. Numerous potential dens. Very strong dog indication of live odour.	Dog indication & quoll den habitat only.			2872-2873
6	23/07	002	Medium rock outcrop with good	17° 9'30.90"S 145°23'29.20"E	Strong	Sparky	Rocks, boulders, crevices. Strong dog indication. Good	Dog indication & quoll den habitat			2874-2875

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
			size crevices.				potential dens.	only.			
7	23/10	102	Large rock outcrop with boulders, crevices, tunnels.	17° 9'29.30"S 145°23'29.20"E	Strong	Sparky	Boulders, crevices, tunnels. Numerous potential dens. Strong dog indication.	Scats collected near rock tunnel. Dog indication & quoll den habitat		CC002	2876-2878
8	23/10	103	Large rock outcrop with small overhang.	17° 9'28.70"S 145°23'27.70"E	Strong	Sparky	Large rock outcrop with crevices. Good dog indication at overhang.	Scats collected under overhang. Dog indication & quoll den habitat		CC003	2879
9	23/10	104	Rocky boulders - highest point on ridge towards Nth face.	17° 9'25.80"S 145°23'28.20"E	Strong	Sparky	Med to Lge boulders. numerous potential crevices as dens. Very strong dog indication.	Dog indication & quoll den habitat			2880-2882
10	23/10	105	Same area as wpt 104 - top of Boulder pile outcrop.	17° 9'25.60"S 145°23'28.70"E	Strong	Sparky	Boulders, crevices. Numerous potential dens. Strong dog indication.	Scats collected from on top of large flat boulder to Nthn edge of boulder pile. Dog indication & quoll den habitat		CC004	2883
11	23/10	106	Boulder piles - edge of drop off (Bluff?)	17° 9'24.00"S 145°23'31.50"E	Strong	Sparky	Boulders, crevices. Numerous potential dens. Strong dog indication.	Dog indication & quoll den habitat			2884
12	23/10	107	Large flat rock outcrop with small	17° 9'22.50"S	Strong	Sparky	Boulders, some crevices -	Dog indication&			2885-

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
			boulders.	145°23'29.70"E			potential overnight den cover.	quoll den habitat			2886
13	23/10	108	Rocky boulders on grassy hill.	17° 9'22.10"S 145°23'28.60"E	Strong	Sparky	Small boulder pile, crevices. Strong dog indication in crevices.	Dog indication & quoll den habitat			2887
14	23/10	109	Large flat rock outcrop with crevices on edge.	17° 9'20.30"S 145°23'26.50"E	Strong	Sparky	Crevices between rock faces. (crevices the only shelter on flat boulder outcrops)	Dog indication & quoll den habitat			2888-2889
Creek line A Site 2 Start: 17° 9'18.20"S 145°23'19.50"E End: 17° 9'38.90"S 145°23'27.40"E											
15	23/10	112	2 x Rock Boulders edge of creek line. (where rocks above have more relief changes)	17° 9'22.30"S 145°23'20.80"E	Strong	Sparky	Boulders with tunnels underneath in creek bank. Good potential dens. Strong dog indication.	Dog indication & quoll den habitat			2890-2891
16	23/10	113	Rock boulders in creek bank.	17° 9'23.30"S 145°23'21.60"E	Strong	Sparky	Boulders with burrows underneath in creek bank. Numerous potential dens - 4 entrances. Scat on boulder above burrows. Strong dog indication.	Dog indication & quoll den habitat		CC005	2892-2896
17	23/10	114	Small boulder pile on creek bank	17° 9'25.70"S 145°23'24.30"E	Strong	Sparky	Boulders -minimal good crevices, but enough potential refuge during travel. No other boulders or ideal refuge between wpt 114 & end of transect search wpt 115.	Dog indication & quoll den habitat			2897

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
Ridgeline B Site 3 Start: 17°10'31.10"S 145°22'5.30"E End: 17°10'30.90"S 145°22'5.40"E											
18	23/10	117	Rocky boulder pile 80m from road and 100m from camera trap.	17°10'33.80"S 145°22'2.40"E	Strong	Kuna	Highly likely - numerous crevices as dens Very strong dog indications. **key site for trapping program	Dog indication & quoll den habitat Strong dog indications of live quoll.	Sparky was tested on this site as well with 100% accuracy to Kuna's indication location. Both dogs tested twice.		2898-2903
19	23/10	118	Large rock outcrop (single rock) with rock tunnel at base.	17°10'34.40"S 145°22'4.30"E	Strong	Kuna	Rock outcrop with rock tunnel for refuge/den. Strong dog indication directly at rock tunnel.	Dog indication & quoll den habitat			2904-2905
20	23/10	119	Fallen tree stump/rocks/dirt with tunnels.	17°10'36.50"S 145°22'1.50"E	Strong	Kuna	Rock boulders nearby, tunnels at base of stump. Likely den. Strong dog indication.	Dog indication & quoll den habitat			2906-2907
21	23/10	120	Large flat rock outcrop.	17°10'38.50"S 145°22'2.10"E	Moderate	Kuna	No obvious likely crevices/dens. Quoll odour was saturated over rock from dog's indications.		Not flagged or photographed.		
22	23/10	121	Rocks and boulders all over dense grassy hill with grass trees.	17°10'39.30"S 145°22'4.20"E	Strong	Kuna	Rocks, boulders, numerous crevices - highly likely dens. Very strong dog indication	Dog indication & quoll den habitat			2908

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
							**Key site for trapping program				
Ridgeline B Site 4 Start & End: 17°10'36.00"S 145°22'13.20"E											
23	24/10	124	Start of Boulders. One small rock outcrop with crevices, grass trees and dense grass.	17°10'43.20"S 145°22'9.10"E	Strong	Kuna	Boulders, good crevices for dens. Highly likely active den by very strong dog indication. **Key site for trapping program	Dog indication & quoll den habitat			2917-2920
24	24/10	125	Large rock outcrop with scattered boulders/rocks, hollow logs.	17°10'46.70"S 145°22'11.70"E	Strong	Kuna	Boulders, crevices, hollow logs. Highly likely dens. Very strong dog indication.	Dog indication & quoll den habitat			2921-2924
25	24/10	126	Rock piles on large rock outcrop.	17°10'48.30"S 145°22'11.60"E			Boulders, crevices. Numerous potential dens. Strong odour all over.	Dog indication & quoll den habitat			2925
26	24/10	127	Rock outcrop with large boulder pile/crevices.	17°10'48.70"S 145°22'10.90"E	Strong	Kuna	Boulders, numerous crevices. Highly likely dens. Very strong dog indication.	Dog indication & quoll den habitat	(Same area as wpt 126 but different boulders and indication site).		2925
27	24/10	128	Rock boulder piles continuing along outcrop.	17°10'50.30"S 145°22'11.90"E	Moderate	Kuna	Boulders, crevices	Dog indication & quoll den habitat			2926
28	24/10	129	Large rock outcrop with boulders and	17°10'51.40"S	Strong	Kuna	Boulders, crevices.	Dog indication &	2 x independent positive		2927

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
			crevices.	145°22'16.60"E				quoll den habitat	indications at the same site.		
29	24/10	130	Rock piles and boulders on dense grassy hill with grass trees.	17°10'52.00"S 145°22'19.90"E	Strong	Kuna	good crevices - highly likely dens. Strong dog indications. **Key site for trapping program	Dog indication & quoll den habitat	Sparky tested as well with 100% accuracy to Kuna's crevice indication.		2929-2936
Ridgeline B Site 5 Start: 17°10'46.60"S 145°22'27.70"E End: 17°11'12.80"S 145°22'39.10"E											
30	25/10	134	Boulder pile & large rock outcrop 200m from Camera trap on Road edge.	17°10'50.10"S 145°22'27.10"E	Strong	Sparky	Boulders, crevices - highly likely den & strong dog indication	Dog indication & quoll den habitat			2939
31	25/10	135	Boulder pile 20m behind wpt 134.	17°10'51.10"S 145°22'27.40"E	Moderate	Sparky	Boulders, crevices - good day dens	Dog indication & quoll den habitat			2940
32	25/10	136	Large rocky outcrop with boulders, broken rock and large and small crevices.	17°10'53.90"S 145°22'27.00"E	Strong	Sparky	Boulders, rocks, numerous crevices - Very strong dog indication of live odour. Highly likely active dens. **Key site for trapping program	Scats collected from rock near crevice. Dog indication & quoll den habitat	Prioritize camera trapping – dogs behaviour indicated active den	CC006	2941 - 2943
33	25/10	138	Large to med boulder pile at spur.	17°10'59.00"S 145°22'24.60"E	Strong	Sparky	Boulders/crevices - highly likely dens.	Dog indication & quoll den habitat			2944-2946

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
34	25/10	139	Large flat rock outcrop with rocks and boulder piles on spur of ridge	17°11'3.80"S 145°22'25.40"E	Strong	Sparky	Boulders, crevices, hollow logs - good hollow logs and crevices as dens. Strong dog indication	Dog indication & quoll den habitat			2947
35	25/10	140	Boulder pile Nth East facing spur	17°11'2.90"S 145°22'26.90"E	Strong	Sparky	Boulders, crevices - Highly likely dens. Very strong dog indication **Key site for trapping program	Dog indication & quoll den habitat			2948
36	25/10	141	2nd Boulder pile Nth East spur.	17°11'3.70"S 145°22'27.30"E	Strong	Sparky	Boulders, crevices - Highly likely dens, very strong dog indication Edge of spur has boulder piles all along & down face of slope - all good den areas - good shelter on ridge edge **Key site for trapping program	Dog indication & quoll den habitat	High dog interest across area & down ridge slope at wpt 140 & 141 Small water pools regularly on large flat rock outcrops on top of ridge.		2949-2955
37	25/10	143	Boulder pile top of ridge	17°11'4.90"S 145°22'26.50"E	Strong	Sparky	Boulders, crevices, termite mounds - Likely dens - shelter on ridge top. Strong dog indication	Dog indication & quoll den habitat			2956-2957
38	25/10	144	Same boulder piles area as 143 - just behind with deep crevices under boulders - ideal	17°11'5.20"S 145°22'26.40"E	Strong	Sparky	Boulders, deep crevices - Highly likely dens. Very Strong dog indication	Dog indication & quoll den habitat			2956-2957

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
			dens.								
39	25/10	145	Large boulder pile with numerous crevices - Eastern end of spur adjacent to powerline & near small tower.	17°11'10.70"S 145°22'30.60"E	Strong	Sparky	Boulders, crevices, termite mounds nearby. Highly likely dens - deep crevices. Very strong dog indication over area. **Key site for trapping program (Directly behind boulder pile is Large flat/rounded rock outcrop with rock dips in middle that form large pools of water & several small pools of water over the outcrop. (large pool has extensive moss). (Below large outcrop is hairy oak, paperbark, grass tress and several termite mounds).	Dog indication & quoll den habitat	Highest Prioritize site for camera trapping – dog behaviour indicated active den& strong odour all over area		2958-2964
Creek line B Site 6 Start: 17°10'29.80"S 145°23'9.70"E End: 17°10'32.00"S 145°23'8.10"E											
40	25/10	150	Large rocks - start of creekline	17°10'28.30"S 145°23'7.80"E	Moderate	Kuna	No obvious crevices - but small rock overhang as potential quick shelter.	Dog quoll odour indication. Minimal good dens.			2972
41	25/10	151	Large rock in creekbank.	17°10'28.10"S 145°23'6.80"E	Moderate	Kuna	Not likely den, no crevices - definitely quoll odour over site by dog indication	Dog quoll odour indication.			2973

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
42	25/10	152	Large rock outcrop with rock tunnel and small rockpiles/crevices.	17°10'26.60"S 145°23'4.00"E	Strong	Kuna	Rock tunnel, crevices. Limited as dens but rock tunnel could provide quick refuge. (Where there is very limited dens along creekline). Large flat rock outcrop collects small pools of water.	Dog indication.			2974-2975
43	25/10	154	Log piles.	17°10'24.20"S 145°23'2.40"E	Strong	Kuna	Log piles with burrow. Good potential refuge under length of log.	Dog indication.	(no other likely refuge to shelter in between wpt 152 & 154)		2978
44	25/10	155	Boulder piles above creek bank.	17°10'23.30"S 145°22'60.00"E	Strong	Kuna	Potential dens/refuge along a poor refuge section of creek. Boulders, crevices, burrow under boulder & shelter under fallen tree. Very strong dog indication.	Dog indication & quoll den habitat			2979
45	25/10	156	Large tree in creek with hollow with dead tree with hollow and burrow under tree roots & log piles.	17°10'19.70"S 145°22'57.20"E	Strong	Kuna	Tree hollows, burrows, log piles. Highly likely dens. Dog sat and strongly indicated at entrance to burrow under tree roots.	Dog indication & quoll den habitat			2983-2988
46	25/10	157	Boulder pile against creekbank near large bare rock with small water pools.	17°10'19.80"S 145°22'55.60"E	Strong	Kuna	Boulders, crevices - good potential dens. Strong dog indication.	Dog indication & quoll den habitat			2991

No	Date 2012	Wpt No	Location Description	GPS Location Latitude Longitude	Dog indication Response for Quoll odour	Carnarvon Canine	Quoll den habitat features	Quoll evidence collected	Comments	Scat voucher no.	SSEC photo no.
47	25/10	158	Large tree with rocks and hollow around roots.	17°10'37.04"S 145°22'53.80"E	Strong	Kuna	Tree hollows - good refuge in hollow where refuge is very limited.	Dog indication & quoll den habitat			2992-2994

10. **APPENDIX B - Secondary findings: Incidental observations**.

Date 2012	Site No	Site Name	Wpt No	Location Description	Species Name	Common Name	No	ID Method HE = heard SE = seen EV = evidence FO = flying over	Comments	Voucher no	SSEC photo no
23/10	1	Ridgeline A	097	Rock outcrop	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed.	CC001	
23/10	1	Ridgeline A	098	Grass tree patch between rocky outcrops wpt 097 & 099		Unidentified snail shell	1	EV	17°09'33.0"S 145°23'30.1"E Specimen collected		
23/10	1	Ridgeline A	100	Found inside crevices of boulders		Unidentified snail shell	1	EV	Specimen collected		
23/10	1	Ridgeline A	101	Found inside crevices of boulders		Unidentified snail shell	1	EV	Specimen collected		
23/10	1	Ridgeline A	102	Grass surrounding boulders		Pheasant coucal	1	SE	Flushed out of grass & flew off North of boulder site		
23/10	1	Ridgeline A	102	Near rock tunnel	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed.	CC002	
23/10	1	Ridgeline A	103	Small rock overhang on large outcrop	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed	CC003	
23/10	1	Ridgeline A	105	Top of large flat boulder to Nth edge of boulder pile	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed	CC004	
23/10	1	Ridgeline A	108	Grassy hill with rocky	*Centropus*	Pheasant coucal	1	SE	Flew of out of		

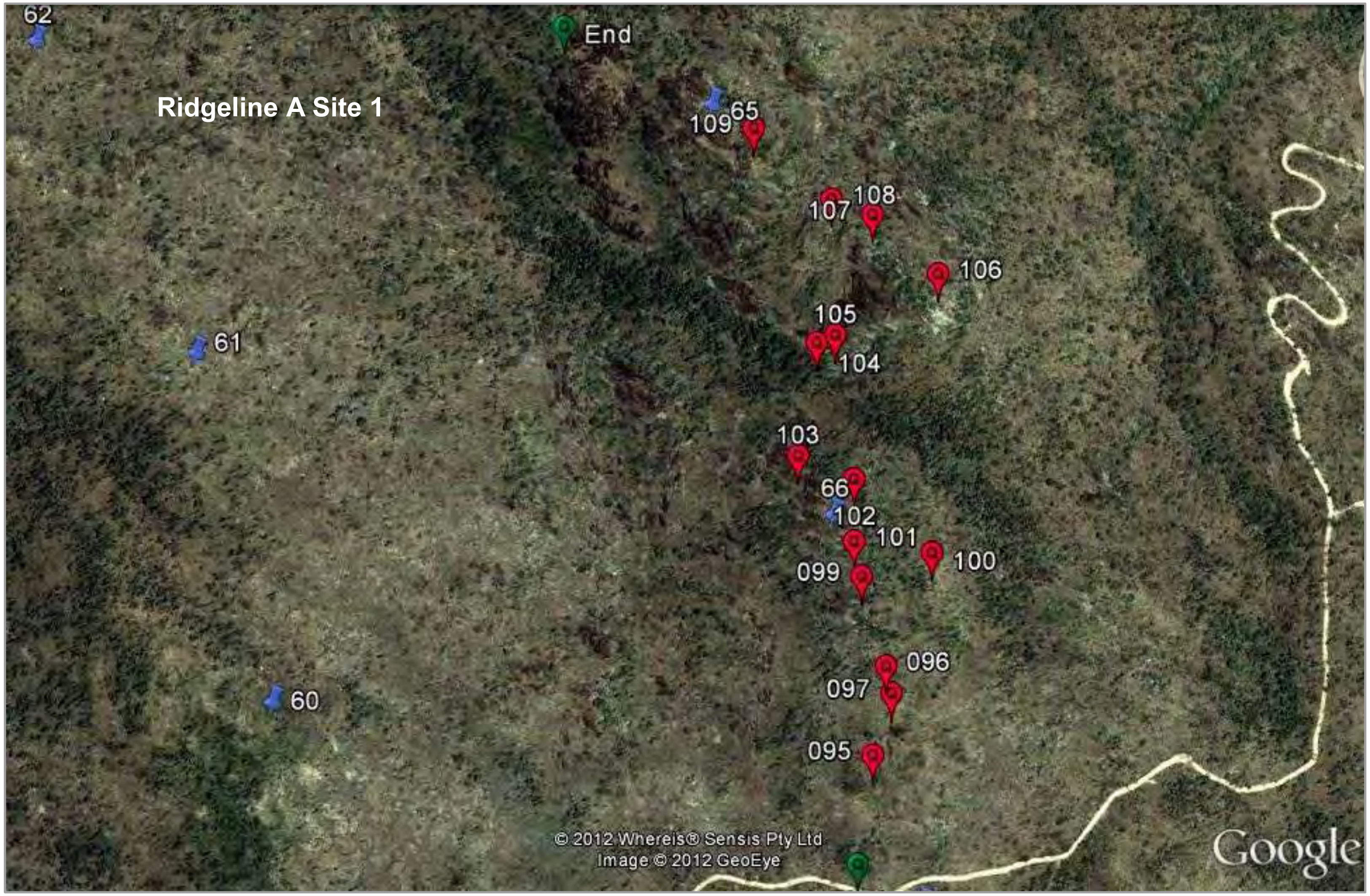
Date 2012	Site No	Site Name	Wpt No	Location Description	Species Name	Common Name	No	ID Method HE = heard SE = seen EV = evidence FO = flying over	Comments	Voucher no	SSEC photo no
				boulders	*phasianinus*				grass		
23/10	1	Ridgeline A	108	Top of very large boulder outcrop		Unidentified macropod	1	EV	Scats collected		
23/10	2	Creek line A	113	Top of boulder above burrows in creek bank	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed	CC005	
24/10	4	Ridgeline B	127	Inside a crevice of boulder pile		Cane Toad	1	EV	Cane toad head skeleton with skin, no evidence of body.		
24/10	4	Ridgeline B	127	Inside a crevice of boulder pile		Unidentified snail	1	EV	Shell collected		
25/10	5	Ridgeline B	136	Inside crevice of dog indication	Dasyurus hallucatus	Northern quoll		EV (Scat)	Scat ID to be confirmed		
25/10	5	Ridgeline B	137	Inside crevice of boulder pile		Unidentified snail	1	EV	Shell collected		
25/10	5	Ridgeline B	140	Inside crevice of boulder pile		Unidentified snail	1	EV	Shell collected		
25/10	5	Ridgeline B	142	Rock can with surveyors post? inside rock ring							
25/10	5	Ridgeline B	142	In soil at large flat boulder edges/cracks		Unidentified		EV	Numerous cone shaped diggings in soil & disturbed tubers		
25/10	5	Ridgeline B	144	Inside crevice in		Unidentified	1	EV	Shell collected		

Date 2012	Site No	Site Name	Wpt No	Location Description	Species Name	Common Name	No	ID Method HE = heard SE = seen EV = evidence FO = flying over	Comments	Voucher no	SSEC photo no
				boulders		snail					
25/10	5	Ridgeline B	145	Inside crevice in boulders		Unidentified snail	1	EV	Brown shell collected		
25/10	5	Ridgeline B	145	Calling from tree nearby	*Corvus orru*	Torresian crow	1	HE			
25/10	5	Ridgeline B	145	Flying approx 10 metres above ridgeline over survey site wpt 145	*Grus antigone*	Sarrus crane	8	SE FO	Flew from NW 10 m above ridgeline then rose to still below top of highest ridgeline point, approx. 200m from track near wpt 145. Then circled ridge edge calling (high pitched trumpet call like baby elephant) then flew NE direction		2968, 2969 & 2971
25/10	5	Ridgeline B	146	Track edge		Wild Dog	1	EV	Numerous old Dog scats all along track from wpt 146 to start of Ridgeline B survey location (close to camera trap on track edge)		
25/10	5	Ridgeline B	148	On track		Unidentified bird (owl species?)	1	EV	Bird kill evidence – feathered wing remains collected		

Date 2012	Site No	Site Name	Wpt No	Location Description	Species Name	Common Name	No	ID Method HE = heard SE = seen EV = evidence FO = flying over	Comments	Voucher no	SSEC photo no
25/10	6	Creek line B	153	Creek bank		Unidentified reptile		EV (burrows)	15 x active reptile burrows in bank		2976
25/10	6	Creek line B	153	Creek bank		Unidentified spider		EV	1 x Large spider tunnel in bank		2977
25/10	6	Creek line B	155	On rocks in creek line	*Carlia jarnoldae*	*Carlia* skink	1	SE	ID matched breeding male		2980-2982
25/10	6	Creek line B	155	On rocks in creek line	Carlia sp.	Carlia skink	1	SE	General ID, size, head shape & body markings matched *Carlia mundivenisis*		No photo taken
25/10	6	Creek line B	156	On rocks in creek line	*Amphibolurus nobbi*	Nobbi dragon	1	SE			2989-2990
25/10	6	Creek line B	156	On leaves of tree		Unidentified invertebrate	50+	SE	Leaves were covered in bright luminescent green beetles with orange legs, belly & band across back		2989-2990
25/10	6	Creek line B	157	On boulder creek bank	*Diporiphora australis*	Tommy roundhead dragon	1	SE	Darker grey body with general ID markings, Gular fold present		No photo taken
25/10	6	Creek line B	157	Flew in and out of trees along creek bank	*Taeniopygia bichenovii*	Double barred finch	20+	SE	Approx. 10m from wpt 157 opposite side of creek		

Date 2012	Site No	Site Name	Wpt No	Location Description	Species Name	Common Name	No	ID Method HE = heard SE = seen EV = evidence FO = flying over	Comments	Voucher no	SSEC photo no
25/10	6	Creek line B	157	Flew over creek line	*Calyptorhynchus banksii*	Red-tailed black cockatoo	1	SE FO			

11. APPENDIX D - LOCATION MAPS OF SURVEY AREA AND POSITIVE QUOLL ODOUR INDICATIONS




62
Start
Creekline A Site 2
65
112
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61
114
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© 2012 Whereis® Sensis Pty Ltd
Image © 2012 GeoEye
End
Google


Ridgeline B Site 3
18
End
Start
117
118
119
19
120
121
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 GeoEye
Google
20


Start & End
19
Ridgeline B Site 4
124
125
20
126
127
128
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130
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 GeoEye
Google


Start
20
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134
Ridgeline B Site 5
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© 2012 Whereis® Sensis Pty Ltd
Image © 2012 GeoEye
End
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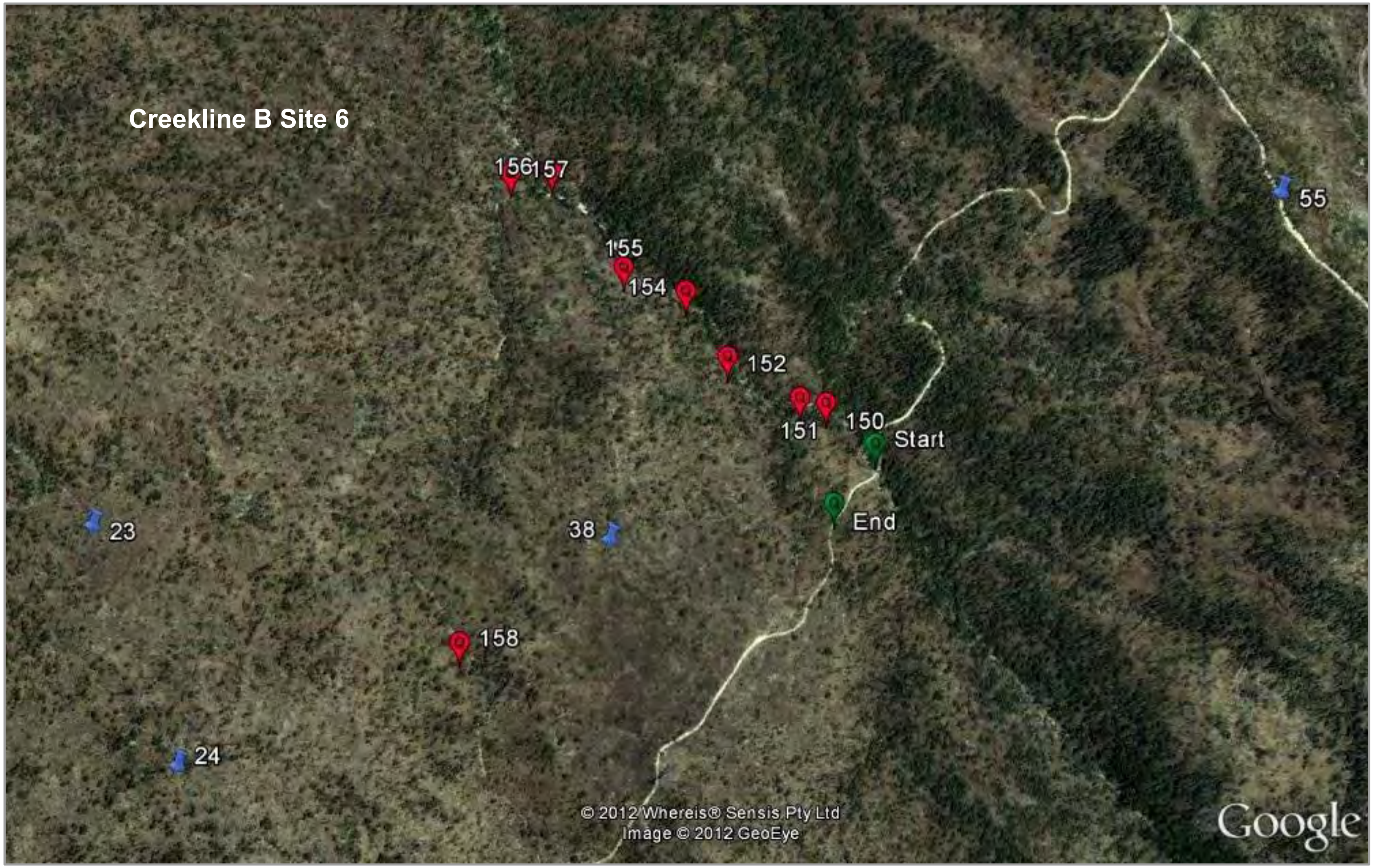
Creekline B Site 6
156
157
155
154
152
151
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Start
End
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23
38
158
24
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Image © 2012 GeoEye
Google

12. **APPENDIX E -** ***Carnarvon Canines - Quoll Detection Dog Proforma***

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SADDLER SPRINGS
EDUCATION CENTRE

Site No.		**Recorder:**		**Date/Time:**	
Purpose	QPWS – CNP Salvator Rosa Section – Mitchell Springs – Northern Quoll Survey				
Locality					

GPS Start	**Zone**			**E**								**N**								**Datum**	GDA94
GPS End	**Zone**			**E**								**N**								**Datum**	GDA94

Transect Description (e.g. creek line, rocky outcrop, spring, easement & approx. m):	**GPS Track Y / N Track No:**
	Quoll Dog Indication: Positive= + (strong sit & bark response) **Recheck= ?** (weak response – revisit with 2nd dog & visual obs)

Site Description within Transect search: (e.g. Start of creek line search) (i.e. At location of Quoll Evidence &/or Dog indication)	**Quoll Odour Dog Indication (Tick)**			**Flagged GPS Wpt**	**Quoll Evidence (Tick)** S=Scat D=Den T=Track Q=Quoll O=Other V=Voucher						**Quoll Den Habitat:** (Crevice, Boulders, Outcrop, Logs, Termite mounds)	**Comments** (Dog behaviour & Quoll Evidence notes) (For other species, habitat, impact notes record back page with wpt ref)	**Camera Trap Set**		
	+	**?**	**Dog Name**		**S**	**D**	**T**	**Q**	**O**	**V**			**Y/ N**	**Camera Number**	**Results Form No**

Photos Nos:

Voucher Specimens: (Desc. Wpt & ref code on sample)

Vegetation Description (Upper, Mid, Ground, Soil)**:**

Microhabitat Notes (Circle):

Rock Cover: None | Few | Moderate | Many

Type: Rocks | Boulders | Outcrop

Notes (Dens):

Logs (hollows): None | Few | Moderate | Many

Dead standing trees (hollows): None | Few | Moderate | Many

Leaf litter: None | Few | Moderate | Many

Termite mounds: None | Few | Moderate | Many

Bare soil patches: None | Few | Moderate | Many

Burrows: None | Few | Moderate | Many

Water body type: None | Soak | Spring | Creek |

Distance to permanent water:

Disturbances (Circle): (Ferals – record as Incidental records, weeds record esp. WONS)

Ferals: Pigs | Dogs | Cats | Rabbits | Toads | Cattle | Horses

Impacts:

Fire: None | Light | Moderate | Severe

Impacts:

Weeds: None | Light | Moderate | Severe

Species known:

Other:

Fauna Incidental Observations: ID - HE=heard SE=seen EV=evidence FO=flying over

Species (for EV only record e.g. Echidna scat)**:**	**No.**	**ID Method**	**Confirmed by**

Appendix 23

Mt Emerald Wind Farm: Turbine collision risk assessment for Sarus Crane & Wedge-tailed Eagle

Prepared by Biosis

Mt Emerald Wind Farm:
Turbine collision risk assessment for Sarus Crane & Wedge-tailed Eagle

FINAL REPORT

Prepared for RPS Australia Asia Pacific

31 October 2013

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- Daniel Gilmore

Contents

1 Introduction

1.1 Project background

Ratch Australia Corporation Limited is in the process of developing a wind energy facility at Mount Emerald in the Herberton Range approximately 50km west/south-west of Cairns, Queensland. The project has been determined to be a Controlled Action under provisions of *Environment Protection and Biodiversity Conservation Act 1999*. The controlling provisions are listed threatened species and ecological communities and listed migratory species. The assessment process under the Act is an Environmental Impact Statement and *Final Guidelines for an Environmental Impact Statement for the Mt Emerald Wind Farm* were issued in April 2012. Amongst other requirements, the *Guidelines* require:

> *a) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to:*
>
> *i. collision risk from turbines*

Biosis has been commissioned by RPS Australia Asia Pacific to undertake the present assessment of the risk of collision with wind turbines for two bird species at Mt Emerald Wind Farm. The first, Sarus Crane *Grus antigone* is a listed migratory species under provisions of the EPBC Act. The second, the mainland Wedge-tailed Eagle *Aquila audax* is not listed under provisions of the EPBC Act nor the *Nature Conservation (Wildlife) Regulation 2006* of the Queensland *Nature Conservation Act 1992*. Nonetheless, Wedge-tailed Eagles are readily observed and have been documented to have collided with turbines at wind farms elsewhere in Australia, albeit at lesser frequency than some other bird species that are also not threatened (Smales in press).

The collision risk assessment has been undertaken using a mathematical modelling process for which the primary inputs are data for flights by the two species collected at the Mt Emerald Wind Farm site. The data were collected by RPS to a rigorous program of point counts designed to quantify bird flights under a protocol provided by Biosis. The fieldwork was undertaken in 2012 and 2013.

The Biosis Deterministic Collision Risk Model was used to provide the risk analysis (Smales et al. 2013). It provides annual projections of potential numbers of collisions by the two species for the number and specific dimensions of the turbines proposed to be used at Mt Emerald Wind Farm.

2 Background to collision risk modelling

Mathematical modelling is simply a method by which available information is used to predict what may occur in the real world. We all use modelling all the time – although we generally don't call it that. Simple examples are when we calculate how long it will take us to travel from one place to another or how much fuel we will use to do so. We are using maths to make predictions based on available evidence.

The fundamental objective of modelling of risk is to provide a rigorous process by which probability can be assessed and to do so in a manner that can be replicated.

When making predictions of risk using a model, the rationale behind the predictions is explicitly stated in the mathematics of the model, which means that the logical consistency of the predictions can be easily evaluated. This is the case regardless of the type of model used.

The only real alternative to the use of a model is the use of subjective judgement to predict risks. Compared to subjective judgement, the explicit nature of inputs and rigour entailed in modelling makes models more open to analysis, review or modification when new information becomes available. Although there may be assumptions used and some arbitrary choices made when deciding on the structure and parameters of a model, these choices are stated explicitly when using a model but this is difficult to do when making subjective judgements. The assumptions underlying a model can be tested. Models can be used to help design data collection strategies. They can also help to resolve and avoid inconsistencies, and the rigorous analysis of data can help to clarify thoughts.

Models are often also valuable for their heuristic capacities, by focussing attention on the important processes and parameters when assessing risks (Brook et al. 2002). All risk assessment must incorporate processes for refinement and improvement as more data come to hand. It is vital that there is a feedback loop allowing this to occur (Burgman 2005). This should be expected of a model and the use of a model explicitly facilitates that process.

All of these benefits are difficult, if not impossible to achieve with subjective judgement. Another drawback of subjective judgement is that it may lead to biased predictions of risk, and such biases vary unpredictably among people (Tversky and Kahneman 1974; Ayton and Wright 1994; Gigerenzer and Hoffrage 1995; Anderson 1998). The predictions of models tend to be less biased (Brook et al. 2000, McCarthy et al. 2004). There are thus considerable benefits to be gained by employing a model when assessing risk.

In the case of modelling for risk of avian collisions with wind turbines, Madders and Whitfield (2006) have drawn attention to the transparency and objectivity of collision risk modelling relative to assessment without quantitative modelling. As those authors do, we also recognise that collision risk modelling is reliant on a combination of empirical data and some assumptions.

With regard to the purpose and capacities of collision risk modelling, we also agree with Madders and Whitfield (2006) that, "care must be taken not to over interpret the model outputs, which are probably best used to evaluate different wind farm configurations". In that respect, it is worth noting that numerical results of modelling we present here are provided to two or more significant places. This should not be misinterpreted to indicate a particular level of precision in the results. The purpose of providing results in this form is to permit comparative evaluation between species or, potentially, between different turbines in precisely the manner suggested by those authors.

Ideally, collision risk modelling should provide projections which reflect mean annual risk for various species over the expected life of the wind farm. In order to achieve that, input values for bird activity that pose risk should be values that are as representative as possible of long-term variations in bird utilisation of the site. The model's projections are determined from empirical data as this offers the only valid basis for such analyses, but it must be recognised that there are practical limitations on obtaining longitudinal datasets that may account for all possible environmental variables. In the present case, a substantial body of data has been collected in various seasons and times of the diel cycle, a range of weather conditions and extrinsic factors experienced during data collection such as land management practices and activities on the site. However, the data were collected in just one twelve-month period and it should be recognised that this may not be entirely representative of longer time frames.

It is important to recognise that while a model such as the one used here attempts to quantify risks, it makes no assessment of the 'value' of its subjects. Whether any species has more or less significance than any other taxon, and thus whether predicted risk to any particular taxon is 'acceptable' or not, is a further evaluation that must be made. Use of a model allows a clear distinction to be made between potential risks and subsequent judgements about those risks.

Biodiversity legislation and accompanying guidelines for its application provide the legal mechanisms for the subsequent evaluation of the significance of potential impacts on a threatened species. For instance the *EPBC Act policy Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia 2009) provides specific criteria applicable under that legislation to define significant impacts on taxa listed under various categories of threat and for listed migratory species. In the main, those criteria relate to impacts on populations rather than on individuals since populations are the key units of conservation.

3 Methods

The Biosis Deterministic Collision Risk Model was used to provide the risk analysis. A full, published description of the model is provided in Smales et al. (2013), which is reproduced as Appendix 1 of this report. The following provides details of the inputs parameter requirements of the model and the specific values used for Sarus Cranes and Wedge-tailed Eagles for Mt Emerald Wind Farm.

3.1 Input parameters of birds

Bird utilisation data

Numbers of flights made by Sarus Cranes and Wedge-tailed Eagles that may be at risk of collisions with turbines are drawn from empirical data collected during bird utilisation surveys at the Mt Emerald Wind Farm site. Surveys were conducted by RPS during a total of 26 days of fieldwork. These included five days in August 2012; four days in November 2012; four days in January 2013; two days in February 2013; four days in April 2013; and seven days in July 2013.

All surveys took the form of timed, fixed point counts at a number of predetermined locations across the study area. Count sites were selected to provide a representative sample of topography and environments within the overall site.

Observation time of all point counts combined totalled 21760 minutes. During the counts the following flights were documented and are used in the model:

Sarus Cranes: 0 flights below rotor-swept height; 132 flights within rotor-swept height.

Wedge-tailed Eagles: 15 flights below rotor-swept height; 79 flights within rotor-swept height.

(see *Risk relative to flight height and turbine components*, below).

Numbers of birds at risk

Where an estimate of the size of the population at-risk is available, this is factored into the model to provide results in the form of an expected number of individuals at risk of collision per annum. This is an important consideration because an input measured in terms of bird movements cannot provide an output in terms of individual birds. Where a species makes more flights per year than the number of individuals, as is frequently the case, this also provides for the logic that the number of collisions cannot exceed the number of birds that could collide. The population at-risk is the number of individual birds per annum that fly within the wind farm and thus may encounter turbines.

In the present case, the maximum number of Sarus Cranes near the wind farm is a flock estimated to include 600 Sarus Cranes observed approximately two kilometres south east of the wind farm site (RPS data). Experience of RPS on the site suggests there were up to 18 Wedge-tailed Eagles at the site on occasions. For the two species, these two values have been used as the total populations at risk of collisions at Mt Emerald Wind Farm.

Risk relative to flight height and turbine components

Collision risk is considered to differ according to whether a bird in flight may encounter the simple, static structure of a turbine or the rotors in motion. This allocation of differing risk is based on the consideration that birds will avoid collision with the stationary elements of turbines (static components) in all but the most exceptional circumstances and the model uses 99% avoidance rate for these components. The capacity of birds to avoid moving rotor blades (dynamic components) is generally expected to be lower, and the model has the scope to examine multiple scenarios for birds' avoidance capacity of the dynamic elements of operational turbines (see *Collision avoidance capacity*, below).

Thus, for the purposes of the model, a turbine is decomposed into its static and dynamic components. The static components include the entire turbine (nacelle, tower structures and the stationary rotor). The dynamic component incorporates the additional risk associated with the area swept by rotors in the time it takes the particular bird to fly through the depth of the swept disk. This additional risk is relevant only to flights within rotor-swept height. Turbine dimensions used to determine these are taken from specifications of the particular make and model of turbine proposed for the wind farm.

In order to account for the static and dynamic turbine components, data for bird flights are divided into two height zones: those below- and those within-rotor swept height. Siemens SWT 3.0-108 turbines with a hub height of 79.5 metres are proposed to be used at Mt Emerald Wind Farm. Rotor-swept height of this turbine spans the zone from 25.5 to 133.5 metres above the ground and flights below rotor-swept height are those between the ground and 25.5 metres high. Note that flights above the maximum height of the rotor tips are not at risk of collision and for that reason flight records from above that height are not relevant to collision risk modelling.

Flights relative to time & space

The collision risk model generates a measure of site utilisation from flights recorded in a defined amount of airspace and a defined time period. The model assumes no relationship between this constant, average utilisation of the site by birds, and the location of individual flights relative to the geographic locations of turbines. The model thus assumes a flat rate of utilisation across the site to account for the infinite possibilities of individual flight paths relative to turbine placements. Although this uniform utilisation measure means the model is not geographically spatial, it still requires metrics to account correctly for the interactions of bird flights with the volume of space occupied by turbines, including rotor swept volumes.

For this reason flight data has been documented from a specified volume of airspace. A cylinder of space used for this purpose is defined by the top height of the rotor tips for the turbine in question (in this case 133.5 metres) and a horizontal radial distance from observers. The size of this cylinder of space is considered to be large enough to sample the airspace meaningfully with minimal influence of surveys on bird behaviours, yet not so large as to be affected by observer detectability range, and with a view to avoiding double counting of bird flights that might otherwise occur due to overlap of simultaneous counts by more than one observer. The radial distance used can be tailored to the capacity for observers to detect particular species in flight. Large birds including Sarus Cranes and Wedge-tailed Eagles are readily detected over a considerable distance and we have used 2000 metres as this is strongly supported by multiple records in the present data of flights observed at that distance and beyond. The observational cylinder is a device used to calculate the flight density under the assumption that all observational cylinders used are in other respects equivalent to each other.

The numbers of bird flights-at-risk, as recorded during the combined duration of all timed point counts, are extrapolated in the model to determine an estimated number of movements-at-risk per annum. This extrapolation is based on the number of hours per day during which particular species may be in flight and whether they are year-round residents or annual migrants and thus the portion of the year that they may be at risk on the wind farm site. In the present case, Wedge-tailed Eagles are diurnal and were modelled for an average daily period of twelve hours of available flight time and for their being year-round residents. Sarus Cranes appear to fly primarily during daylight hours and were also modelled for an average daily period of twelve hours of available flight time, however, it is acknowledged that they may fly at night although the frequency of any such flights is unknown. Sarus Cranes are annually present in the region between June and late November or early December and we have modelled for their presence and potential risk for six months per annum.

Collision avoidance capacity

As outlined above, the model provides for different capacities of birds to avoid collisions. This capacity may include cognitive behaviours, in which a bird becomes aware of a potential risk and takes evasive action, and involuntary behaviours such as the variations between species in natural flight modes and innate aerial agility. A 90% avoidance rate means that in one of every ten flights a bird would not avoid an obstacle in its path. While many bird species have better avoidance capacity than this and it is well established that most species avoid collisions with wind generators on most occasions, actual turbine avoidance rates are unknown or poorly defined for most taxa (Chamberlain et al. 2006). Avoidance rate of Wedge-tailed Eagles has been investigated at Studland Bay and Bluff Point Wind Farms in north-west Tasmania (Hull and Muir 2013). In respect of risk modelling, an avoidance rate of 95% has been found to equate closely with the actual experience of Wedge-tailed Eagle collisions there (Smales et al. 2013). However, there are some ecological differences between Tasmanian and mainland Wedge-tailed Eagles and specific conditions of particular sites may influence avoidance rates, so we still provide a range of avoidance rates for the species in collision modelling for Mt Emerald Wind Farm.

We consider that birds will avoid collision with the static components of turbines in all but the most exceptional circumstances and the model uses 99% avoidance rate for these components. The capacity for birds to avoid the dynamic components of turbines can be expected to be lower, and the model provides scope to examine avoidance rates for the dynamic elements of operational turbines. Since the avoidance capacity exhibited by particular species requires confirmation based on actual experience, we provide results for a range of avoidance rates for both species. In the current case, predictions for the dynamic components are provided for each of 90%, 95%, 98% and 99% avoidance rates.

3.2 Parameters of turbines

Turbine presented area

Turbines present risk to flying birds both by the static obstacle they present and due to the motion of rotors. The first of these is represented by mean area (m^2 per turbine) of the entire machine, including tower, nacelle and stationary rotor blades. The mean area presented by a turbine to a bird in flight is between the maximum (where the direction of the bird is perpendicular to the plane of the rotor sweep) and the minimum (where the direction of the bird is parallel to the plane of the rotor sweep). The mean presented area is determined from multiple dimensions and rotor speed of the particular make and model of turbine, as supplied by the manufacturer.

The additional area (m^2 per turbine) presented by the movement of rotors during the potential flight of a bird through the disc swept by rotors is determined via a calculation involving species-specific, independent parameters of the bird's body length and flight speed and of rotor geometry and rotation speed, as supplied by the turbine manufacturer.

Body lengths of birds are as provided in standard references, primarily the various volumes of the Handbook of Australian, New Zealand and Antarctic Birds (Birds Australia, various editors). Body length of Sarus Crane used in the model is 1.60 metres and for Wedge-tailed Eagle is 0.95 metres.

Accurate determinations of bird flight speeds are complex and difficult to obtain (Videler 2005; Pennycuick 2008). Pennycuick (2008) makes the point that for reasons of physical dynamics of flight and of optimal energetics, there is generally little difference between average maximum and average minimum flight speed of most species. We are not aware of published empirical data for average flight speed of Sarus Crane or Wedge-tailed Eagle, but mean air-flight speeds for closely related northern hemisphere taxa, Common Crane *Grus grus* and Golden Eagle *Aquila chrysaetos*, are provided in Bruderer & Boldt (2001) and equate to 45 km/h for both species.

The component of risk associated with the rotation of blades is not applicable for time when the rotors are stationary and the static turbine alone presents risk. The percentage of the year when this applies because turbines are not expected to be operational is derived from wind speed data collected from the site and accounts for the average time per annum when wind speed is too low or too high for turbines to operate in addition to time required for turbine maintenance. The projected annual percentage downtime for Mt Emerald Wind Farm site is 7.8%.

Potential number of turbine encounters

The number of turbines that a bird may encounter in a given flight depends on the total number of turbines and their configuration in the wind farm, as well as the flight behaviours of the species.

As it is not realistic to assume that a bird might encounter every turbine in the wind farm in a given flight, we need to ascertain the average number of turbines that might be encountered in a flight. It is assumed for the purposes of the assessment that a bird might fly from any point in the wind farm to any other and that many flights will not follow a straight path. In the case of a scattered turbine array, when multiple flight paths are drawn randomly across a plan view of the wind farm, some paths may be circuitous and have potential to encounter many turbines while others will pass through a small portion of the site and have potential to encounter relatively few turbines. Mathematically, the 'average' path will intersect with $\sqrt{N}$ turbines (where N is the total complement of turbines comprising the wind farm). For scattered turbine configurations this value is used in the model for the number of turbines that might be encountered per flight.

For the case of a linear, single row of turbines the number of turbines that may be encountered in a given flight requires a different calculation. In this array it will be rare, but not implausible, for a bird to fly along the row of turbines encountering all of them. It is much more likely that a given flight will encounter few of the turbines and the closer the flight is to a perpendicular crossing of the row, the more likely it is that the flight will encounter a maximum of one turbine. In modern wind farm designs a whole or part of a wind farm comprised of a single rows of turbines is rare, but it can be seen that the risk rate would generally be low compared to a scattered array, as the majority of bird flights are likely to encounter few turbines.

As required, the model has capacity to scale between the scattered and linear configurations for a wind farm that is either one or the other, or consists of any combination of a clustered and linear array of turbines. This is done by a single parameter which scales linearly between the two extremes.

The turbine layout proposed for Mt Emerald Wind Farm is a scattered configuration and bird encounters with turbines are modelled as such.

3.3 Model output metrics

Data collected during point counts documents the number of flights made by particular species of birds ('flights-at-risk'). It is important to note that the number of flights-at-risk differs from the number of individuals that might collide with turbines ('individuals-at-risk'). Only where an estimate is available for the size of the population at risk, flights-at-risk may be converted into a number of individuals-at-risk by incorporating a population estimate into calculations. One logical outcome of this function in the model is that the projected number of collisions cannot exceed the number of birds at risk.

As outlined above (Section 3.1 *Numbers of birds at risk*), the sizes of populations at risk of both Sarus Cranes and Wedge-tailed Eagles have been determined and have been incorporated into the model. A modelled projection of the mean annual number of individual birds at risk is thus provided here for each species.

[If data for flight-at-risk are available but no population estimate is available, risk is necessarily expressed only in terms of the number of flights-at-risk per annum. Whilst this metric is not the same as the number of collisions that might occur, it is nonetheless of value for purposes such as comparing risk posed by different types or configurations of turbines.]

4 Results

On the basis of input values described above, collision risk modelling has provided projected mean annual number of individuals at risk of turbine collisions for the Sarus Cranes and Wedge-tailed Eagles. The results are presented in the table below for both species at four different avoidance rates for dynamic components of turbines and a standard 99% avoidance rate for static components.

Table 1. Mean projected numbers of collisions per annum for Sarus Crane and Wedge-tailed Eagle at four dynamic avoidance rates.

Static avoidance rate **Dynamic avoidance rate**	**99%** **90%**	**99%** **95%**	**99%** **98%**	**99%** **99%**
Sarus Crane	0.83	0.45	0.22	0.14
Wedge-tailed Eagle	0.76	0.42	0.22	0.15

For both species, the projected estimates equate to an average of a little less than one collision per annum (if dynamic avoidance rate is 90%) to an average of about one every seven years (if dynamic avoidance rate is 99%).

The range of results is slightly wider for Sarus Crane than for Wedge-tailed Eagle. This is because the range of results for any species is influenced by the relative proportion of flights below- and within rotor-swept height and the avoidance rates assigned to those two height zones. In the case of these two species at Mt Emerald, all observed Sarus Crane flights were within rotor-swept height, whereas 84% of observed Wedge-tailed Eagle flights were within rotor-swept height and16% were below that height.

5 Discussion

The results of collision risk modelling provides projected estimates of turbine collision risk encompassing a range for each species depending on the rate at which birds avoid turbines, especially the moving rotors. As discussed above, there is no empirical information available about turbine avoidance behaviours – and thus avoidance rates - for Sarus Cranes. The empirical information for avoidance rates for Wedge-tailed Eagles (Hull and Muir 2013) is from a quite different environment in Tasmania.

It is important to note that the projections represent *annual average numbers* of potential collisions. As a consequence, and also because the projections are for statistically small numbers, prediction of a frequency distribution for any real collisions is beyond the capacity of the model. Behaviours of the birds and numerous other factors may influence the real-life incidence of any collisions. It is thus well within probability and the annual average predictions provided here that no collisions might occur over many years, or that more than one collision could occur in close succession.

Potential limitations of this modelling are that it is based on flight data obtained during one twelve-month period which may or may not be representative of longer-term movements by the two species and these may be affected by a wide range of environmental influences. The data were collected prior to construction of the proposed wind farm and it is possible, that an operational wind farm could influence flight behaviours. Evidence from an operational wind farm in Tasmania suggests that there is little effect on utilisation of sites by Wedge-tailed Eagles but their behaviours were responsive to the presence of turbines (Hull and Muir 2013), As yet there is little empirical experience of cranes interacting with wind farms in Australia and none for Sarus Crane.

Behaviours and collisions have been investigated for Whooping Crane *Grus americana* and Sandhill Crane *Grus canadensis* at some operating wind farm in the USA (Nagy et al. 2012; Derby et al. 2012). Nagy et al (2012) monitored both species intensively during five seasons in which they were present at a wind farm. They documented 11,330 Sandhill Crane flights over, around and through the wind farm during spring and autumn periods. Up to five endangered Whooping Cranes were also observed there. No collisions of either species were detected. Their observations of the cranes indicated they avoided turbines by flying over, around or through spaces between turbines. Derby et al. (2012) monitored both species at five wind farms. They reported that approximately 600,000 Sandhill Cranes and 300 Whooping Cranes migrate twice per year through the area where these wind farms are situated. Their study included approximately 61,700 individual searches for bird carcasses under turbine over multiple years. Both studies detected no crane collision casualties or fatalities and concluded that collision risk for these species was low.

This is not to suggest that collisions by those species do not occur, nor that collisions of Sarus Cranes at Mt Emerald Wind Farm may not occur. This discussion is not intended to present an exhaustive review of crane collisions with wind turbines, but it does represent some of the latest information from relatively large studies of congeneric species to the Sarus Crane. We consider it is probable that Sarus Cranes will have high collision avoidance capacity.

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Appendix

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Wind Energy and Wildlife Conservation

A Description of the Biosis Model to Assess Risk of Bird Collisions With Wind Turbines

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ABSTRACT We describe the model of Biosis Propriety Limited for quantifying potential risk to birds of collisions with wind turbines. The description follows the sequence of the model's processes from input parameters, through modules of the model itself. Aspects of the model that differentiate it from similar models are the primary focus of the description. These include its capacity to evaluate risk for multi-directional flights by its calculation of a mean presented area of a turbine; its use of bird flight data to determine annual flux of movements; a mathematical solution to a typical number of turbines that might be encountered in a given bird flight; capacity to assess wind-farm configurations ranging from turbines scattered in the landscape to linear rows of turbines; and the option of assigning different avoidance rates to structural elements of turbines that pose more or less risk. We also integrate estimates of the population of birds at risk with data for numbers of their flights to predict a number of individual birds that are at risk of collision. Our model has been widely applied in assessments of potential wind-energy developments in Australia. We provide a case history of the model's application to 2 eagle species and its performance relative to empirical experience of collisions by those species.

KEY WORDS bird, collision, model, risk, turbine, wind energy.

A number of mathematical models have been developed for the purposes of either describing the interaction of a bird with a wind turbine or to predict the risks of bird collisions with turbines (Tucker 1996*a*, *b*; Podolsky 2003, 2005; Bolker et al. 2006; Band et al. 2007). Tucker (1996*a*, *b*) and Band et al. (2007) detailed their models in the peer-reviewed literature. The collision risk model developed by Biosis Propriety Limited has been widely used to assess wind-energy developments in Australia since 2002, but it has not previously been described in detail. Given high levels of interest in effects of wind turbines on fauna, we believe it is important for the model to be accessible.

Our model provides a predicted number of collisions between turbines and a local or migrating population of birds. It has the potential to be modified to accommodate Monte-Carlo simulation, although at its core it uses a deterministic approach. It is modular by design, and allows various customizations, depending upon the unique configuration of the wind facility and characteristics of the taxa modeled.

The initial calculation involves species-specific parameters for speed and size of birds and specifications of the turbine, including its dimensions and rotational speed of its blades. Using these parameters, we derive the mean area of turbine presented to a bird in flight. This allows the model to accommodate flight approaches from any potential direction. Alternatively, unidirectional flights can be modeled by using the relevant turbine surface area presented to birds approaching from a given direction.

Data for bird flights are collected at the wind-farm site according to a specific and consistent field methodology. These data are used to determine the flux (density) of bird flights. When combined with turbine specifications, this yields the probability of collision during a single flight–turbine interaction. The density flux approach has not been used for this application previously.

The number of movements at risk of collision with one turbine is then scaled according to a typical number of turbines that a bird might encounter in a given flight. This is further refined by a metric for the capacity of the particular species to avoid collisions. Where a population census or estimate is available for the number of birds that may be at risk, a further deduction is used to attribute the number of flights-at-risk to individuals, and hence provide a final model output as the number of individuals at risk of collisions. The ability to transform from flights-at-risk to individuals-at-risk has been uniquely developed and applied as a routine component of our model.

DESCRIPTION OF THE MODEL

The model requires data for input parameters and, using these, functions in a sequence of modules (Fig. 1).

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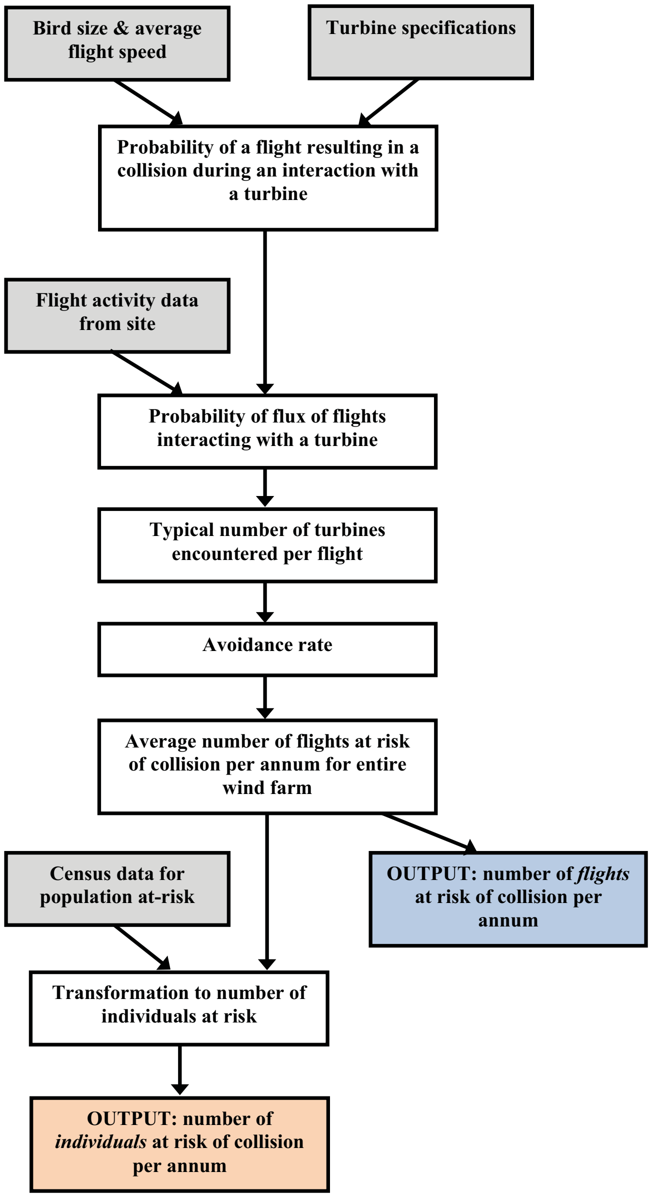

Figure 1. Overview of the collision risk model that quantifies risk to birds of colliding with wind turbines, showing input parameters (gray boxes), modules, and sequence.

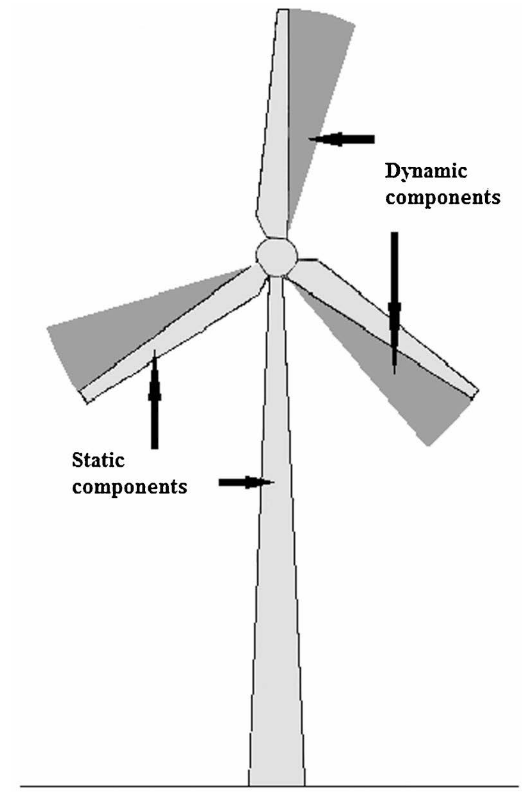

Figure 2. Schematic indication of the static and dynamic components of a wind turbine that may be encountered by a flying bird. The dynamic component is the area swept by rotor blades during the time that a bird of a particular species would take to pass through the rotor-swept zone.

Model Inputs

Turbine parameters.—The primary risk faced by a flying bird, whether it may strike or be struck by a turbine, is that the machine presents a potential obstacle in its path. Ultimately this equates to the surface area of the turbine presented to the bird from whatever its angle of approach. Other models, such as probably Band et al. (2007), use individualistic representations of birds. Our model uses a projection of the presented area onto all possible flight angles. For this reason, multiple dimensions of turbine components and rotor speed for the particular type of turbine are used as input values to the risk model. Turbine specifications are as provided by the machine's manufacturer.

The modeled wind turbine consists of 2 fundamental components representing potentially different risks. We refer to these as the static and dynamic components (Fig. 2). The static areas of a turbine include all surfaces of the entire machine comprising a tower, which in current turbines is a simple taper with known base and top diameters; a rectangular nacelle housing the generator; a hemi-spherical hub; and rotor blades that taper in 2 planes. The dynamic component is the area swept by the leading edges of rotor blades during the time that a bird would take to pass through the rotor-swept zone.

Size and flight speed of birds.—For each taxon, the model requires values for the total length of the bird in flight, from bill tip to tip of the tail or outstretched legs, and the average speed of the species' flights. We obtained bird lengths either from museum specimens or from standard ornithological texts.

Accurate determinations of bird flight speeds can be complex and difficult to obtain (Videler 2005, Pennycuick 2008) and published data are not available for most species. However, published radar studies (e.g., Bruderer 1995, Bruderer and Boldt 2001) provide ranges of flight speeds for a variety of species, including congenerics with similar morphologies and ecological traits to a number of species we have assessed. Use of radar to collect bird flight data at the wind-farm site may provide flight speeds for species of interest. We consider that average ground speed (as opposed to air speed) is appropriate for modeling of multidirectional movements of birds.

Bird flight data.—The model requires data from the wind-farm site for the number of flights made by species of interest within a measured time and volume of airspace. Movement data may be obtained from fixed-time point counts using a methodology adapted from Reynolds et al. (1980), incorporating an effective detection range (Buckland et al. 1993). It may be collected by human observers or by using horizontal and vertical radar combined with call recording or visual species identification (e.g., Gauthreaux and Belser 2003, Desholm et al. 2006). Data represent the number of flights that birds make within a cylinder of airspace that is centered horizontally on the observer and the height of which is the maximum reached by rotor blades of the turbines. The data collection regime is designed with the aim of providing a representative sample of flight activity across the local range of diel, seasonal, and other environmental variables.

Model Modules

Probability of a single flight interacting with a turbine.—In some situations, such as during highly directional migratory passage, the presented area of turbines is determined from the angle of the birds' flight relative to the compass orientation of turbines. However, for the great majority of species (including temporary or permanent residents at an on-shore wind farm) this does not apply, and flights can be expected to approach turbines from any direction. For this situation, all dimensions of the turbine contribute to the area with which a flying bird might collide and the model uses a simple integration to determine a mean presented area. This represents a substantial advance over other collision risk models that depend on the assumption of a specific angle of approach as a bird encounters a turbine (e.g., Tucker 1996*a*, *b*; Bolker et al. 2006; Band et al. 2007).

We calculate the area presented by the static components of a turbine using a conservative assumption that none of them overlap or obscure any others. The area of each component is calculated individually, and these are then summed to determine a total static area for the turbine. Static areas are calculated from the simple length × width dimensions of all components visible by line of sight. These are then projected onto an arbitrary approach direction (effectively scaling by the cosine of the approach angle). For example, viewed directly from one side, only the side panel of the nacelle is visible. However, approached from 45° to the turbine, both the front and side panels are visible, and are thus scaled by $\cos(45)\varrho 1/\sqrt{2}$ to match that particular angle of view.

We calculate the dynamic area, swept during the movement of blades, from the dimensions of the stationary blades and the distance they travel at their average speed during the time taken by a bird to fly through the rotor-swept area. We assume that all flights involve forward movement, so the swept-area is derived from the length and speed of the particular species of bird, in combination with the thickness of the sweeping blade.

Each rotor blade is tapered in 2 planes. Thus the thickness of the blades, used to determine the time taken for a bird to cross through the swept area, is actually a function of the point in the rotor radius at which an individual bird's flight intersects the swept area. This presents a complication that we overcome by defining an effective blade, which is a simple rectangular cross-section that sweeps out precisely the same volume of space as the physical blade. In doing so, we calculate a constant thickness of blade that accounts for the fact that the thinner tips actually sweep far more space than the thicker base of the blade. This ensures also that our flux calculation is not compromised by introduction of a spatial variation at odds with other aspects of the model.

A further input parameter is the percentage of time per annum when rotors are not turning due to inappropriate wind speeds and routine turbine maintenance. Prior to commissioning of a wind farm, wind speed data are usually gathered and the expected percentage of downtime due to inappropriate wind speeds is determined. During downtime periods the rotor simply stops turning; and so risks associated with dynamic components only are reduced by this percentage of time, while all static components of the turbine remain as potential obstacles to flying birds.

Combining all presented areas of the turbine.—Modeling for multidirectional bird movements requires no dependence on approach angles nor on complexities of interactions between flight direction and wind direction. We thus reduce the turbine to its mean presented area. This is solved by the equation

$$\frac{1}{\pi}\int_0^{\pi} A(\theta)\,\mathrm{d}\theta$$

where A is the presented area of the turbine as a function of approach angle θ. We solve this numerically using a trapezoidal integrator (Press et al. 1992).

Probability of multiple flights interacting with a turbine.—Because counts of bird flights have been made across the wind-farm site and there is no obligatory relationship between point-count locations and particular sites proposed for turbines, we combine the data collected from all point counts. This provides a measure of flight activity, which is assumed to be constant across the site. Thus the field data reduce to a single ratio value for the subject species, which is the sum of all flights documented during all counts divided by the total time of observations. This equates to a maximum likelihood estimation of the mean of an assumed Poisson distribution.

To calculate a number of flights at risk of collision, we first reduce documented bird movements (M) to a measure of flux (F) using the equation

$$F = \frac{M}{T_{\mathrm{obs}} A_{\mathrm{obs}}}$$

where T_{obs} is the combined total time of all point counts and A_{obs} is the area of the vertical plane dissecting the observation cylinder. This flux is a measure of bird movements per time per square meter of vertical airspace. The third dimension, volume of airspace, is redundant (or tacit) due to the assumption that, unless involved in a collision, flight paths do not end arbitrarily in space.

We next multiply activity measure by the number of minutes in which the species is active during the 24-hour diel period, T, and the total presented area of the turbine, A. For year-round resident species, the "active minutes" are calculated for the entire year, while for seasonal or migratory species, they are calculated for the portion of the year that the species is present at the site. This then gives a measure of risk to the bird movements, $M_{\text{risk}} = \text{FTA}$.

Because the flight data are a measure of movements by the species in question and do not discriminate the number of individuals making the movements, the measure (M_{risk}) quantifies the total movements-at-risk for the species and does not reflect risk to individual birds.

To determine a risk rate from total of recorded movements-at-risk, it is necessary to extrapolate to a total number of expected bird movements per annum, M_{yearly}. We calculate this from the flight data, extrapolating the movements to a yearly total through the equation

$$M_{\text{yearly}} = M \frac{T_{\text{yearly}}}{T_{\text{obs}}}$$

We then deduce a probability of flights at risk of collision as $M_{\text{risk}}/M_{\text{yearly}}$. Note that T_{year} is the total time in a year, and not the diel activity period of the species, which has already been factored into the calculation of movements at risk.

The resultant value is now a probability of flights being at risk of collision with a single turbine. To this point, no account is taken of the bird's own ability to avert a collision. This is modified later through use of an avoidance factor.

Estimating number of turbines encountered per flight.—Every turbine is presumed to represent some risk for birds, so the total number of turbines proposed for the wind farm is an input to the model. Turbine layout of modern wind farms is primarily determined by the wind resource and turbines are micro-sited accordingly. Consequently, the machines are usually scattered on the landscape. Older wind farms had turbines arrayed in rows, and occasional modern facilities may be linear where they follow a single topographic feature.

To account for the number of turbines with which a single flight might interact, it would be necessary either to know precisely the route of every flight or to make informed assumptions about flight paths. The manner in which turbines are arrayed in the landscape is important to ascertain a typical number of turbines that a bird might encounter in a given flight. This number differs according to whether turbines are in a scattered array or a single row, and these require different calculations.

For a row of turbines, the likely number of encounters can be visualized by considering a row of N turbines in plan view and a flight path at angle Φ to the row. A flight directly along the line of turbines (Φ') will interact with all N turbines. As the angle of flight relative to the row increases toward 90°, flight paths have potential to interact with fewer turbines until an angle (Φ'') is reached at which the path has potential to interact with a maximum of one turbine.

For a single row of turbines, we define the piecewise smooth function, which gives the number of turbines for a given angle of crossing with,

$$n_{\text{interaction}} = \begin{cases} N, & \text{if } \theta \leq \phi\prime \\ \cot(\theta), & \text{if } \phi' < \theta \leq \phi'' \\ 1, & \text{if } \phi'' < \theta \leq \frac{\pi}{2} \end{cases}$$

This gives us an expected number of interactions as

$$\langle n_{\text{interaction}} \rangle = \frac{2}{\pi} \left[N \arctan\left(\frac{1}{N}\right) + \frac{\pi}{4} - \ln\left(\sqrt{2}\sin\left(\arctan\left(\frac{1}{N}\right)\right)\right) \right]$$

For scattered turbine arrays it is not realistic to assume that a bird will encounter all turbines in the wind farm in a given flight. We assume each flight has potential to cross between any 2 points on the outer edges of the farm. Given the size of most on-shore wind farms, this is a reasonable assumption for typical species of concern, such as raptors. When multiple flight paths are drawn randomly across the plan view of a wind farm, some paths may be circuitous and have potential to encounter many turbines, while others will pass through a small portion of the site and have potential to encounter relatively few turbines.

To deduce an average number of turbines likely to be encountered by any flight we use a topological, non-affine mapping technique. This spatial transformation can be illustrated as follows: if we were to throw a lasso around the perimeter of the site and shorten it to its minimum, we would find that all the turbines had collected in a circle. A straight flight path through this "lassoed" site is mathematically equivalent to a random walk across the unconstrained layout. The average of all flight paths crossing the center of this remapped farm will intersect with $\sqrt{N}$ turbines (where N is the total no. of turbines in the wind farm). This value is used in the model for the number of turbines that might be encountered per flight within a scattered turbine array.

For arrays that are neither entirely scattered nor linear, the model employs a simple weighted average of the values for fully scattered and entirely linear arrays.

Application of turbine avoidance capacity.—Birds have substantial ability to avoid obstacles; therefore, it is necessary to incorporate this capacity into the model. In common with other workers (Percival et al. 1999), we use "avoidance" in specific reference to behavior on the part of a bird that averts a potential collision with a turbine. The "avoidance rate" equates to the proportion of flights that might otherwise have involved interaction with a turbine but where the bird alters course and the flight does not result in a collision. For the purposes of the model it is of no consequence whether or not this is a result of a cognitive response by the bird to the presence of the turbine.

Turbine avoidance remains little-studied for any species, and empirical information about actual avoidance can be obtained for a given site only by studying the responses of birds in the presence of operational turbines (Chamberlain et al. 2006). One recent investigation has compared flight behaviors of 2 species of eagles in the presence of turbines at

2 operating wind farms with their behaviors at a site without turbines (Hull and Muir 2013).

Avoidance rate is incorporated into the model by scaling the movements at risk by $(1 - v)$, where v is a measure of the bird's ability to avoid objects. In this scenario, $v = 0$ corresponds to a blind, non-responsive projectile, and $v = 1$ represents a perfectly responsive bird able to avoid any object.

A novel feature of our model is its capacity to apply different avoidance values to the static and dynamic portions of a turbine. As noted by Martin (2011), birds are known to collide with both stationary and moving parts of turbines. This aspect of our model allows for differences in capacity of birds to detect and avoid the large, static components of modern turbines relative to their capacity to detect and avoid the small and fast-moving leading edges of rotor blades.

Size of population at risk.—When information about the size of the population at-risk is available, this can be factored directly into our model to provide results in the form of an expected number of individuals at risk of collision per annum. This is an important consideration because an input measured in terms of bird movements cannot provide an output in terms of individual birds. This aspect appears to have been largely overlooked by other workers, although Chamberlain et al. (2006) alluded to the use of a number of flights only, without incorporation of the number of individuals, as a potential issue in evaluation of collision estimates provided by the Band model (Band et al. 2007).

To deduce a predicted number of individual birds that are at risk of collision, a valid estimate is required of the number of individuals that may interact with turbines at the wind farm in the course of a year. If it is not feasible to obtain this for a species, then the output of the collision risk model will necessarily be the number of flights-at-risk per annum. Although this metric is not predictive of the number of individuals that might collide, it permits risk to be compared for various designs of a wind farm or between one facility and another. In rare cases, such as where there is a single migration passage through the site per annum, the number of movements may equate with the number of individual birds that are at risk. The great majority of risk modeling we have undertaken has been for raptors that are year-round residents. Due to their territoriality and relatively low densities, our studies at wind-farm sites have been able to ascertain the number of individuals using a site per annum, including both resident adults and juveniles, with a high level of confidence. For some other species, such as cranes (Gruidae), we have undertaken home-range studies to determine numbers present during the breeding season, and we have obtained local census data to estimate numbers of individuals that might encounter turbines during non-breeding seasons.

Given a population estimate, the number of flights at risk is attributed equally to the relevant number of individuals through the simple relation $M_{\text{individuals}} = \text{Yearly Movements}/\text{Population}$. We can then attribute individual mortality through

$$\text{mortality} = \text{Population}\left(1 - \frac{\text{Movements At Risk}}{\text{Yearly Movements}}\right)^{M_{\text{individuals}}}$$

MODEL VALIDATION

The model we describe here has been used to assess potential turbine collision risk for numerous species of birds for 23 commercial-scale wind farms proposed in Australia and one in Fiji. Eleven of these facilities have subsequently been built and are now operational. The model's projections have been used by regulatory authorities in determination of approval or modification to wind-farm designs for a range of species of concern. These include taxa as diverse as the orange-bellied parrot (*Neophema chrysogaster*), wedge-tailed eagle (*Aquila audax*), brolga (*Grus rubicunda*), and the large and readily observable Pacific fruit-bat (*Pteropus tonganus*) in Fiji.

The model's performance can be validated only when it can be compared with post-construction mortality data that are sufficient to permit calculation of an actual annual mortality rate and a 95% confidence interval for that rate. Conditions of regulatory approval for most wind farms that have been built to-date in Australia have varied considerably between state jurisdictions and over time. Generally they have not required rigorous investigation or public reporting of avian collisions that occur during operation. We have thus had limited opportunity to validate our model against empirical information for actual collisions. However, where these are available, we can compare the model's predicted average estimates with the measured confidence interval for actual mortalities to assess its predictive capacity. We present one such case study below.

Comparing the Model's Predictions With Empirical Data—A Case History

Substantial investigations have been undertaken at Bluff Point and Studland Bay wind farms in northwestern Tasmania entailing a number of studies of wedge-tailed eagle and white-bellied sea-eagle (*Haliaeetus leucogaster*). These have included utilization surveys designed to measure eagle activity before and after development of the wind farm; collision monitoring; eagle breeding success; eagle behaviors and movements relative to turbines and observers; and investigations and trials aimed at reduction of collisions (Hull et al. 2013). Commissioning of turbines began at Bluff Point Wind Farm in 2002 and at Studland Bay Wind Farm in 2007. Bluff Point Wind Farm consisted of 37 Vestas V66 turbines in a scattered array on an area of 1,524 ha. Studland Bay Wind Farm was situated 3 km south of Bluff Point and comprised 25 Vesta V90 turbines in a scattered array over an area of 1,410 ha. Both wind farms were close to the coast of northwestern Tasmania and resident white-bellied sea-eagles and Tasmanian subspecies of wedge-tailed eagle (*A. a. fleayi*) occurred at both sites.

Monitoring Eagle Flights

Movement data for both species were collected during point counts at Bluff Point Wind Farm site in 3 years prior to construction of turbines and in 4 years after they commenced operating. At Studland Bay, they were collected in 6 years prior to turbine construction and in 3 years after turbines commenced operation. As prescribed by regulatory authorities, point counts were undertaken in the austral autumn and spring. Ten replicate point counts were made in each season at 18 locations per wind farm. There were 545 point counts undertaken at Bluff Point between 1999 and 2007 and 854 point counts at Studland Bay between 1999 and 2009.

Collision Risk Model Results

We used the model to estimate risk based on movement data collected prior to construction for populations of 6 wedge-tailed eagles and 4 white-bellied sea-eagles at-risk per annum at each of the 2 wind farms.

State regulatory authorities have required that the collision risk model be re-run with the accumulated sum of eagle movement data obtained during the entire period of both pre-construction and operation of the 2 wind farms spanning the period from 1999 to 2009 (Table 1). We modeled static avoidance rate at 99% in all cases.

Documented Eagle Collisions

Carcass monitoring surveys were conducted at the Bluff Point and Studland Bay wind farms since they commenced operating. Fences to exclude mammalian scavengers were maintained at 27% of turbines across the 2 sites. All turbines, both fenced and unfenced, were searched routinely within a 100-m radius of the tower base. Search frequency was initially informed by trials to determine rates of loss to scavengers and of observers' capacity to detect carcasses. Since 2007, searches were carried out twice weekly during periods that may have represented higher risk to the species (i.e., eagle display period Jun–Aug, inclusive; and eagle fledging period mid-Dec–Feb, inclusive) and fortnightly outside these periods (Hull et al. 2013). Assessment of the extent of undetected eagle collisions (Hydro Tasmania 2012; Hull et al. 2013) concluded that it is unlikely that significant numbers of eagle carcasses were missed because they are conspicuous; the search zone around turbines was adequate to detect eagle carcasses where they will fall after colliding with turbines (Hull and Muir 2010); personnel on site had capacity to detect carcasses that may have been moved from the formal search zones; eagle carcasses in vegetation were found not to decompose readily and, even when scavenged, remains were identifiable; avian scavengers did not remove all evidence of carcasses and, although mammalian scavengers could remove carcasses, this was controlled at the subset of fenced turbines; survey intensity was informed by predetermined scavenger removal rates; and, although a small number of eagles survived collision with a turbine, in all documented cases such birds were unable to fly and are likely to have been detected because both scavenger exclusion and farm fences prevented them from leaving the site.

Table 1. Modeled mean annual turbine collision estimates for 2 eagle species based on movement data collected over the span of pre-construction and operation of 2 wind farms in northwestern Tasmania, Australia, from 1999 to 2009. Estimates are shown for 4 potential dynamic avoidance rates. Static avoidance rate was modeled at 99% in all cases

	White-bellied sea-eagle		Wedge-tailed eagle	
Dynamic avoidance rate (%)	**Bluff Point**	**Studland Bay**	**Bluff Point**	**Studland Bay**
90	0.9	0.8	2.7	1.9
95	0.5	0.4	1.5	1.1
98	0.2	0.2	0.7	0.5
99	0.1	0.1	0.4	0.3

Comparison of Collision Risk Model Estimates With Actual Mortality Rates

Given constraints of statistically low collision numbers, the model's estimates of annual collisions, based on the combined total of movement data from pre-construction and operation of the 2 wind farms from 1999 until 2009 (Table 1), compare well with actual mortality of the 2 eagle species at both wind farms (Table 2). The model's estimate of the number of wedge-tailed eagle collisions per annum at Bluff Point at a 95% avoidance rate was 1.5, which is the same as the mean number of documented mortalities per annum. Estimates provided for this case by model iterations for 90% and 95% avoidance rates fell within the 95% confidence interval of measured mortality rates. The model's estimates for number of collisions at a 95% avoidance rate for white-bellied sea-eagles at Bluff Point (0.5) and for wedge-tailed eagles at Studland Bay (1.1; Table 1) also closely approximated the mean numbers of documented mortalities per annum for the 2 species (0.4 and 1.0, respectively; Table 2). For those cases, the model's estimates for the range of avoidance rates between 90% and 99% fell within the 95% confidence interval of measured mortality rates. No white-bellied sea-eagle collisions have yet been reported from Studland Bay so, to date, the model's estimates are higher than actual experience for that species there.

MANAGEMENT IMPLICATIONS

We consider that there are 2 different, although not mutually exclusive, applications for modeling of bird collision risks at prospective wind farms. These are to provide projections of long-term effects of a particular wind-energy facility on key bird species; and to determine relative risks for key species that are associated with different wind-farm sites, different portions of large wind farms, and different types of turbines and/or turbine configurations.

In many respects, we consider the latter use of collision risk modeling is the most important contribution it offers. This application provides a tool for planning of wind farms to avoid, reduce, or mitigate potential risks to birds. The model we describe here has now been used in such an iterative manner for a number of prospective sites to evaluate relative risks to key species posed by different types, sizes, numbers, and layouts of turbines.

The integration in our model of data for numbers of bird flights with numbers of birds in the population at-risk is key to the accurate prediction of potential numbers of collisions. This aspect appears not to have been adequately considered previously but has real implications to the appropriate determination of actual risks posed by a wind farm. Our model's use of bird flight data to determine annual flux of movements; a mathematical solution to the typical number of turbines that might be encountered in a bird flight; capacity to assess wind-farm configurations ranging from turbines scattered in the landscape to linear rows of turbines; and the option of assigning different avoidance rates to components

Table 2. Average annual mortality rate and variance for 2 eagle species based on carcasses detected at 2 wind farms in northwestern Tasmania, Australia

Wind farm	White-bellied sea-eagle		Wedge-tailed eagle	
	Mean annual mortality	Annual variance (95% CI)	Mean annual mortality	Annual variance (95% CI)
Bluff Point 2002–2012	0.4	0.1–1.0	1.5	0.8–2.6
Studland Bay 2007–2012	0.0	0.0–0.7	1.0	0.3–2.2

of turbines that pose more or less risk, all represent refinements designed to improve the predictive capacity of turbine collision risk modeling.

In the cases outlined here, where long-term mortality data sets have permitted validation of the model's collision estimates at given avoidance rates, the two have closely approximated each other. We will seek further opportunities to compare the results of our model with empirical mortality information from operating wind farms, with a view to wider application of the model.

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The model described here is the property of Biosis Propriety Limited, an environmental consultancy business incorporated in Australia. It is used commercially by Biosis Propriety Limited.

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Appendix 24

Mount Emerald Wind Farm – Microchiropteran Bat Ultrasonic Call Assessment

Prepared by RPS

Mount Emerald Wind Farm

Microchiropteran Bat Ultrasonic Call Assessment

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1.0 Introduction

The proposed Mount Emerald Wind Farm (MEWF) project consists of construction and operation of a wind farm located approximately 20km SSW of Mareeba on the Atherton Tablelands including of approximately 70 wind turbines, associated access tracks and an electricity substation that will feed into the main electricity grid (the Chalumbin – Woree transmission line). The general characteristics of wind turbines being considered include the following:

- upwind pointing horizontal axis wind turbine;
- three-bladed design with blade lengths between 50m and 54m (100m to 108m diameter);
- turbine capacity of approximately 3.0MW;
- cylindrical steel towers providing a hub height of 78m to 80m;
- blade length of approximately 50m; and
- total height to blade tip between 130m and 134m.

This project is intended to supply approximately 500,000 megawatt hours which should supply sufficient renewable energy to power the equivalent annual needs of approximately 75,000 North Queensland homes over a 20 year period. The site has been selected primarily as it displays an excellent wind resource, there are few residences in close proximity to the site, and the site is traversed by existing Powerlink transmission line infrastructure (providing ease of connection).

1.1 Site Description

The wind farm project site, hereafter referred to as the “site” or “project area” is a single rural property, formerly described as Lot 7 on Plan SP235244, and covering an area of approximately 2422 ha (**Figure 1**).

The site is situated at the northern most end of the Herberton Range, which forms part of the Great Dividing Range. The site varies in altitude from 540 m ASL at the northern-most point along Kippen Drive to 1089 m ASL in the south-eastern most section closest to Mt Emerald. The north-western section of the site is dominated by Walsh’s Bluff (907 m ASL) (**Figure 1**).

The site is dominated by a series of three, approximately parallel high rhyolite ridges running in a south-east to north-west direction (**Figure 1**). There is a large area (~500 ha) of relatively flat country located in the western section (**Figure 1**). The site is dissected by a series of steep rocky ephemeral drainage lines and gorges, including the headwaters of a tributary of Granite Creek (**Figure 1**).

The site is intersected by a 5-10 m wide, 6.7 km long access track for Powerlink’s Chalumbin to Woree 275 kV transmission line that roughly traverses the property (**Figure 1**). Two other vehicle tracks, 750 m and 2.95 km in length respectively, connect the two test wind towers with the main power line access track (**Figure 1**).

The site is not currently grazed by domestic stock and aside from the cleared areas of access tracks and test wind monitoring tower pads, consists entirely of remnant vegetation. The site is located on the boundary of the Einasleigh Uplands and the Wet Tropics Bioregions, both of which are characterized by high levels of bioregional endemic flora and fauna species.

1.2 Objective

Under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*), actions that have, or are likely to have, a significant impact on a Matters of National Environmental Significance (MNES) require approval from the Australian Government Minister for the Environment (the minister). The proposed development has been deemed a controlled action under the provision of the *EPBC Act* as the action has the potential to have a significant impact on a number of MNES and therefore required an EIS before approval could be considered.

The controlling provisions for the proposal under the *EPBC Act* are:

(a) Listed threatened species and ecological communities (sections 18 & 18A);

(b) Listed migratory species (sections 20 & 20A);

(c) World Heritage Properties (sections 12 & 15A); and

(d) National Heritage Places (sections 15B & 15C).

The following three species of EPBC listed threatened microchiropteran bats are assessed as moderately to highly likely to occur on (or in the immediate vicinity of) the MEWF site:

- Greater Large-eared Horseshoe Bat, *Rhinolophus philippinensis* (large form), listed as endangered under the EPBC;
- Bare-rumped Sheathtail Bat, *Saccolaimus saccolaimus nudicluniatus,* listed as critically endangered under the EPBC; and
- Semon's Leaf-nosed Bat, *Hipposideros semoni,* listed as endangered under the EPBC.

Of these species, only *S. s. nudicluniatus,* has been detected at the proposed Mt Emerald Wind Farm project site.

The purpose of this report is to present the findings of all of the pre-construction bat call surveys conducted at the MEWF project site. Ultrasonic call using detectors based on the ground or on wind monitoring towers are the standard methods used to conduct microchiropteran bat utilisation at Australian wind energy facilities and were deployed on the study site.

2.0 Methodology

2.1 Early Dry Season 2010

During the early dry season surveys, passive monitoring was undertaken for four consecutive nights in the vicinity of Granite Creek at c. 327359 8099784 between 10 and 13 May 2010 (**Figure 1**).

2.2 Late Wet Season – Dry Season 2011 Surveys

During the late wet season surveys (28/3/2011 to 1/4/2011), passive monitoring using ANABAT SD1 detectors (Titley Electronics, Ballina NSW) were conducted for 1-2 nights at a number of the proposed turbine locations, i.e. # 30, #26, #60, #56, #55 (April 2011 layout) (**Figure 1**). At each site, monitoring commenced at dusk (approximately 1830 hours) and continued until dawn (approximately 0545 hours). ANABAT SD1 detectors were attached to tree trunks and set ~2m above the ground with the microphones angled 45 degrees upwards. Active monitoring was also conducted on the nights of 29 and 31 March using an ANABAT SD1 detector from a slow-moving vehicle travelling along the power line access track from the vicinity of proposed turbine # 67 to the south-eastern section of the property in the vicinity of proposed turbine #22 (**Figure 1**).

Ultrasonic call monitoring was conducted within the proposed rotor sweep area between 1/06/11 and 4/6/11 using stereo-channel SM2BAT full-spectrum detectors (Wildlife Acoustics, 2011) fitted with two omni-directional ultrasonic SM-UX microphone at the two meteorological testing towers (80 m high and 50 m high respectively) (**Plate 1**). A SM2BAT unit was attached to each tower at ~ 3 m off the ground with one microphone directly connected to the unit oriented horizontally and the other microphone connected to the unit by an extension cable and attached in a horizontal orientation to the top of each tower.

Additional ground level ultrasonic call monitoring was conducted at shrub-level (~3 m above the ground) at three proposed turbine locations between 8/06/2011 and 11/6/2011 (**Figure 1**).

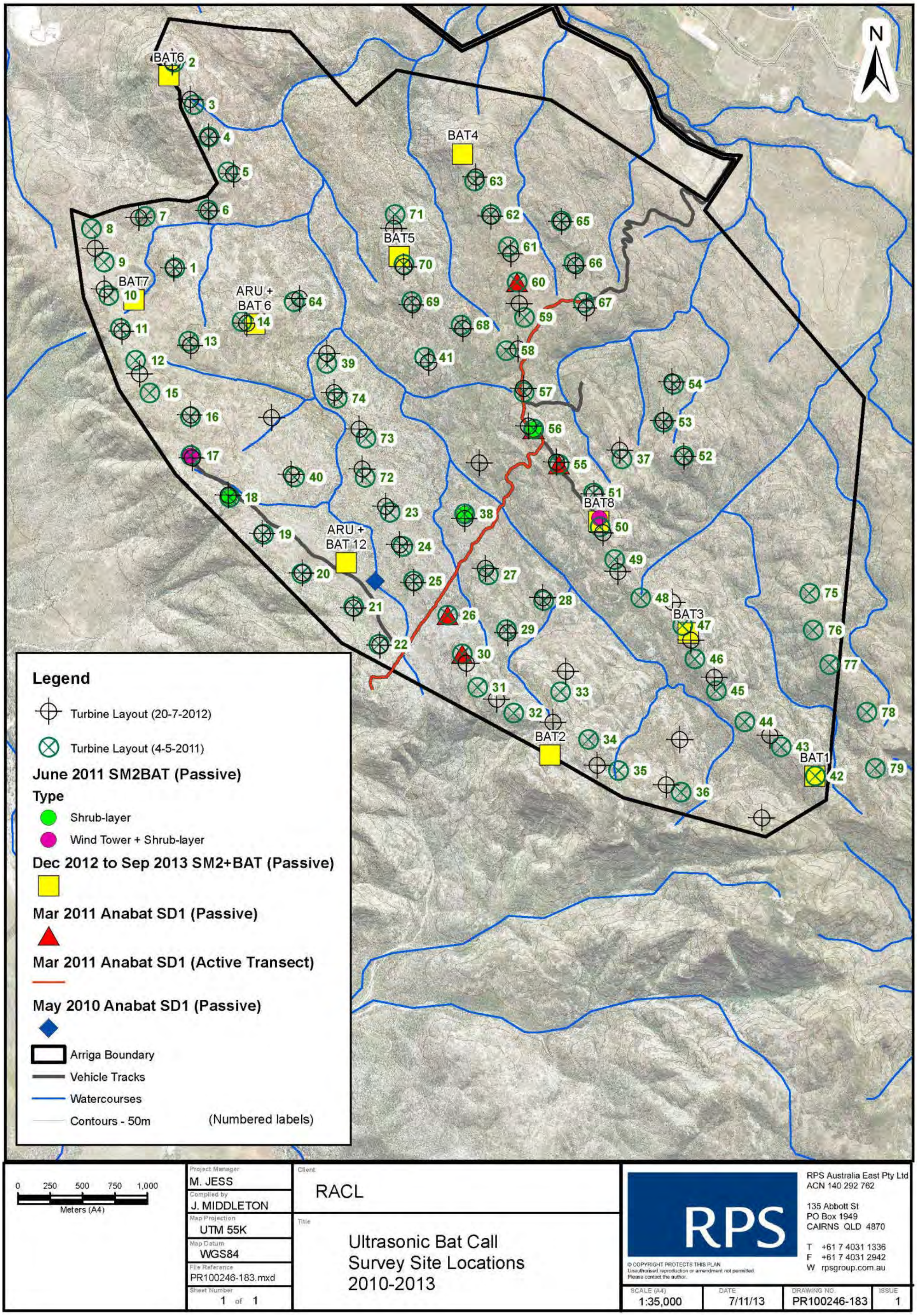

Figure 1 Bat Call Survey Sites 2010-2013

2.3 Permanent Monitoring Towers (Dec 2012 to Sep 2013)

Ten permanent monitoring sites were selected to provide optimal spatial coverage of the site and were located along representative ridge lines where turbines are proposed to be located (**Figure 1**).

A six m tall tower (50 mm diameter steel pipe; guyed with 4 mm wire ropes attached at 4 m above the ground) was erected at each site in December 2012. A Wildlife Acoustics SM2+BAT unit fitted with a SM-UX ultrasonic microphone and a SMX-FMC “night flight” acoustic microphone and powered by a 12V 30 amp hr sealed lead acid gel cell battery and charged by a 30W solar panel was established at each site. The two microphones were located at the top of the tower approximately 6 m above the ground and connected to the SM2+BAT unit by 6 m cables.

Each SM2+BAT unit was programmed to sample in stereo (left channel ultrasonic and right channel acoustic) continuously in one hour-blocks from sunset to sunrise in Wildlife Acoustics proprietary WAC compression format on either four 64 GB or 16 GB Lexar SD-XC memory cards (256 GB or 64 GB total memory). The recording setup file was reviewed by Wildlife Acoustics Australia supplier (Faunatech) and by Greg Ford (Balance Environmental). Sampling commenced at each site on 12 December 2012.

Each site was visited approximately every two months, the four 64 GB cards collected and replaced with four 16 GB cards. One week later, each site was then revisited and the four 16 GB cards were then replaced with four 64 GB cards.

The total survey duration varied from 42-96 nights across the ten detector tower sites (**Attachment A**). A total of 631 detector survey nights were conducted in the 257 days between 11 December 2012 and 28 August 2013 at the ten detectors towers.

Microbat call analysis was conducted by recognised microbat bat call analyst Greg Ford (Balance Environmental, 2013), who is familiar with North Queensland species likely to occur on the site. Balance Environmental possesses an extensive bat call reference library including numerous calls from the critically endangered Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus nudicluniatus*) from a range of locations. Details supporting the identifications are provided, as recommended by the Australasian Bat Society (ABS 2006) in **Attachment B**.

2.3.1 Limitations

Due to the inherently high wind and harsh monsoonal conditions combined with the remoteness of the ridgelines of the study site (albeit consistent with positive conditions for wind turbine operations), data collection was not continuous. Issues arose from water-damaged microphones, wind-damaged night-flight microphones, and access where weather and helicopter availability were restrictive. There were also occasional hardware and software malfunctions, regardless, extensive wet and dry season records have been collected across the site aspect.

Plate 1 Bat Call Detection Tower (ultrasonic microphone shown at top of pole)

3.0 Results

A total of 654 detector nights of microchiropteran bat call surveys were conducted within the MEWF site between May 2010 and September 2013 (**Attachment A**).

Over the entire sampling period, a total of 17 species of microchiropteran bats were assessed as occurring on the site on the basis of calls that were identified as belonging to the particular species with a high degree of certainty (**Table 1**). Additional species (between three and six species) were assessed as potentially occurring on the site, on the basis of the calls not being able to be reliably separated from other species with similar calls (**Table 1**).

Table 1 Summary of Call Analysis

Scientific Name	Common Name	Family	EPBC	NCA
Calls Identified with High Certainty				
Saccolaimus flaviventris Peters, 1867	Yellow-bellied Sheathtail Bat	Emballonuridae		
Saccolaimus saccolaimus Temminck, 1838	Bare-rumped Sheathtail Bat	Emballonuridae	CE	E
Hipposideros diadema Geoffroy, 1813	Diadem Leaf-nosed Bat	Hipposideridae		NT
Austronomus australis (=Tadarina australis)	White-striped Freetail Bat	Molossidae		
Chaerephon jobensis	Northern Freetail Bat	Molossidae		
Mormopterus beccarii	Beccari's Freetail Bat	Molossidae		
Mormopterus loriae ridei Felten, 1964	Eastern Little Freetail Bat	Molossidae		
Mormopterus 'species' 2	Undescribed species Adam *et al.,* 1988)	Molossidae		
Rhinolophus megaphyllus	Eastern Horseshoe Bat	Rhinolophidae		
Chalinolobus gouldii	Gould's Wattled Bat	Verspertilionidae		
Chalinolobus nigrogriseus	Hoary Wattled Bat	Verspertilionidae		
Miniopterus australis	Little Bent-wing Bat	Verspertilionidae		
Miniopterus orianae oceanensis (=M. schreibersii oceanensis)	Eastern Bent-wing Bat	Verspertilionidae		
Pipistrellus adamsi	Forest Pipistrelle, Cape York Pipistrelle	Verspertilionidae		
Scotorepens orion	Eastern Broad-nosed Bat	Verspertilionidae		
Scotorepens sanborni	Northern Broad-nosed Bat	Verspertilionidae		
Vespadelus troughtoni	Eastern Cave Bat	Verspertilionidae		
Species/Calls Not Reliably Identified				
Taphozous georgianus	Common Sheath-tail Bat	Emballonuridae		
Taphozous troughtoni[A]	Troughton's Sheath-tailed Bat	Emballonuridae		LC
Nyctophilus species	Long eared Bat (could be Eastern Long-eared Bat (*N. bifax*), Lesser Long-eared Bat (*N. geoffroyi*) and Gould's Long-eared Bat (*N. gouldii*). Not possible to differentiate with Anabat zero-crossing files.	Verspertilionidae		

[A] *T. troughtoni* is currently only known to occur in the vicinity of Mt Isa.

The surveys conducted at the 80 m tall test wind tower detected a total of five or six bat species with the majority of call sequences recorded with the microphone set at 80 m (91 calls) compared with the microphone set a 3 m above the ground (32 calls) (**Attachment B**). At the lower 50 m tall wind tower, a similar number of species was recorded; however, no calls were detected at the microphone at 50 m, only from the 3m microphone (**Attachment B).**

3.1 Conservation Significant Species

3.1.1 Diadem Leaf-nosed Bat (*Hipposideros diadema*)

A single call belonging to *H. diadema* was recorded on an Anabat SD1 detector in the vicinity of Granite Creek on the 12 May 2010 (**Figure 1**). No subsequent calls were recorded for this species during the survey period at any location on the site.

3.1.2 Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus nudicluniatus*)

The characteristic call attributes of *S. saccolaimus* (**Attachment B**) according to Ford (2013) include:

- a dominant harmonic with characteristic frequency around 22-25 kHz;
- at least 3 and up to five distinct harmonics at approximately 13 kHz intervals (1 below and up to 3 above the dominant harmonic); and
- call pulses sometimes in “triplet” sets with pulse intervals of approximately 10-20ms between first and second pulses and 20-40ms between second and third pulses and an inter-triplet interval of about 80-100ms.

A single call, potentially belonging to *S. Saccolaimus,* was first recorded on the site in March 2011 (**Attachment B)**. However, it was not possible then to reliably discriminate between three species with similar call attributes (i.e. *S. flaviventris, S. saccolaimus* and *T. troughtoni*) as the calls were recorded on Anabat detectors which do not allow harmonic characteristics of the calls to be examined, unlike full-spectrum Wildlife Acoustic Song Meter (SM2Bat and SM2+BAT) detectors, which were used on all subsequent surveys. A single call sequence was recorded in June 2011 on a full-spectrum SM2BAT detector and it was considered highly probable that it belonged to *S. saccolaimus* (**Attachment B).**

A total of 182 call sequences from nine of the ten 6-m tall towers were recorded between 20-28 February 2013 that could have potentially been Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus)* (**Attachment B**). However, after further examination, it was concluded that the calls were more likely to have been *Mormopterus beccarii* (Beccari’s Freetail Bat). A total of 30 call sequences recorded between 11 December 2012 and 28 May 2013, were assessed with high confidence of belonging to *S. saccolaimus* (**Attachment B**).

4.0 Discussion

The relationship between call activity and actual population abundance of microchiropteran bats is not well understood. In addition, the detection distance of the Wildlife Acoustics SM2+BAT Song Meters is only recently thought to be 20-30 m (Wildlife Acoustics, pers. comm.). *S. saccolaimus* is thought to be a fast, high-flyer and even the microphones placed at the top of the 6 m towers may not have been able to sample the lower limit of the rotor sweep area (~35 - 135 m above the ground) adequately as the microphones were angled at 45 degrees to reduce exposure of the sensitive diaphragm to rain. Therefore, it is difficult to make reliable assumptions about the relative abundance (actual call activity) of the species within the site.

Best practice guidelines from Australia and overseas highlight the requirement to monitor the call activity of microchiropteran bats at the proposed turbine hub height (EPHC, 2010; Bat Conservation Trust, 2011). Due to the large area of the MEWF site (2422 hectares) and the difficulties imposed on access due to minimal track coverage, rugged terrain and weather conditions, it was considered that to gain an indication of spatial and temporal patterns of microbat utilisation, a higher frequency of monitoring points was preferential to the limited wind monitoring tower locations that were available for higher elevation monitoring;

Only a relatively few call passes were classified as belonging to *S. saccolaimus* with high confidence. It is possible that the species is not present in high abundances, calling activity of the species on the site was low or simply that its' preferred foraging zone was not adequately surveyed.

4.1 Future Research

Faunatech Australia has recently developed a pulley system that allows microphones and cables to be easily placed within the proposed rotor sweep zone on meteorological towers. Further surveys should be conducted within the proposed rotor sweep area zone at the two test towers on the site, in order to better understand the temporal utilisation patterns of microchiropteran bats, particularly the Bare-rumped Sheathtail Bat, at these two locations.

Very lightweight full spectrum bat detectors, such as the Nanobat device being developed by Roger Coles (University of Queensland) or FM-radio microphones (Griffin & Thompson, 1982; Fenton & Griffin, 1997; Albrecht and Grünfelder, 2011 in BSG, 2011) could be attached to moderately sized (3-4 m3) helium balloons or kites (Gilliam et al., 2009) to monitor bat calls within the rotor sweep area at the proposed turbine locations rather than being restricted to the two meteorological towers.

5.0 References

Australasian Bat Society (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. http://ausbats.org.au/resources/4553704436

Albrecht, K., and Grünfelder, C. H. (2011). Pre-construction study: Recording bats in heights with collision risk using a helium balloon and an automated system *In* BSG Ecological Consultants (2011). Bats and onshore wind farms – technical review of presentations from the Tronheim Conference on Wind Energy and Wildlife, May 2011.

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Bat Conservation Trust (2011). *Bat Surveys – Good Practice Guidelines, 2nd Edition. Surveying for Onshore Wind Farms*. Bat Conservation Trust, London.

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Gilliam, E. H., McCracken, G. F., Westbrook, J. K., Lee, Y., Jensen, M. L., and Balsley, B. B. (2009). Bats aloft; variability in echolocation call structure at high latitudes. *Behav. Ecol. Sociobiol*., 64: 69-79.

Griffin, D. R., and Thompson, D. (1982). High altitude echolocation of insects by bats. *Behavioural Ecology and Sociobiology,* 10: 303-306.

Fenton, M. B., and Griffin, D. R. (1997). High-altitude pursuit of insects by echolocating bats. *Journal of Mammalogy*, 78(1): 247-250.

Attachment A

Summary of Microchiropteran Bat Call Surveys

Detector Type	SITE ID	Survey Type	Detector ID	Easting	Northing	Survey Period Start Date	Survey Period Finish Date	Survey Duration (Nights)	Total Survey Duration (Nights)
Wildlife Acoustics SM2+BAT	ARU 12 + BAT	Passive	RPS 010342	327124	8099910	30/12/2012	4/01/2013	5	78
						8/01/2013	20/01/2013	13	
						20/02/2013	28/02/2013	9	
						18/04/2013	30/05/2013	43	
						17/07/2013	24/07/2013	8	
	ARU 6 + BAT	Passive	RPS 010379	326444	8101751	12/12/2012	6/01/2013	25	42
						20/02/2013	28/02/2013	9	
						22/05/2013	28/05/2013	7	
						13/08/2013	13/08/2013	1	
	BAT 1	Passive	RPS 010388	330752	8098285	11/12/2012	21/12/2012	11	45
						20/02/2013	28/02/2013	9	
						17/04/2013	5/05/2013	19	
						16/07/2013	21/07/2013	6	
	BAT 2	Passive	RPS 010375	328705	8098455	11/12/2012	23/12/2012	13	68
						20/02/2013	28/02/2013	9	
						17/04/2013	22/05/2013	36	
						17/07/2013	26/07/2013	10	
	BAT 3	Passive	RPS 010359	329769	8099386	11/12/2012	31/12/2012	21	58
						20/02/2013	28/02/2013	9	
						17/04/2013	6/05/2013	20	
						21/08/2013	28/08/2013	8	
	BAT 4	Passive	RPS 010382	328025	8103096	11/12/2012	22/12/2012	12	96
						20/02/2013	28/02/2013	9	
						18/04/2013	7/05/2013	20	
						17/06/2013	11/08/2013	55	

Detector Type	SITE ID	Survey Type	Detector ID	Easting	Northing	Survey Period Start Date	Survey Period Finish Date	Survey Duration (Nights)	Total Survey Duration (Nights)
	BAT 5	Passive	RPS 010386	327545	8102283	11/12/2012	25/12/2012	15	54
						20/02/2013	28/02/2013	9	
						16/04/2013	25/04/2013	10	
						17/06/2013	4/07/2013	18	
						13/08/2013	14/08/2013	2	
	BAT 6	Passive	RPS 010372	325749	8103687	11/12/2013	24/12/2013	14	76
						16/04/2013	16/05/2013	31	
						17/06/2013	17/07/2013	31	
	BAT 7	Passive	RPS 010360	325476	8101965	11/12/2012	5/01/2013	25	63
						20/02/2013	28/02/2013	9	
						16/04/2013	26/04/2013	11	
						17/06/2013	4/07/2013	18	
	BAT 8	Passive	RPS 010387	329079	8100241	11/12/2012	24/12/2012	14	51
						26/01/2013	26/01/2013	1	
						20/02/2013	28/02/2013	9	
						17/03/2013	17/03/2013	1	
						16/04/2013	26/04/2013	11	
						16/07/2013	30/07/2013	15	
Anabat SD1	Turbine #35 (20/7/12 layout)	Passive	AB01	328045	8099230	28/03/2011	28/03/2011	1	1
	Turbine #26 (4/5/11 layout)	Passive	AB01	327901	8099510	29/03/2011	30/03/2011	2	2
	Turbine #60 (Apr 2011 layout)	Passive	AB01	328432	8102088	31/03/2011	31/03/2011	1	1
	Turbine #56 (Apr 2011 layout)	Passive	RPSZcairn	328560	8100966	28/03/2011	29/03/2011	2	2

Detector Type	SITE ID	Survey Type	Detector ID	Easting	Northing	Survey Period Start Date	Survey Period Finish Date	Survey Duration (Nights)	Total Survey Duration (Nights)
	Turbine #55 (Apr 2011 layout)	Passive	RPSZcairn	328780	8100670	30/03/2011	31/03/2011	1	1
	22-67-22 (Apr 2011 layout)	Active	AB03			29/03/2011	29/03/2011	1	2
	Granite Creek			327359	8099784	31/03/2011	31/03/2011	1	
Wildlife Acoustics SM2BAT	Turbine #56 (Apr 2011 layout)	Passive	SM2BAT_005106	328578	8100964	8/06/2011	11/06/2011	4	4
	Turbine #38 (Apr 2011 layout)	Passive	SM2BAT_0057322	328058	8100294	8/06/2011	9/06/2011	2	2
	Turbine #18 (Apr 2011 layout)	Passive	SM2BAT_005733	326229	8100414	8/06/2011	8/06/2011	1	1
	Test Wind Mast (30 m) (Turbine #15)	Passive		325929	8100744	1/06/2011	3/06/2011	3	3
	Test Wind Mast (80 m) (Turbine #47)	Passive		329098	8100274	1/06/2011	4/06/2011	4	4

Attachment B

Bat Call Analysis – Balance! Environmental

Anabat echolocation data interpretation summary

Client: RPS (Cairns/Townsville) **Job no.:** RPS-1002 **Analysis Date:** 11/06/2010

Project name/location: Arriga Palteau (May 2010 Survey)

Numbers in columns represent number of calls attributed to each species or species group

Species	10-May	11-May	12-May	13-May	Total calls for species
Calls positively identified					
Hipposideros diadema			1		1
Scotorepens sanborni	3				3
Vespadelus troughtoni	1				1
Miniopterus australis	5		1	4	10
Miniopterus orianae oceanensis	20	3	13	21	57
Austronomus australis	1		4		5
Chaerephon jobensis	1				1
Mormopterus ridei				2	2
Saccolaimus flaviventris	1				1
Total calls positively identified	32	3	19	27	81
Calls NOT positively identified					
Chalinolobus nigrogriseus / S. sanborni	1				1
S. flaviventris / C. jobensis	2	1		2	5
unknown bat call	24	1	4	13	42
Total calls NOT positively identified	88	8	41	69	206
Total calls for night	59	5	23	42	129

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

Call identification was based on published call descriptions for southern Queensland (Reinhold *et al* 2001) and the Northern Territory (Milne 2002) and on reference calls collected from central and northern Qld.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes to the table - discussion of species/groups with low reliability of identification

Chalinolobus nigrogriseus / S. sanborni	calls are at similar frequencies; usually differentiated on slightly different pulse shapes but one call form this survey with intermediate shape and could have been either species
S. flaviventris / C. jobensis	call frequency overlaps; usually have different pulse shapes but a few brief calls could have been either species
Unknown calls	these are calls that were too brief, weak or noisy to enable reliable species identification; they represent species already listed above, not additional species

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory* . Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

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Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

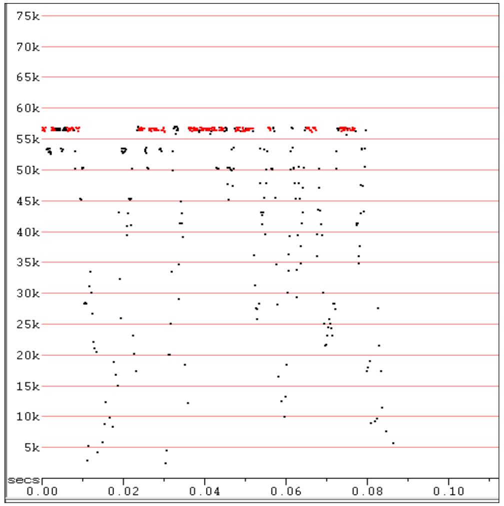
van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

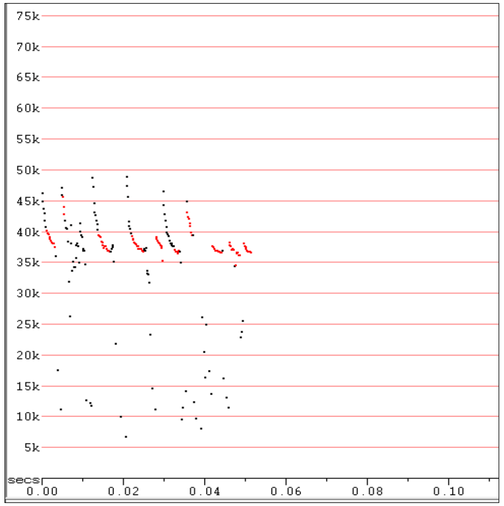
Sample calls extracted from theArriga Plateau survey data (RPS Townsville; May 2010)

Scale: 10 msec per tick; time between pulses removed (*AnalookW* F7 compressed mode)

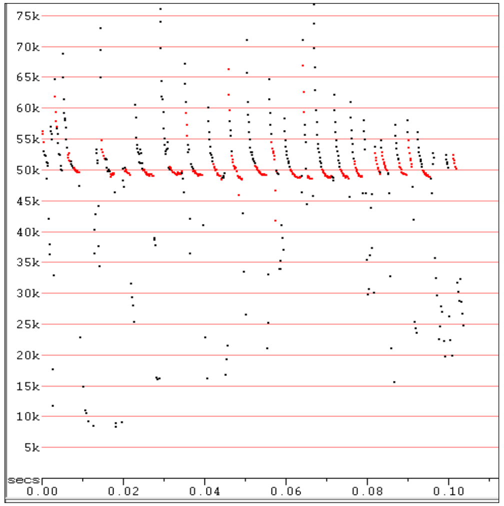
Species positively identified



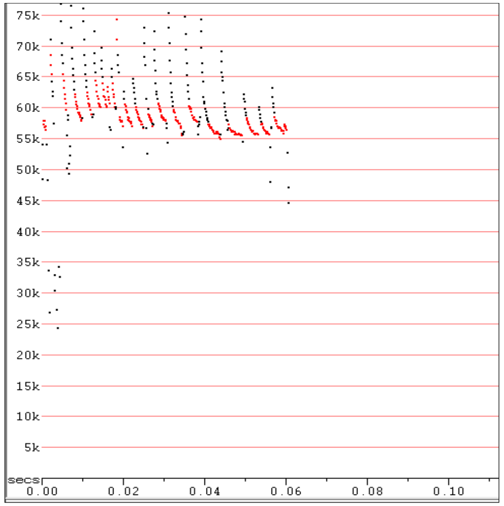
Hipposideros diadema



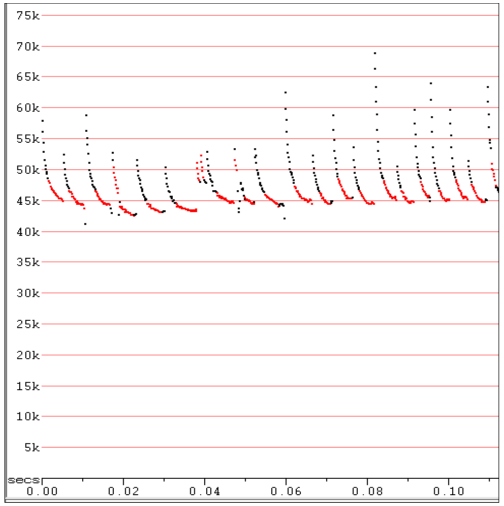
Scotorepens sanborni



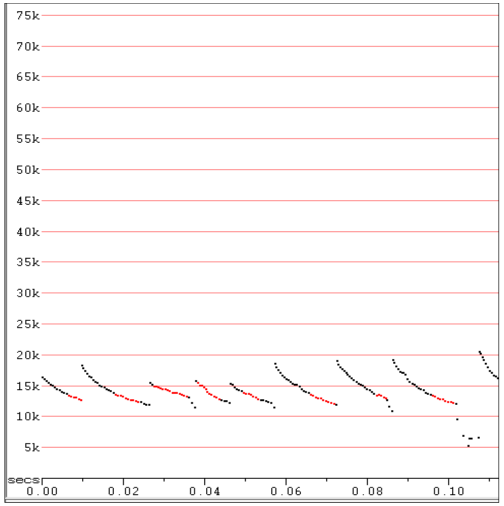
Vespadelus troughtoni



Miniopterus australis



Miniopterus orianae oceanensis



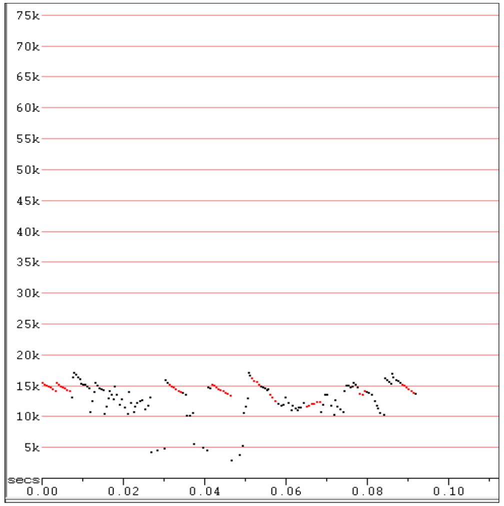
Austronomus australis

Anabat Data Analysis Summary

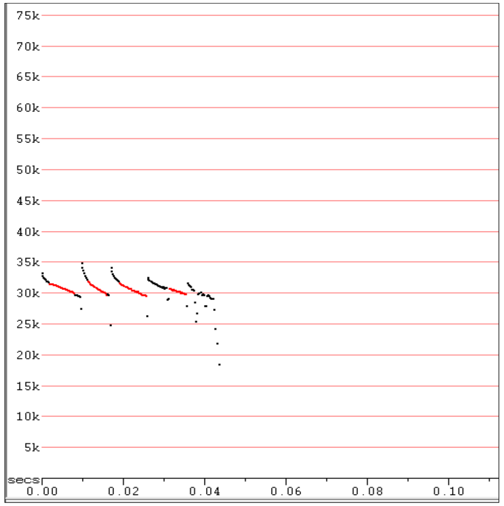
Sample calls extracted from theArriga Plateau survey data (RPS Townsville; May 2010)

Scale: 10 msec per tick; time between pulses removed (*AnalookW* F7 compressed mode)

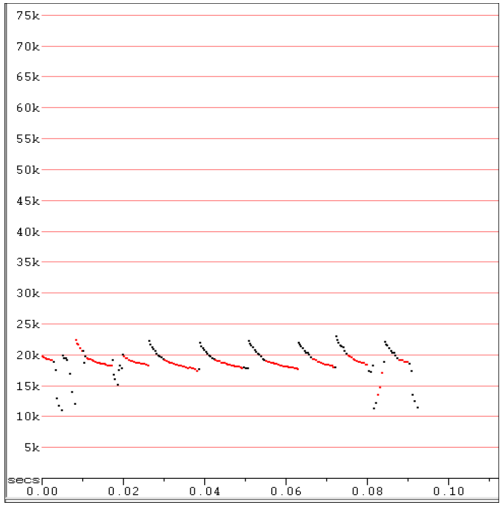
Species positively identified



Chaerephon jobensis

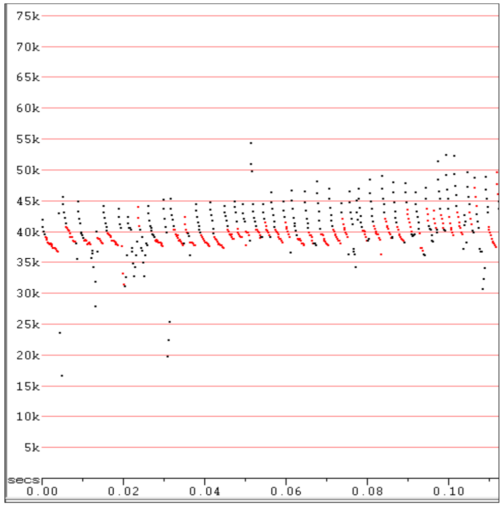


Mormopterus ridei

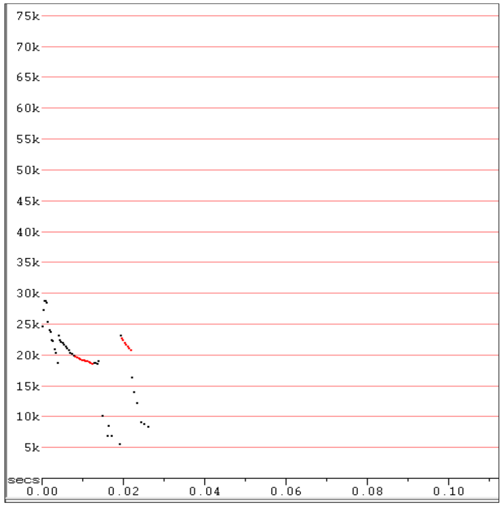


Saccolaimus flaviventris

Calls NOT positively identified



Chalinolobus nigrogriseus / S. sanborni



S. flaviventris / C. jobensis

Anabat echolocation data interpretation summary

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

Species identification summary:

Numbers in columns represent number of calls attributed to each species or species group

Detector:	AB01				AB03			RPS Zcaim			
Date:	**28-Mar**	**29-Mar**	**30-Mar**	**31-Mar**	**28-Mar**	**29-Mar**	**31-Mar**	**28-Mar**	**29-Mar**	**30-Mar**	**31-Mar**
Species positively identified											
Rhinolophus megaphyllus			3		7	1					
Chalinolobus gouldii							4				
Nyctophilus species	2	1	1			3			1		
Scotorepens orion	3	1	1		4	1			1		
Vespadelus troughtoni										1	
Miniopterus australis	1	1	6	1	33	15	6	3	5	2	3
Miniopterus orianae oceanensis	1	5	122	39	11	8	54	29	16	1	1
Chaerephon jobensis			3			1					
Mormopterus beccarii	2	4	5							1	
Saccolaimus flaviventris	2	3	7		2		2	3	2	2	
Total positively identified calls	11	15	148	40	57	29	66	35	25	7	4
Calls NOT positively identified *											
Scotorepens sanborni or *Chalinolobus nigrogriseus*	7	3	7		11	81		1	2	5	2
C. jobensis or *S. flaviventris*	1		1								
M. beccarii or *Taphozous troughtoni*	1		3								
M. beccarii or S. flaviventris	1		1								
S. flaviventris or ***S. saccolaimus*** or *T. troughtoni*			1								
Unidentified bat calls	1		10	1	5	10				1	
Total calls NOT positively identified	11	3	23	1	16	91	0	1	2	6	2
Total calls recorded	22	18	171	41	73	120	66	36	27	13	6

***** Species listed in this section and not above should be considered as possibly present in the study area.
See notes below regarding species identity for calls with poor resolution.

Prepared by Greg Ford
28/04/2011

P.O. Box 1744, Toowoomba QLD 4350

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

No call descriptions or key exists for the survey region; however, published keys and descriptions from other regions (Milne 2001; Reinhold *et al.* 2001; Pennay *et al.* 2004) were used to guide this analysis. Reference was also made to calls collected from bats of known identity in southern, central and north-eastern Queensland.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes - species/calls not reliably identified

***Nyctophilus* species**
The long-eared bats produce distinctive linear calls that are usually distinguishable from other species; however, the species within the genus *Nyctophilus* cannot be differentiated using Anabat data. Three species potentially occur in the survey area: *N. bifax* , *N. geoffroyi* and *N. gouldii* .

Scotorepens sanborni or Chalinolobus nigrogriseus
Calls from these species are virtually impossible to differentiate and both are likely to occur in the study area.

C. jobensis or S. flaviventris
Most calls from these bats are easy to distinguish; however, brief and/or weak calls in the frequency overlap zone (*ca.* 17-20kHz) can sometimes be confused. A few such calls from this survey could not be reliably identified.

M. beccarii or Taphozous troughtoni
These species overlap in frequency around 23-25kHz, but can usually be distinguished due to unique pulse shapes. *M. beccarii* was positively identified from a number of calls; however, a few low quality calls in the frequency range had insufficient definition in the pulse shape to reliably attribute to either species.

M. beccarii or S. flaviventris
Some attack-phase pulses from *S. flaviventris* are similar in appearance to the erratic, steep pulses of *M. beccarii* . Most calls were positively attributed to either species based on distinctive search-phase pulses, but a couple of noisy and weak calls could not be reliably differentiated.

S. flaviventris or S. saccolaimus or T. troughtoni
A single call from AB01 on 30/3 contains clear search-phase pulses like those of *S. flaviventris* , but the frequency is higher than expected for such a call (around 22kHz). It is possible that the call came from *T. troughtoni* , but that species usually generates flatter pulses than those exhibited in this call. With a frequency at *ca* . 22kHz and smoothly-curved, low-bandwidth pulses, it is considered highly probable that this call came from the endangered *S. saccolaimus* as they match the description provided by Corben (2010).

Unidentified bat calls
These were calls that were too brief and/or weak and/or noisy to allow reliable attribution to any species or species group. All such calls were within the frequency ranges of species otherwise listed in the table and are unlikely to represent additional species.

Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2010). Acoustic identification of *Saccolaimus* . *Proceedings of the 14th Australasian Bat Society Conference, Darwin, Australia, 12-14 July 2010* .

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

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Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales.* Department of Environment and Conservation, Hurstville.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

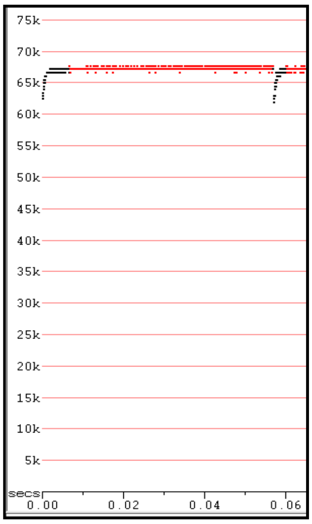
Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

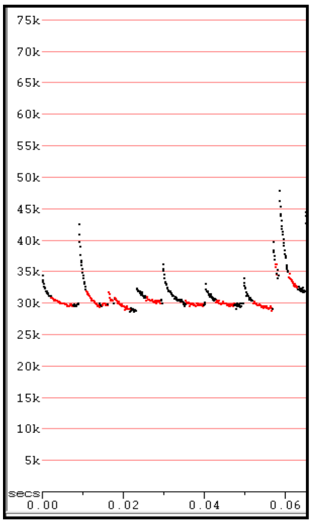
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

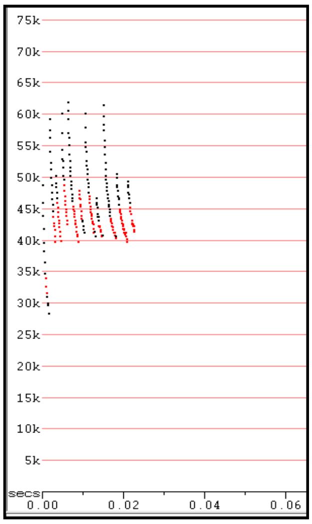
Species positively identified



Rhinolophus megaphyllus



Chalinolobus gouldii



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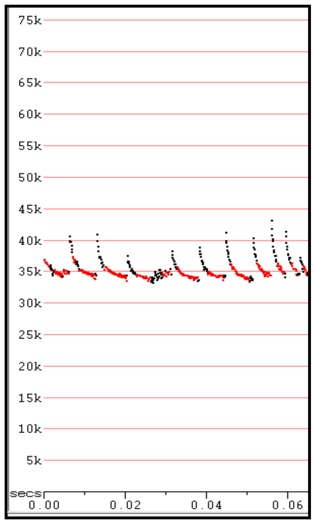
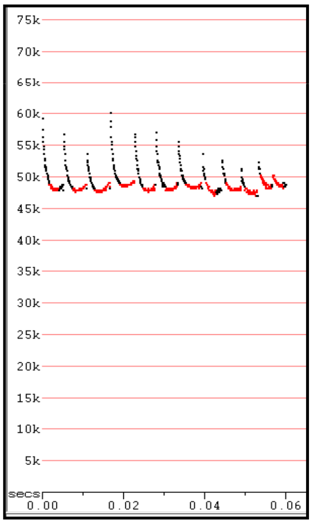
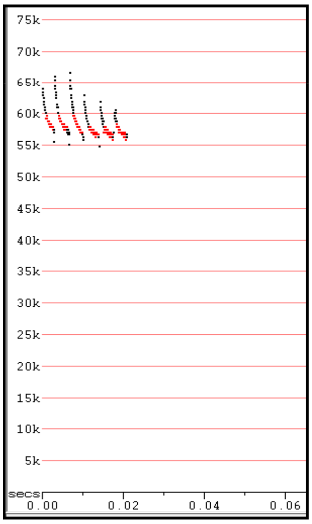


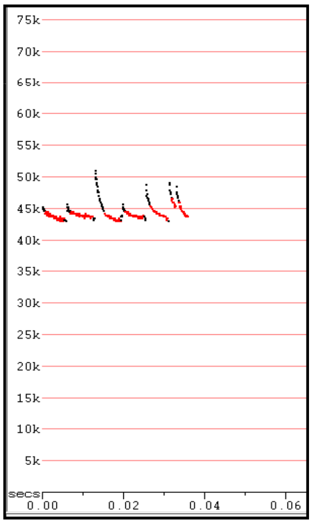
Scotorepens orion



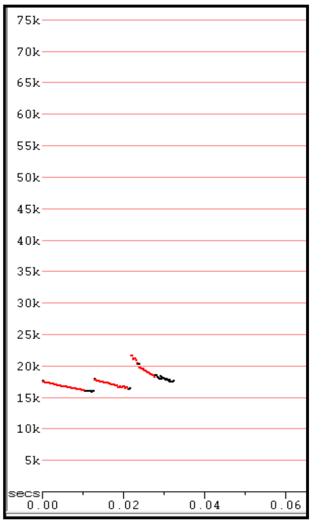
Vespadelus troughtoni



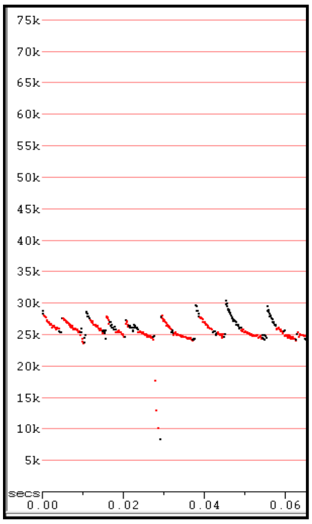
Miniopterus australis



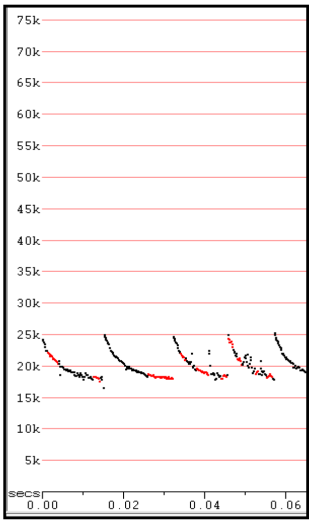
Miniopterus orianae oceanensis



Chaerephon jobensis



Mormopterus beccarii



Saccolaimus flaviventris

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Anabat Data Analysis Summary

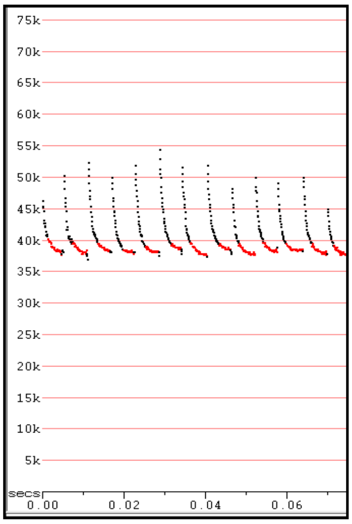
Client: RPS (Townsville) **Client reference:** PR100246-1 **Balance Job no.:** RPS-1104

Project name/location: Arriga Plateau, Atherton Tableland; 28-31 March 2011

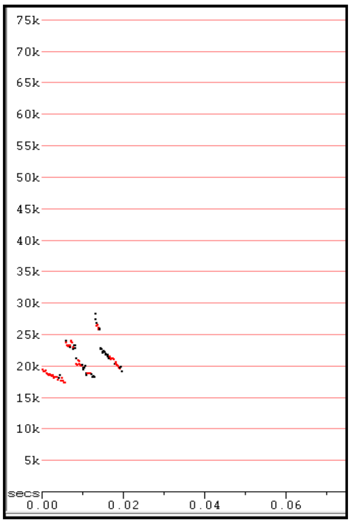
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

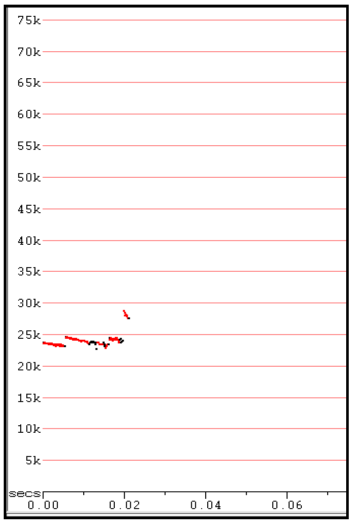
Calls not positively identified



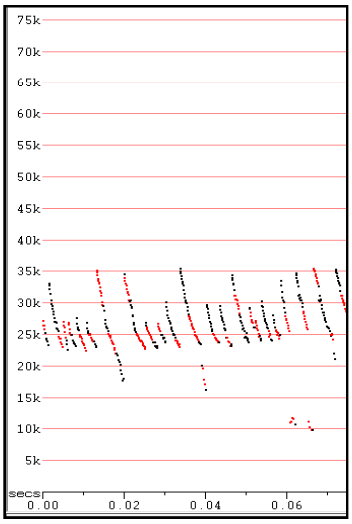
S. sanborni or *C. nigrogriseus*



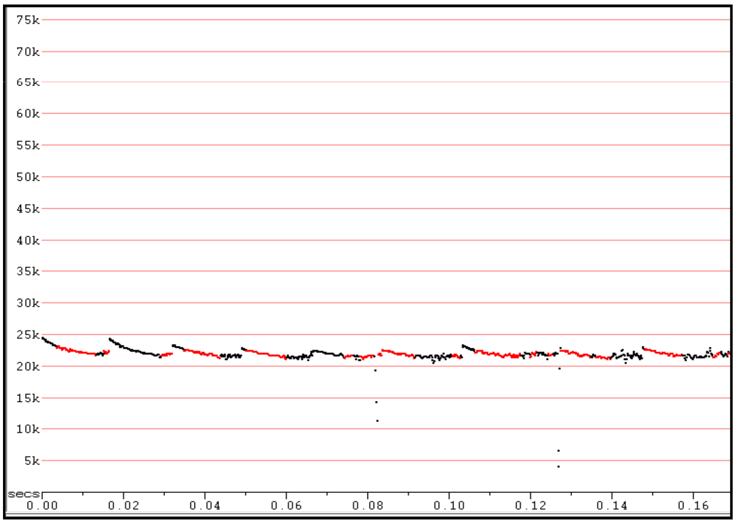
C. jobensis or *S. flaviventris*



M. beccarii or *Taphozous troughtoni*



M. beccarii or S. flaviventris



S. flaviventris or ***S. saccolaimus*** or *T. troughtoni*

Anabat Data Analysis Summary

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Data received for analysis

The echolocation call data analysed here was recorded using several Wildlife Acoustics SongMeter SM2BAT detectors (192kHz Stereo model).

Data was received as WAC files (Wildlife Acoustics proprietary lossless compression format), sorted by SM2BAT unit number or Turbine (site) number.

WAC files were converted to zero-crossing files (ZCA) using *WAC2WAV Version 3.2.3* (Wildlife Acoustics, 2011).

ZCA files were then viewed and calls identified in *AnalookW Version 3.7w* (Corben, 2009).

The WAC to ZCA conversion process generated very large data sets (2,000-10,000 ZCA files) for each detector; however, noise filters applied in *AnalookW* (and also in additional trials using *WAC2WAV*) produced relatively low numbers of files that actually contained bat calls(<100 per night per detector).

TABLE 1 Species identified from the Mt Emerald echolocation call data

Note: The following three SM2BAT detectors were operated with just one microphone connected to the ***Left*** channel and set at shrub level.

Detector	SM2BAT_005106				
Date	8/06/2011	9/06/2011	10/06/2011	11/06/2011	Total
Channel	left	left	left	left	Calls
Species					
Austronomus australis	2	8	6	17	33
Chaerephon jobensis		2			2
Chalinolobus nigrogriseus or *Scotorepens sanborni*	3	3		2	8
Miniopterus australis	4	7	2	8	21
Miniopterus orianae oceanensis	11	27	23	15	76
Mormopterus ridei					0
Rhinolophus megaphyllus		2			2
***Taphozous troughtoni* or *Saccolaimus* species**		**1**			1
Unidentified bat calls	7	11	4	7	29
Total calls recorded	27	61	35	49	172

Detector	SM2BAT_0057322			SM2BAT_005733	
Date	8/06/2011	9/06/2011	Total	8/06/2011	Total
Channel	left	left	Calls	left	Calls
Species					
Austronomus australis	1		1	4	4
Chaerephon jobensis			0	2	2
Chalinolobus nigrogriseus or *Scotorepens sanborni*	2		2		0
Miniopterus australis			0	13	13
Miniopterus orianae oceanensis	1	2	3	6	6
Mormopterus ridei			0		0
Rhinolophus megaphyllus			0		0
Taphozous troughtoni or *Saccolaimus* species			0		0
Unidentified bat calls	1		1	3	3
Total calls recorded	5	2	7	28	28

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Anabat Data Analysis Summary

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Table 1 (cont.)

Note: Both channels were used at the following turbine sites. ***Left*** channel microphone was placed at approximately 80m above ground level. ***Right*** channel microphone was placed at approximately 30m above ground level.

Detector	**Turbine #15**						
Date	1/06/2011		2/06/2011		3/06/2011		Total Calls
Channel	left	right	left	right	left	right	
Species							
Austronomus australis		3				3	6
Chaerephon jobensis							0
Chalinolobus nigrogriseus or *Scotorepens sanborni*		8				1	9
Miniopterus australis		4				1	5
Miniopterus orianae oceanensis		13		2		3	18
Mormopterus ridei						1	1
Rhinolophus megaphyllus							0
Taphozous troughtoni or *Saccolaimus* species							0
Unidentified bat calls		1		6			7
Total calls recorded	0	29	0	8	0	9	46

Detector	**Turbine #47**								
Date	1/06/2011		2/06/2011		3/06/2011		4/06/2011		Total Calls
Channel	left	right	left	right	left	right	left	right	
Species									
Austronomus australis	5		15	8	12	3	1	1	45
Chaerephon jobensis		3		1				1	5
Chalinolobus nigrogriseus or *Scotorepens sanborni*	2								2
Miniopterus australis									0
Miniopterus orianae oceanensis	1	1			1				3
Mormopterus ridei					1				1
Rhinolophus megaphyllus									0
Taphozous troughtoni or *Saccolaimus* species									0
Unidentified bat calls	9	8	17	4	20	1	7	1	67
Total calls recorded	17	12	32	13	34	4	8	3	123

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Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

Call identification for this data set was based on call descriptions and keys presented in Reinhold *et al.* (2001) and Milne (2002) as well as reference calls collected in eastern & northern Queensland and the Northern Territory.

Species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Notes on species present and reliably of call identification

POSSIBLE OCURRENCE OF THREATENED SPECIES - *SACCOLAIMUS SACCOLAIMUS*

Taphozous troughtoni or Saccolaimus species

The calls of these species are dificult to differentiate, as there is significant overlap in their characteristic frequency range and pulse shapes. Typical characteristics, extracted from available reference calls, are compared in Table 2.

A single call of fair quality, recorded on 9/6 by SM2BAT_005106, could have been from any of these three species.

A comparison of major call parameter means (t-test) between the Mt Emerald call and reference calls of these three species suggest it is significantly different from *S. saccolaimus* but that most parameters are not significantly different from either of the other species. It should be noted, however, that the Mt Emerald call only provided 10 pulses for this comparison. The P values for these t-tests are shown in Table 3.

Further analysis by plotting values for major parameters against one-another suggest the call is most similar to reference calls from *T. troughtoni*, although the spread of points for *S. saccolaimus* reference calls (D. Milne, NT specimens) further reduces the reliability of this analysis. See Figures 1-4 for this comparison.

TABLE 2 Typical call characteristics of *Taphozous troughtoni* and two *Saccolaimus species*

Species	*Pulse shape*	*Characteristic freq.*	*Maximum frequency*	*Pulse duration*
T. troughtoni	mostly curved; short initial sweep	21-23 kHz	24 kHz	3-10 ms
S. flaviventris	flat to curved; often steep initial sweep	18-21 kHz	28 kHz	5-15 ms
S. saccolaimus	flat to curved; no apparent steep initial sweep	20-23 kHz	27 kHz	10-25 ms

OTHER SPECIES IDENTIFIED IN THIS DATA SET

Austronomus australis

Calls are distinctive - lower frequency than most other species. Minor frequency overlap with *C. jobensis* (at ca. 14-17kHz), but calls from *A. australis* in overlap zone are 'approach-phase' with steep erratic pulses, *cf.* flat 'search phase' pulses from *C. jobensis*.

Chalinolobus nigrogriseus or Scotorepens sanborni

These two species produce very similar calls, with characteristic frequency around 36-40kHz, that are difficult to differentiate. Both species are likely to be present in the study area, so all relevant calls were considered to potentially represent either.

Chaerephon jobensis

Search phase calls have mainly flat pulses around 14-17kHz and are generally easy to identify. 'Approach phase' calls have steeper pulses that overlap in frequency with those of *Saccolaimus flaviventris* (around 17-21kHz), but which have erratic changes in pulse shape and frequency within the call sequence (*cf.* uniform pulses in *S. flaviventris*). All calls in the relevant frequency range were attributable to *C. jobensis* with no evidence of typical *S. flaviventris* calls.

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Miniopterus australis

Highly distinctive calls with characteristic frequency 56-60kHz - not possible to confuse with any other species that would occur in the study area.

Miniopterus orianae oceanensis

Distinctive calls around 44-48kHz, which are not likely to be confused with any other species that would be present in the study area.

Mormopterus ridei

Calls are fairly distinctive, with flat pulses and frequency range around 30-35kHz. Frequency overlaps with several other species that may be present (e.g. *Scoteanax rueppellii* , *Scotorepens orion*), but those species almost always have steep, curved pulses, rather than the flat pulses typical of *Mormopterus* species.

Rhinolophus megaphyllus

Cannot confuse this species with any other that would be present in the study area. It produces long-duration, constant-frequency pulses around 65-70kHz.

Unidentified bat calls

These were calls that contained only one or two pulses, usually of indeterminate shape, or incompletely recorded, or confused amongst background noise. All such calls were within frequency ranges of species listed above and are unlikely to indicate additional species present in the survey area.

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D. (2002). *Key to the Bat Calls or the Top End of the Northern Territory.* Technical Report No. 71; Parks and Willdife Commission of the Northern Territory; Darwin.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales* . Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Table 3 Results of t-tests for Mt Emerald suspect *Saccolaimus saccolaimus* call against reference calls for similar species.

	P values for call parameters										
	Dur	**TBP**	**Fmax**	**Fmin**	**Fmean**	**Tk**	**Fk**	**Tc**	**Fc**	**S1**	**Sc**
Mt Emerald & *S. saccolaimus* (NT)	0.1717	0.0000	0.0000	0.2127	0.1056	0.0099	0.1693	0.4254	0.5472	0.4233	0.0003
Mt Emerald & *T. troughtoni* (NW Qld)	0.0000	0.0000	0.0000	0.6402	0.0031	0.0576	0.0000	0.0000	0.1483	0.0000	0.0000
Mt Emerald & *S. flaviventris* (SEQld)	0.2233	0.0000	0.0000	0.0004	0.5600	0.0000	0.2290	0.1579	0.0006	0.0000	0.0000

Call parameter glossary:

Dur Pulse duration
Prev Time between pulses
Fmax Maximum frequency of pulses
Fmin Minimum frequency of pulses
Fmean Mean frequency of pulses
Tk Time to knee (from start of pulse to first significant change in slope)
Fk Frequency of knee (frequency at which pulse slope changes)
Tc Time from start of pulse to beginning of characteristic section ('body')
Fc Characteristic frequency (lowest frequency in the characteristic section)
S1 Slope of initial frequency sweep (before knee)
Sc Slope of characteristic frequency section

Prepared by Greg Ford

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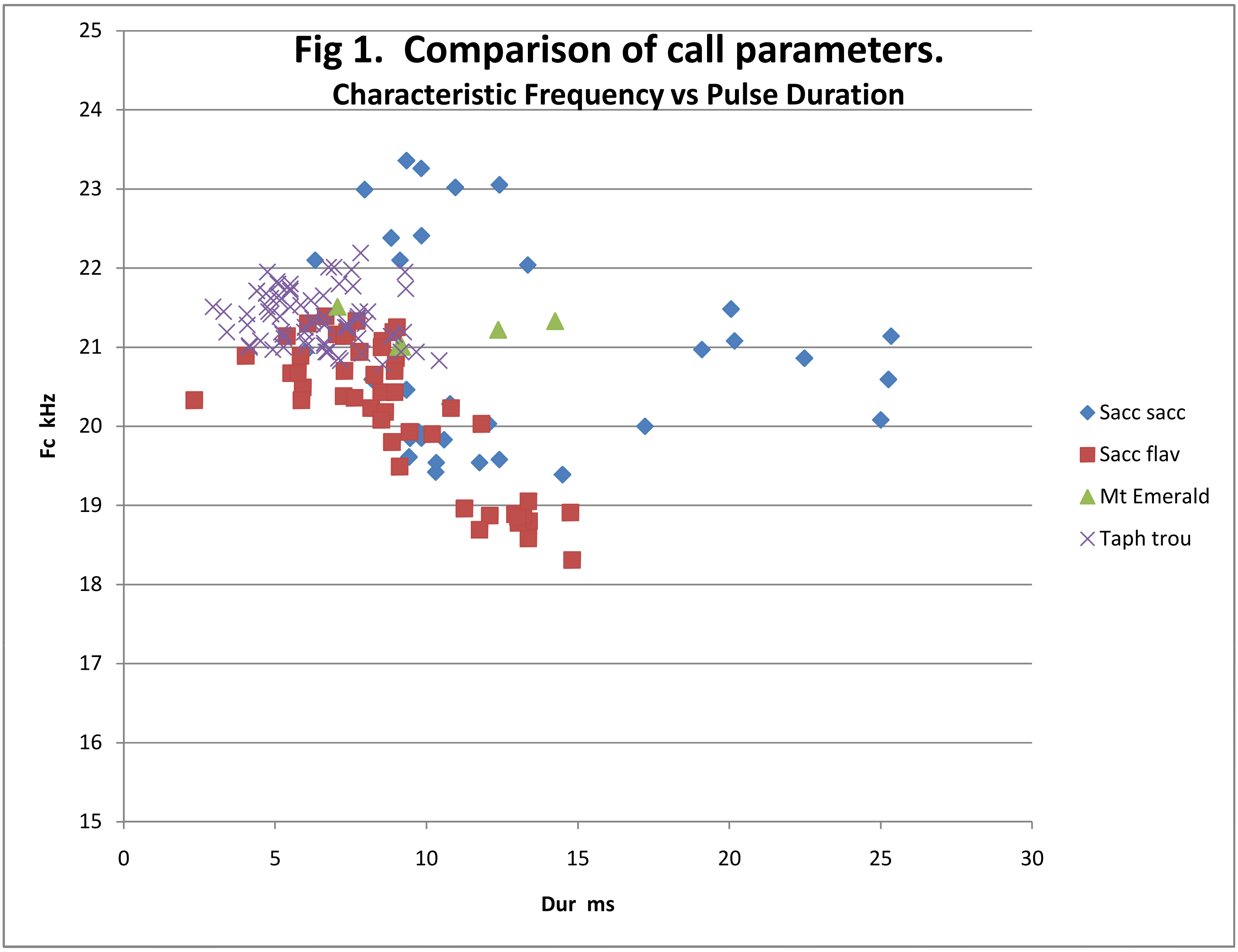
Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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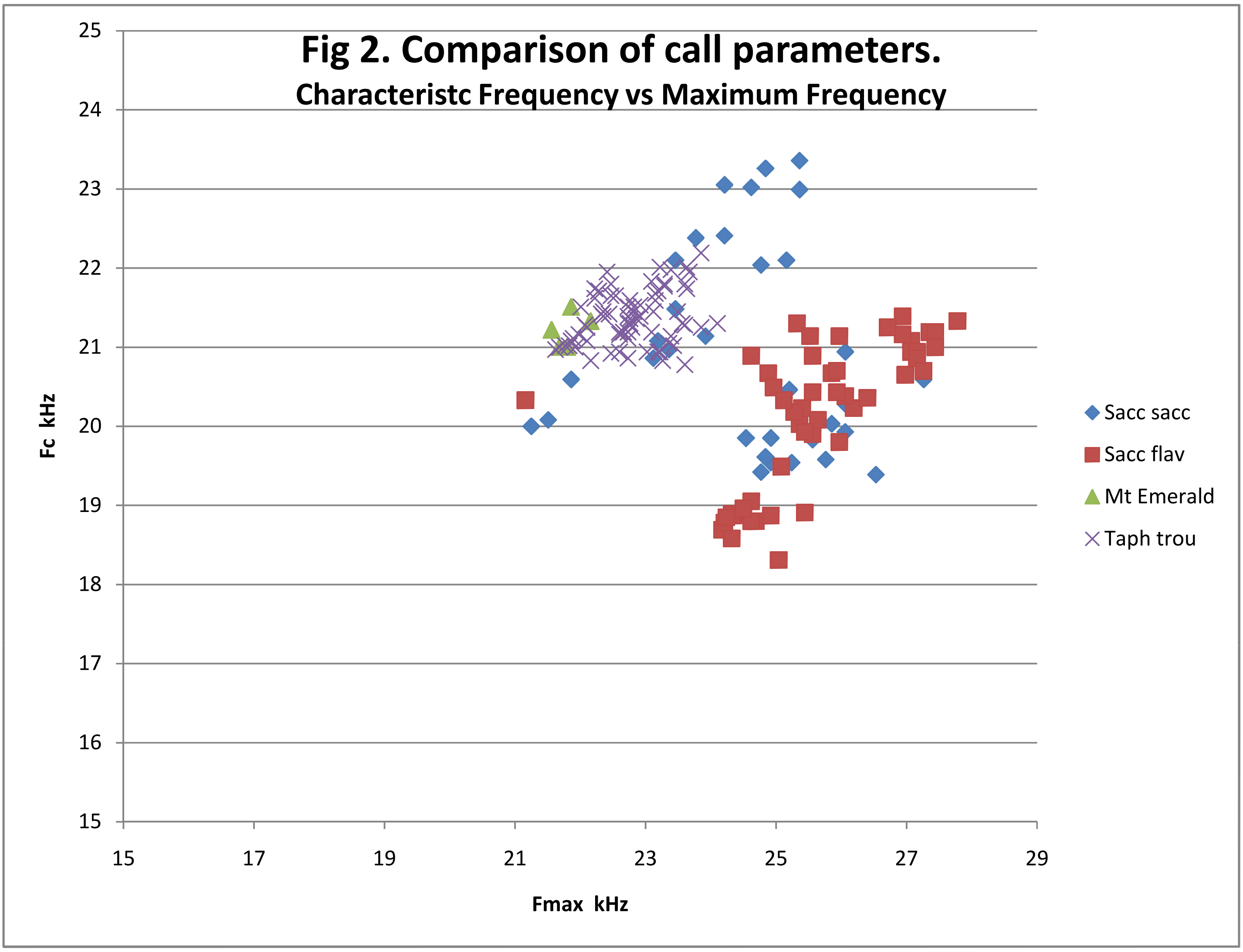
PO Box 1744, Toowoomba Qld 4350

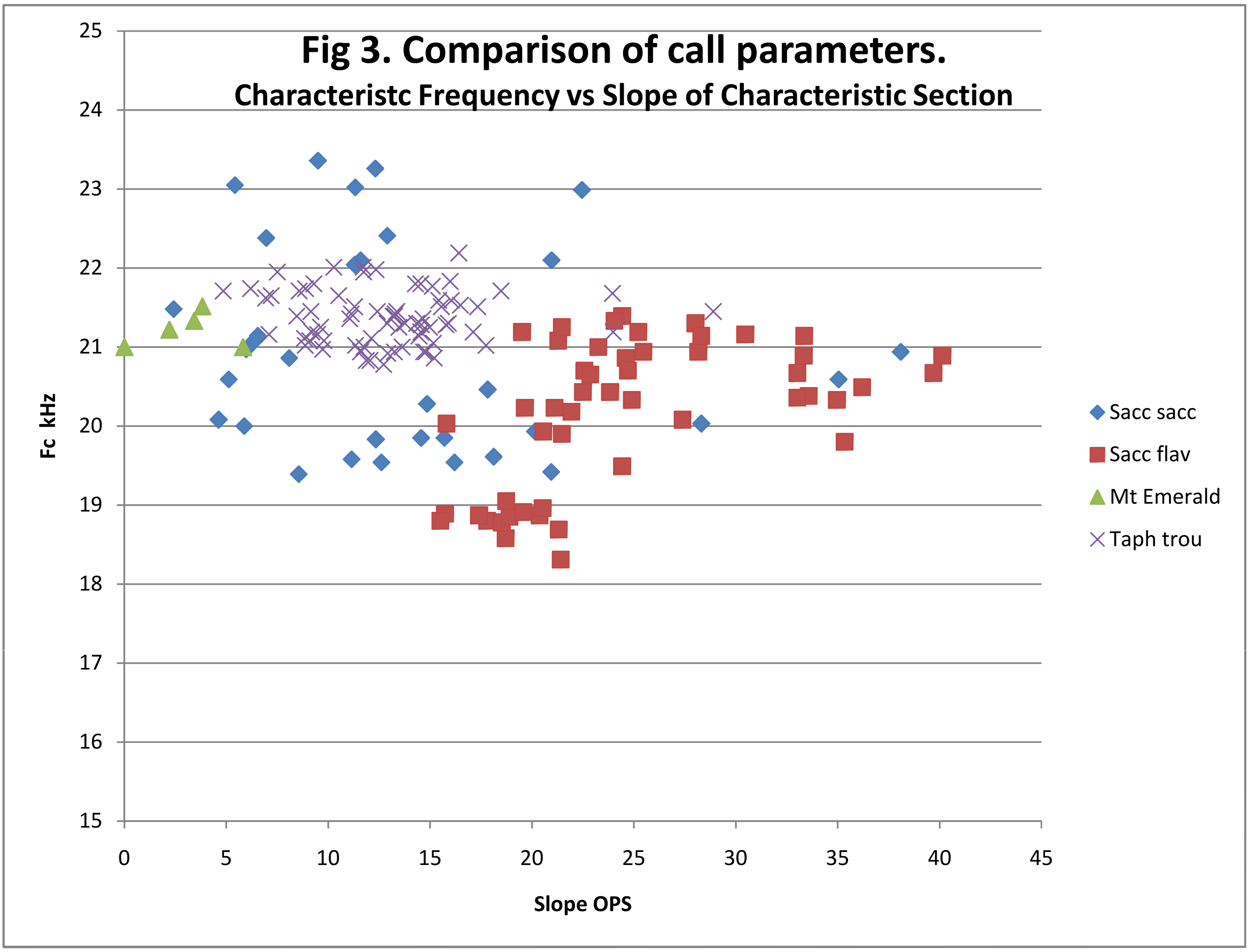
Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011



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Client: RPS Cairns **Contact**: Jeff Middleton **Job no.:** RPS-1106

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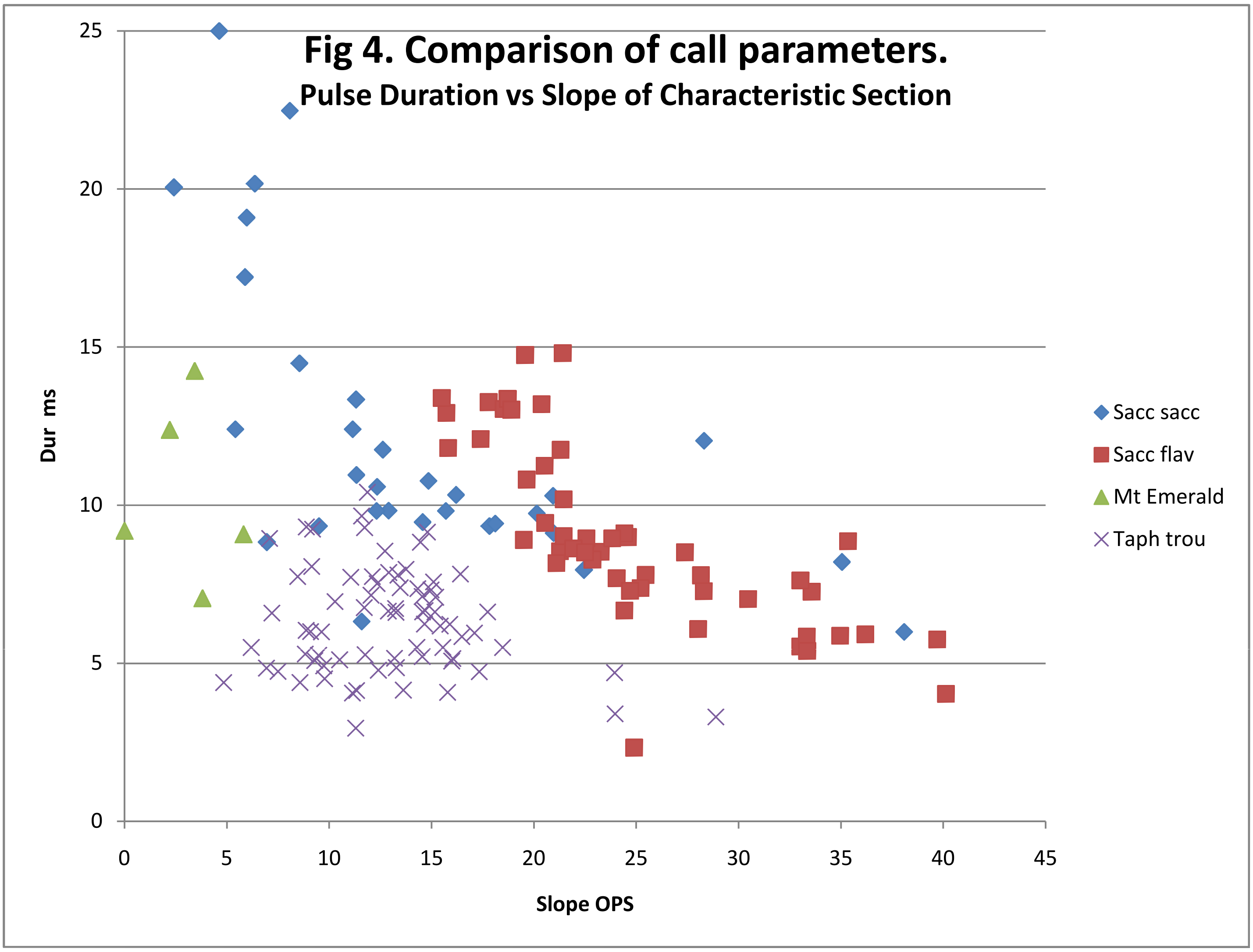

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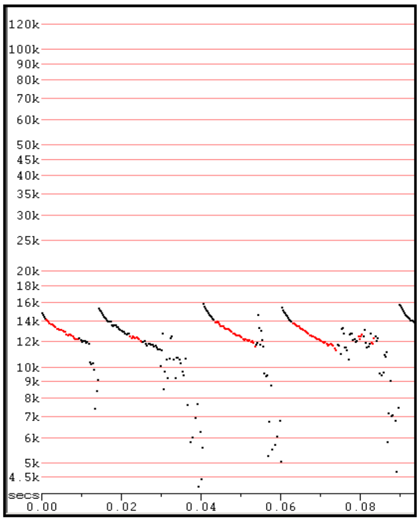
Anabat Data Analysis Summary

Client: RPS Cairns **Contact:** Jeff Middleton **Job no.:** RPS-1106

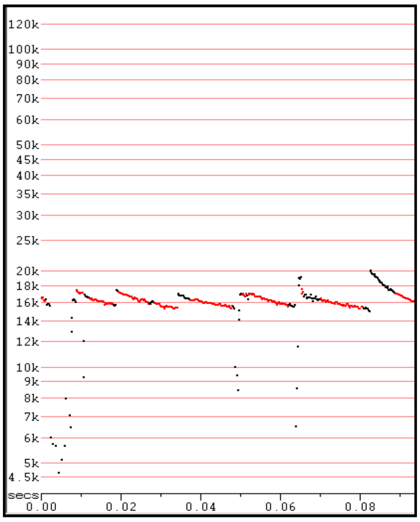
Survey Location & Period: Mt Emerald SM2BAT monitoring, June 2011

Sample calls extracted from the survey data

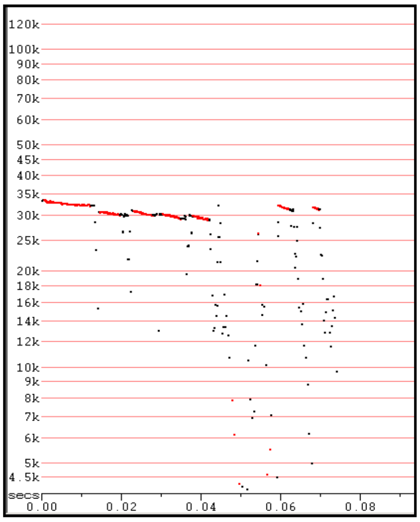
Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)



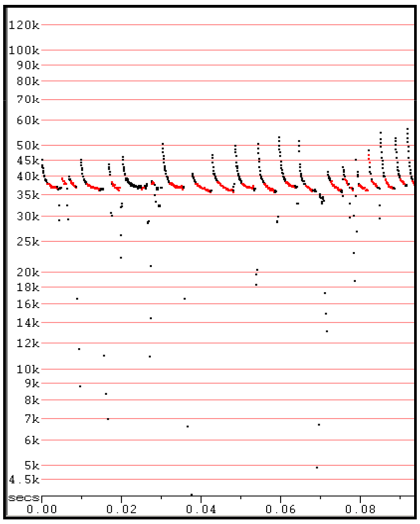
Austronomus australis



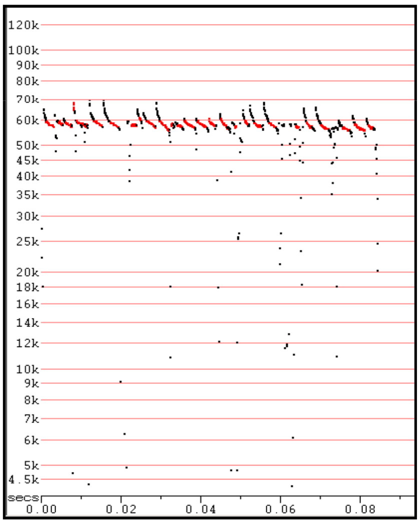
Chaerephon jobensis



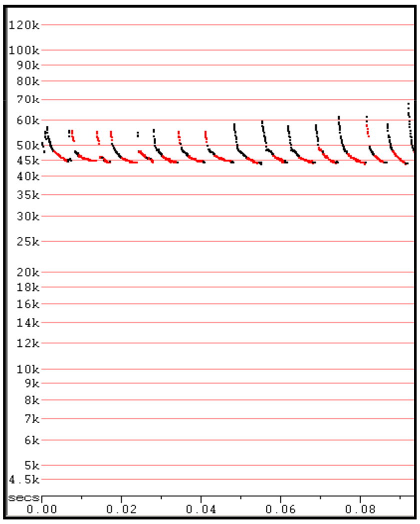
Mormopterus ridei



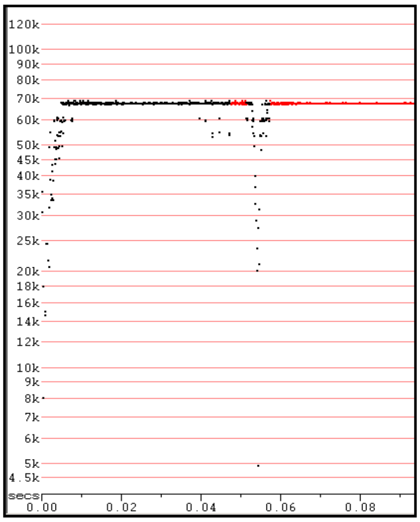
C. nigrogriseus or *S. sanborni*



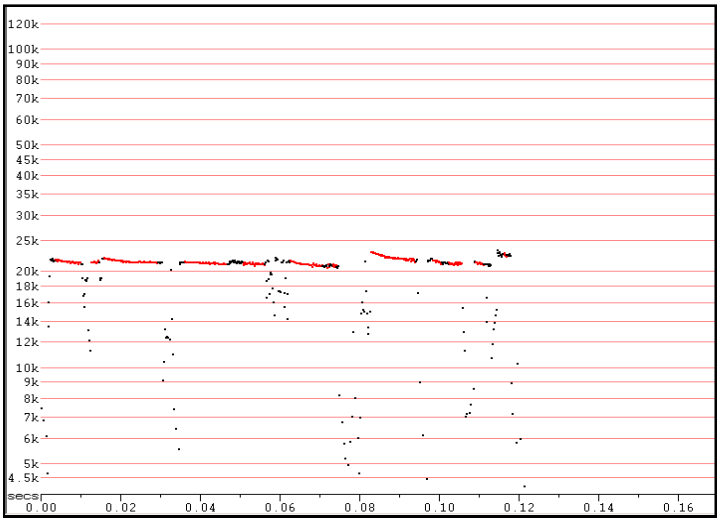
Miniopterus australis



Miniopterus orianae oceanensis



Rhinolophus megaphyllus



Taphozous troughtoni or *Saccolaimus* sp

Microbat Echolocation Call Analysis
Mt Emerald Wind Farm Supplementary - RPS Cairns

Call Parameter	Mean Values Sacsac Cairns reference calls	Mean Values MtEmerald call	P value for t test (2 tails, equal variance)
Dur	12.44252685	10.388	0.05448089
TBP	498.3324268	1479.938	0.00008132
Fmax	24.83718771	21.812	0.00000000
Fmin	22.19417687	21.054	0.15404314
Fmean	23.7098445	21.396	0.00000000
Tk	1.291834129	1.226	0.84852076
Fk	24.33355499	21.628	0.00000000
Tc	11.33818944	9.934	0.16408922
Fc	23.22302431	21.212	0.00000000
S1	38.04766689	-58.528	0.00012234
Sc	7.286603374	3.056	0.00000044
n calls	25	1	
n pulses	297	10	

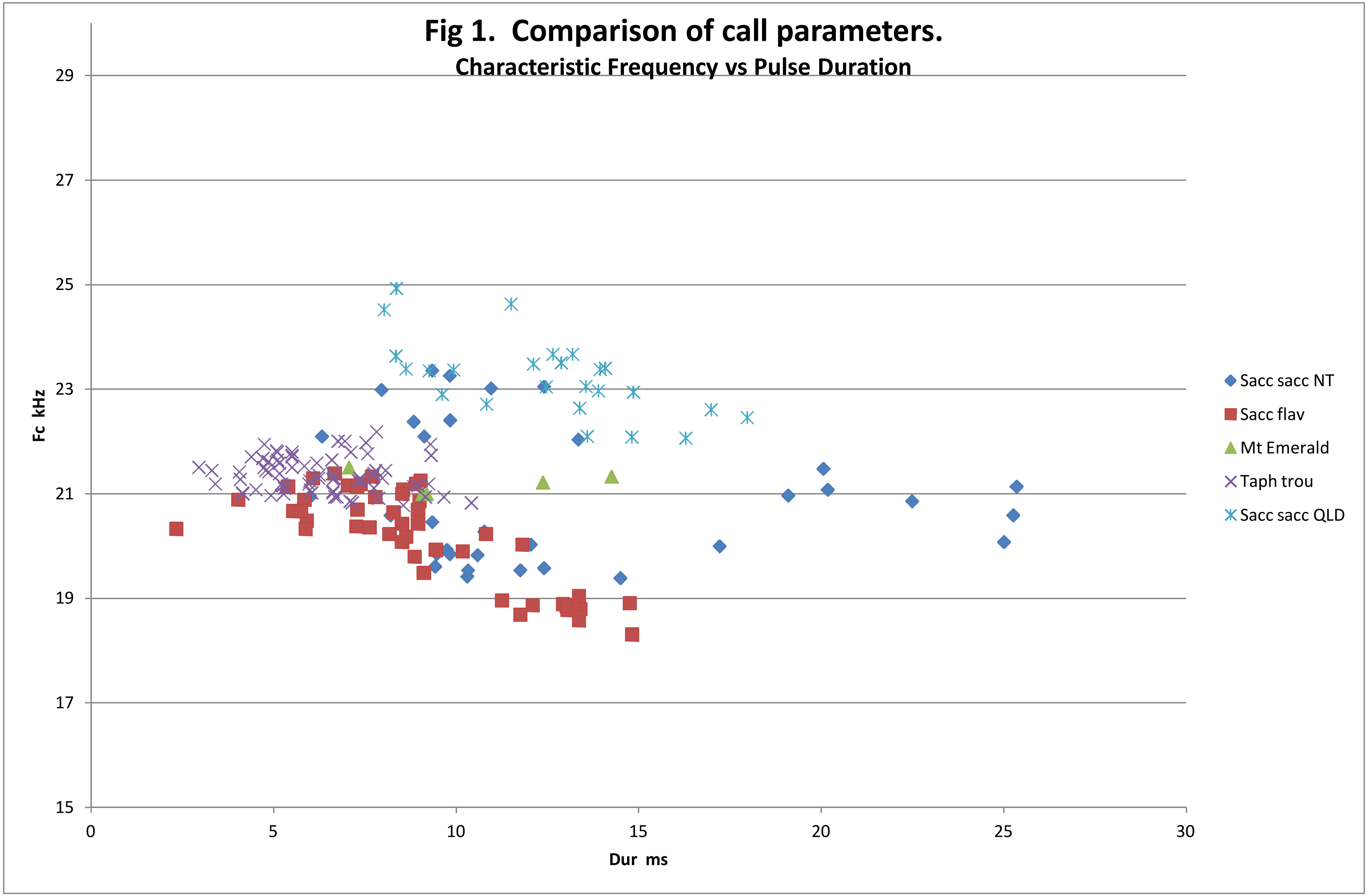


Fig 1. Comparison of call parameters.
Characteristic Frequency vs Pulse Duration
Fc kHz
29
27
25
23
21
19
17
15
0
5
10
15
20
25
30
Dur ms
Sacc sacc NT
Sacc flav
Mt Emerald
Taph trou
Sacc sacc QLD

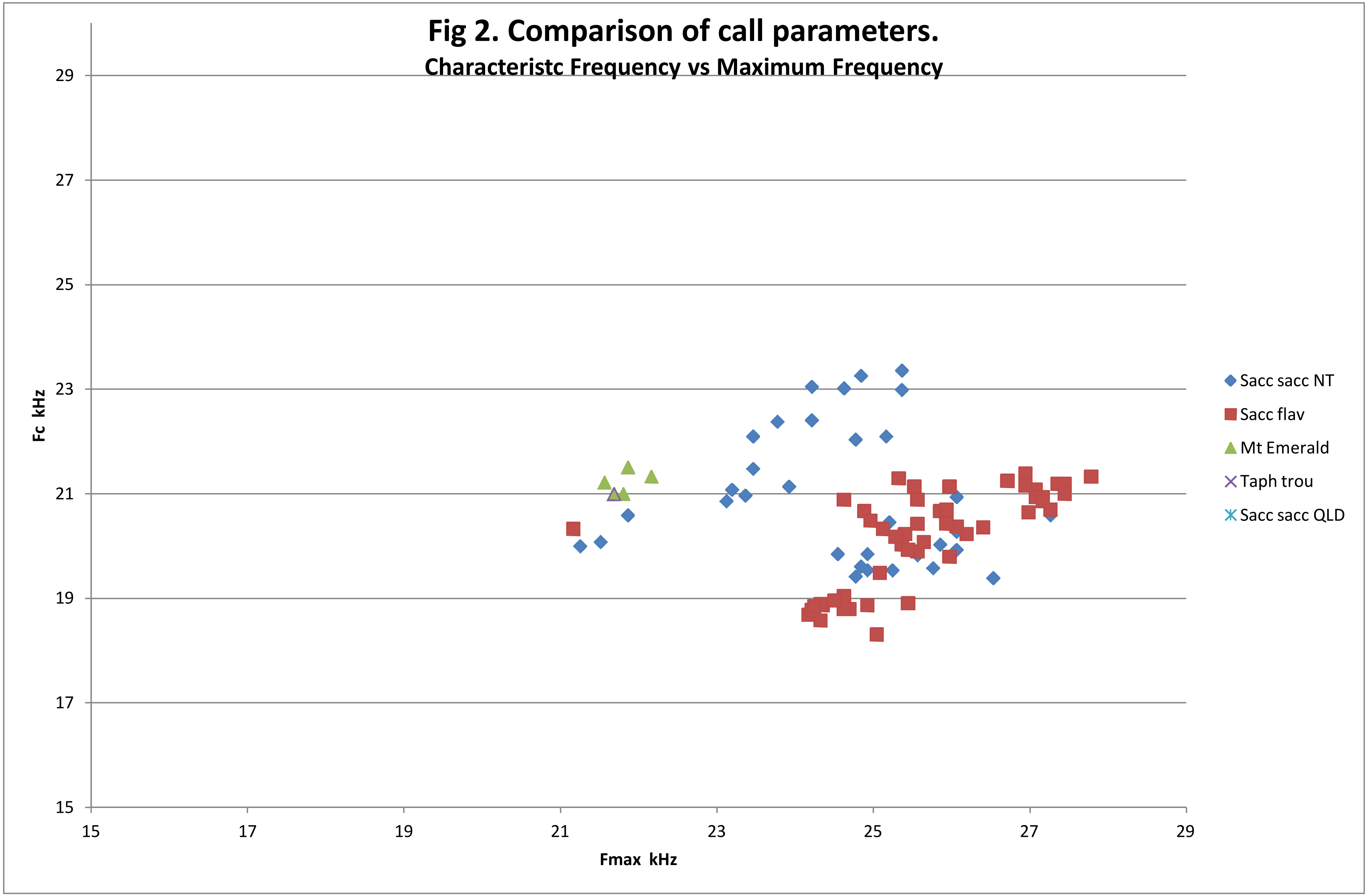


Fig 2. Comparison of call parameters.
Characteristc Frequency vs Maximum Frequency
Fc kHz
29
27
25
23
21
19
17
15
15
17
19
21
23
25
27
29
Fmax kHz
Sacc sacc NT
Sacc flav
Mt Emerald
Taph trou
Sacc sacc QLD

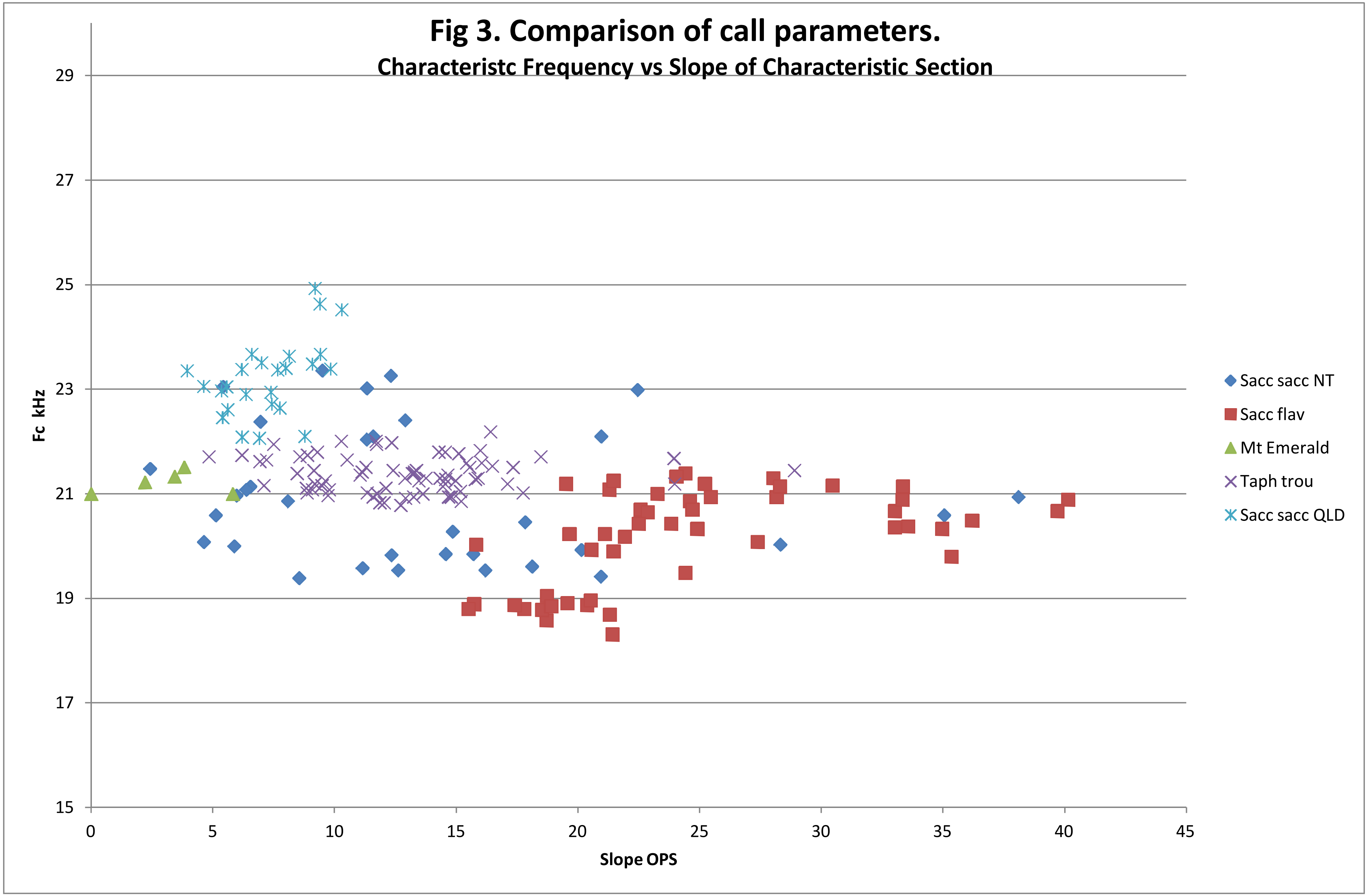


Fig 3. Comparison of call parameters.
Characteristc Frequency vs Slope of Characteristic Section
Fc kHz
29
27
25
23
21
19
17
15
0
5
10
15
20
25
30
35
40
45
Slope OPS
Sacc sacc NT
Sacc flav
Mt Emerald
Taph trou
Sacc sacc QLD

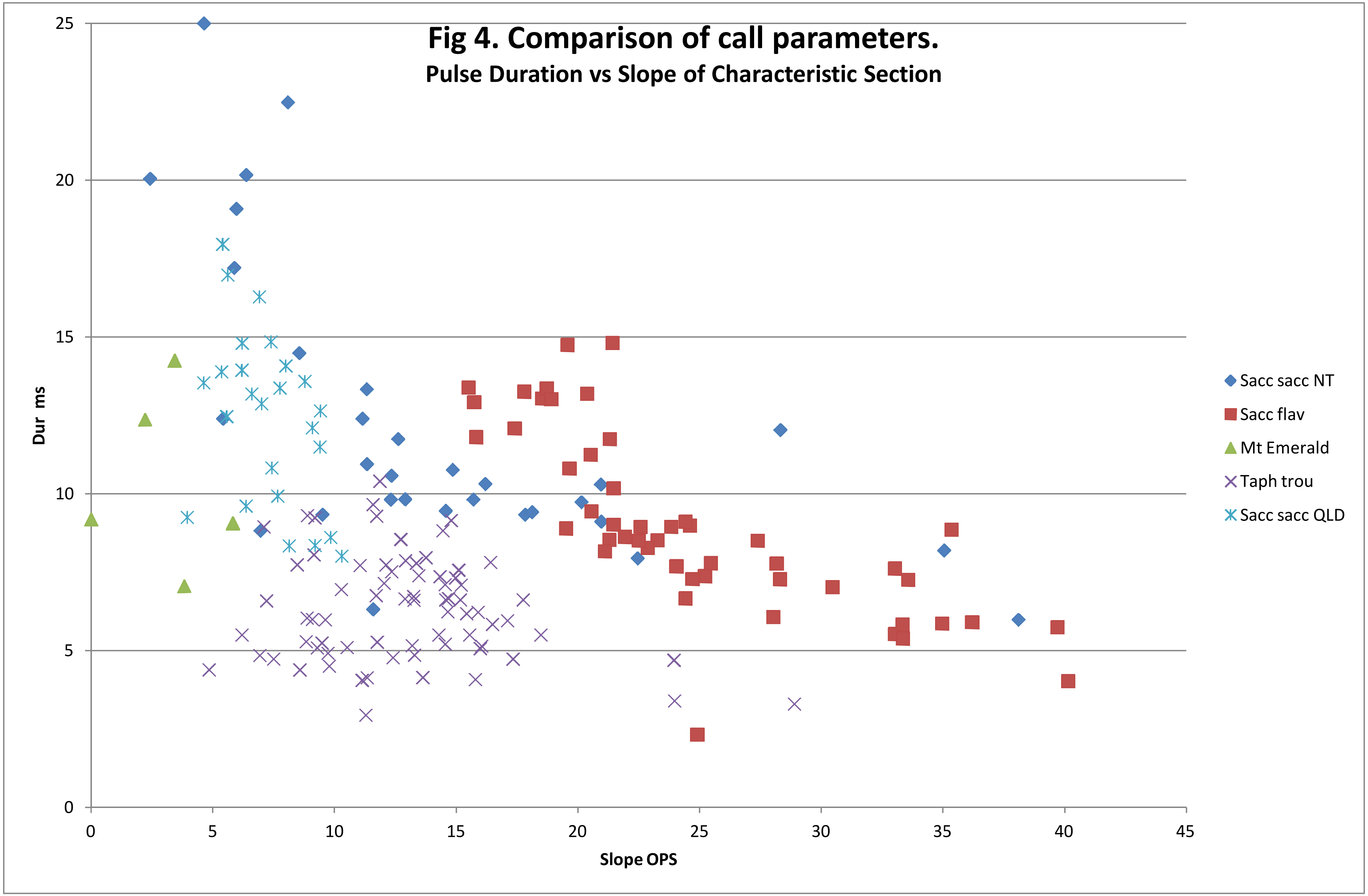


Fig 4. Comparison of call parameters.
Pulse Duration vs Slope of Characteristic Section
Dur ms
Slope OPS
0
5
10
15
20
25
30
35
40
45
Sacc sacc NT
Sacc flav
Mt Emerald
Taph trou
Sacc sacc QLD

Microbat Call Identification Report

Prepared for ("Client"):	RPS (Cairns)
Survey location/project name:	Mt Emerald Wind Farm
Survey dates:	
Client project reference:	PR100246-1
Job no.:	RPS-1303
Report date:	21 May 2013

Methods

Data receipt and processing

Bat calls were recorded using Song Meter detectors (Wildlife Acoustics, Concord MA, USA) and the full-spectrum data files were sent to *Balance! Environmental* for processing and analysis.

All full-spectrum data files were processed with Wildlife Acoustics' *Kaleidoscope* program (version 1.0.0) to produce Anabat sequence files (zero-crossing, or ZC, format) for the primary analysis and call identification. Where necessary, relevant data files were also converted to WAV files for secondary analysis of calls in full-spectrum format.

Dates attached to the data show the surveys were conducted from 20th to 28th February 2013.

Zero-crossing analysis

All Anabat sequence files were viewed using *AnalookW* (version 3.9f; Corben 2013), and species identification attempted on all calls that contained four or more distinct, non-fragmented pulses.

Species identification was achieved manually by comparing calls with published call descriptions (e.g. Reinhold *et al.* 2001; Milne 2002; Pennay *et al*. 2004) and/or with reference calls from Queensland and the Northern Territory.

Specialised *AnalookW* filters were also used to identify files potentially containing calls from the threatened bare-rumped sheath-tailed bat (*Saccolaimus saccolaimus*). These filters were based on call characteristics derived from *S. saccolaimus* reference calls recorded from Cairns in 2012.

Species' identities were also guided by considering their probability of occurrence based on general distribution information (e.g. Churchill 2008; van Dyck & Strahan 2008) and/or database records obtained from the Atlas of Living Australia (http://www.ala.org.au), Wildlife Online (http://www.ehp.qld.gov.au/wildlife/wildlife-online/index.html) and the Queensland Museum.

Full-spectrum analysis

All files identified as containing "possible" *S. saccolaimus* calls during the ZC analysis were subject to more detailed assessment using full-spectrum data (WAV files) in an effort to confirm the presence of *S. saccolaimus*. This species' calls appear very similar to those of several other bats in ZC data, but are somewhat more distinctive in full-spectrum format due to differences in harmonic range and pulse-repetition patterns.

The WAV files were analysed using *Song Scope* (version 4.1.1; Wildlife Acoustics) for both automated identification, using call recognisers built from reference calls collected in Cairns, and for manual identification (i.e. visual comparison of suspect sonograms with those of reference calls).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Armstrong & Reardon (2006).

Results & Discussion

Zero-crossing analysis

At least twelve microbat species were identified from the data set, with another two species potentially also present but not reliably identified due to inter-specific similarities in call characteristics.

Table 1 provides a breakdown of the species recorded by each of the eight detectors over the 8-night monitoring period. Where calls were recorded that may have been from more than one species, all potentially-responsible species are shown as "possibly present". Problems associated with call identification for these species, along with their likelihood of occurrence at the study site, are discussed in the next section.

Relative activity levels (numbers of calls attributed to each species) on each night of the monitoring period are presented for each detector in Appendix 1; and Appendix 2 shows example ZC sonograms extracted from this data set for each of the identified species.

Table 1. Microbats identified by zero-crossing analysis from the Mt Emerald Wind Farm February 2013 echolocation monitoring data.

Detector names relate to the primary folder names provided in the submitted data set.

♦ = species positively identified from call data

□ = species possibly present, but not reliably identified

Detector:	ARU + BAT7 010379	BAT1 010388	BAT2 010375	BAT3 010359	Bat4 010382	BAT5 010386	BAT6 010327	BAT7 010360
Species								
Chalinolobus gouldii	♦	♦	♦	♦	♦	♦	♦	
Chalinolobus nigrogriseus	♦	♦	♦	♦	♦	♦	♦	♦
Nyctophilus sp.							♦	
Scotorepens sanborni	♦	♦	♦	♦	♦	♦	♦	♦
Vespadelus troughtoni		♦	♦	♦	♦	♦		
Miniopterus australis	♦	♦	♦	♦	♦	♦	♦	
Miniopterus schreibersii	♦	♦	♦	♦	♦	♦	♦	♦
Tadarida australis	♦	♦	♦	♦	♦	♦	♦	♦
Chaerephon jobensis	♦	♦	♦	♦	♦	♦	♦	♦
Mormopterus beccarii	♦	♦	♦	♦	♦	♦	♦	♦
Mormopterus species 2	♦	♦	♦	♦	♦	♦	♦	♦
Saccolaimus flaviventris	♦				♦	♦	♦	
Saccolaimus saccolaimus	□	□	□		□	□	□	□
Taphozous georgianus	□	□	□	□	□	□		□

The majority of calls were reliably attributed to known species or pairs of indistinguishable species; however, a number of species were only identified tentatively due to incomplete knowledge of their call characteristics and/or because of the close similarities between some species' calls. Calls that could not be reliably identified due to these factors are attributed to a species group depending on pulse shape, band-width and characteristic frequency (Fc).

Species groupings used in this analysis for calls with low reliability of identification include:

- *Chalinolobus gouldii / Mormopterus* sp. 2;
- *Chalinolobus nigrogriseus / Scotorepens sanborni*;
- *Nyctophilus* spp.;
- *Chaerephon jobensis / Saccolaimus flaviventris*; and
- *Mormopterus beccarii / Saccolaimus saccolaimus / Taphozous australis*.

Where a species group is identified, all species within the group are listed as "possible" in the results; however, if a species within the group was also identified positively from other calls recorded in the same session, then it is listed as such. Identification issues and probability of occurrence for the various group members is discussed below.

C. gouldii / Mormopterus sp. 2

Characteristic frequency (Fc) overlaps (*C. gouldii* Fc=28-34 kHz; *M*. sp. 2 Fc=32-36 kHz), but calls are usually differentiated on the basis of steep, broad-band (*C. gouldii*) versus flat, narrow-band (*Mormopterus*) pulse shapes. However, some brief and/or low-quality calls had pulses of intermediate shape that could have belonged to either of these species.

Chalinolobus nigrogriseus / Scotorepens sanborni

Characteristic frequency (36-40 kHz) and pulse shapes are almost identical in these species and calls are difficult to discriminate. Some *C. nigrogriseus* calls have a flatter pulse body of relatively longer duration than those observed in *S. sanborni* and this feature was used to identify a number of calls to *C. nigrogriseus* for most sessions. Calls with uniformly short duration and curved to cup-shaped bodies were attributed to *S. sanborni*; however, many calls in the relevant frequency range had intermediate pulse characteristics and could have been from either species.

Nyctophilus species

These species' calls are readily distinguished from those of other bats; however, the species within the genus *Nyctophilus* cannot be reliably differentiated from each. Three *Nyctophilus* species potentially occur in the study area, including *N. geoffroyi*, *N. gouldi* and *N. bifax* and any or all of them could have been responsible for the recorded calls.

Chaerephon jobensis / Saccolaimus flaviventris

Frequencies overlap around 17-20 kHz, but *S. flaviventris* pulses are generally uniform and gently-curved, whereas those of *C. jobensis* are more erratic and range from flat to steeply curved within the same sequence. Numerous calls were readily identifiable to each species, but for some sessions, only a few calls with intermediate features were recorded.

Mormopterus beccarii / Saccolaimus saccolaimus / Taphozous georgianus

M. beccarii was positively identified for most sessions from calls with distinctive curved pulses and Fc in the range 24-27 kHz. This frequency range, however, overlaps with that of both *S. saccolaimus* and *T. australis* and some calls had flatter pulses that could have been from one or other of these species.

A small number of calls from several sessions had relatively short-duration, flat pulses around 23-24 kHz and were thought to probably be from *T. georgianus*.

When viewed in zero-crossing format in *AnalookW*, many calls recorded by all detectors had characteristics similar to those of reference calls recorded from *S. saccolaimus* in Cairns. These calls had Fc=22-24 kHz with long-duration pulses that were flat to slightly curved. Such calls are thought to be highly likely from *S. saccolaimus*; however, *M. beccarii* sometimes also produces calls of this type, so the identity of these calls was not conclusive.

Full-spectrum analysis – was *Saccolaimus saccolaimus* present?

Detailed analyses of all calls in the 20-27 kHz frequency range were carried out in an attempt to confirm the presence of *S. saccolaimus*. Numerous files potentially containing *S. saccolaimus* calls were identified by applying *AnalookW* filters to the ZC files and *Song Scope* call recognisers to both ZC and WAV data sets (see Table 2). However, when the full-spectrum sonograms for these files were viewed in *Song Scope*, none contained the diagnostic features typified by the reference call set collected in Cairns.

The key diagnostic criteria used for *S. saccolaimus* calls (see example sonograms at Fig 1) include:

- dominant harmonic with characteristic frequency around 22-25 kHz;
- at least 3 and up to five distinct harmonics at approximately 13 kHz intervals (1 below and up to 3 above the dominant harmonic); and
- call pulses sometimes in “triplet” sets with pulse intervals of approximately 10-20ms between first and second pulses and 20-40ms between second and third pulses and an inter-triplet interval of about 80-100ms.

Table 2. Number of "possible" *Saccolaimus saccolaimus* calls recorded on each night by eight detectors at the Mt Emerald Wind Farm site during February 2013.

Detector names relate to the primary folder names provided in the submitted data set.

Detector	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
aru-bat7	2		1	22	1	1		1	
bat 1				6			1		3
bat 2		1	1	2				4	2
bat 3				51	1	1			2
bat 4	1			10		4	4	7	3
bat 5	7		2	17		1	1		10
bat 6	1	1			1	1			1
bat 7				3		1		2	1

All of the "possible" *S. saccolaimus* calls had either no evidence of additional harmonics or just a single harmonic at approximately 20 kHz above the dominant harmonic (which had Fc = 23-25 kHz). furthermore, there was no evidence of triplet pulse patterns, rather pulses were either uniformly spaced or erratic in nature. A typical example of these "possible" calls is shown in the sonogram at Figure 2.

The characteristics exhibited by the "possible" *S. saccolaimus* calls are all considered more typical of *Mormopterus beccarii*, for which numerous other calls were positively identified during the zero-crossing analysis.

It is concluded, therefore, that *S. saccolaimus* was probably not recorded on any detector during the February 2013 surveys at the Mt Emerald Wind Farm site.

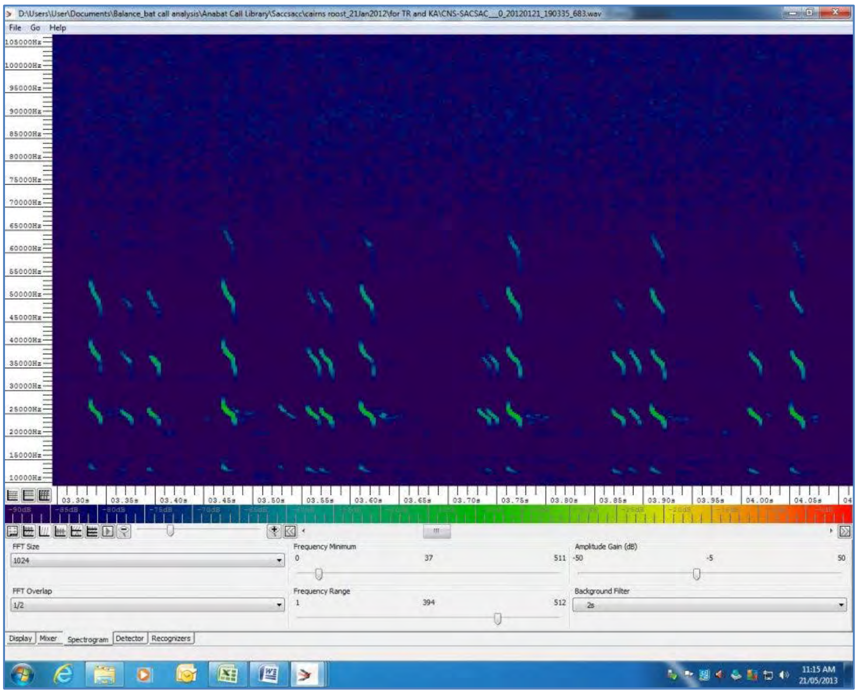


Figure 1. *Song Scope* sonogram of *Saccolaimus saccolaimus* reference call, showing multiple harmonics and pulse triplets described in text.

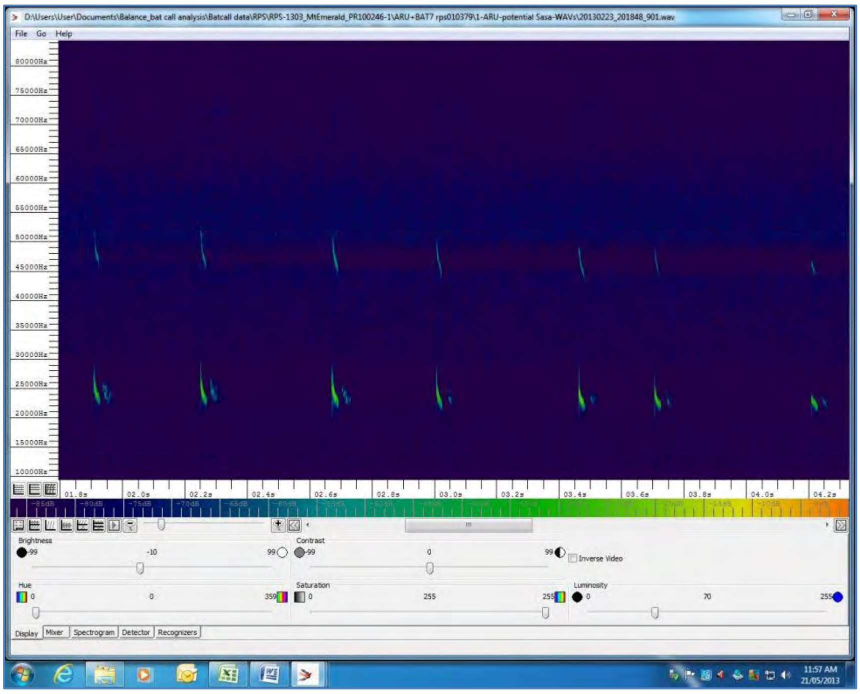


Figure 2. *Song Scope* sonogram of typical "possible" *S. saccolaimus* call from the Mt Emerald data set. Note only one additional harmonic and somewhat uniform repetition of single pulses. The call is probably from *Mormopterus beccarii*.

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Appendix 1. Relative activity levels of microbats (number of calls positively identified) at the Mt Emerald Wind Farm site during February 2013.

Detector:	ARU+BAT7 rps010379								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	25	16	45	72	23	29	51	41	0
No. calls identified:	23	11	34	61	21	26	49	37	0
SPECIES									
Chalinolobus gouldii	1		4	2			1		
Chalinolobus nigrogriseus	1	1	1	4		5	9	7	
Nyctophilus sp.									
Scotorepens sanborni	3	2	6	3	7	8	9	15	
Vespadelus troughtoni									
Miniopterus australis	7	4	6		2	1	17	3	
Miniopterus schreibersii	1	1	2	5	3		1		
Tadarida australis				1					
Chaerephon jobensis			2			1	3		
Mormopterus beccarii	2	1	1	10	1	1	1	1	
Mormopterus species 2	4		2			1	1	4	
Saccolaimus flaviventris	1								

Detector:	BAT1 rps010388								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	181	56	36	94	165	123	59	68	191
No. calls identified:	35	0	26	66	10	15	46	62	33
SPECIES									
Chalinolobus gouldii				4				1	
Chalinolobus nigrogriseus								7	
Nyctophilus sp.									
Scotorepens sanborni	6		4	1	1				
Vespadelus troughtoni				2			1	2	
Miniopterus australis	13		9	5	4	3	3	10	3
Miniopterus schreibersii	1		5	11	2	2	3	23	2
Tadarida australis	2			14		2	26	7	12
Chaerephon jobensis				7			1	3	5
Mormopterus beccarii				2					
Mormopterus species 2	9		2	8		8	4	3	7
Saccolaimus flaviventris									

Appendix 1. Relative activity levels of microbats (number of calls positively identified) at the Mt Emerald Wind Farm site during February 2013.

Detector:	**BAT2 rps010375**								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	23	589	11	35	24	14	71	94	65
No. calls identified:	13	24	8	15	7	8	65	88	43
SPECIES									
Chalinolobus gouldii	1		2	2	4		3	2	
Chalinolobus nigrogriseus		1	1	2	1	3		1	1
Nyctophilus sp.									
Scotorepens sanborni						1	19	3	8
Vespadelus troughtoni	5	18					17	5	
Miniopterus australis			1					2	
Miniopterus schreibersii			1	2	1	1	5	2	
Tadarida australis		1	2	1	1	1	3	59	23
Chaerephon jobensis	3		1	1		1	5	6	2
Mormopterus beccarii		1						4	1
Mormopterus species 2				2				1	3
Saccolaimus flaviventris									

Detector:	**BAT3 rps010359**								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	130	64	153	935	108	104	107	86	173
No. calls identified:	123	54	145	608	95	89	84	79	152
SPECIES									
Chalinolobus gouldii	24	1	10	22	10	1	2		11
Chalinolobus nigrogriseus	5		12	8	1		1		
Nyctophilus sp.									
Scotorepens sanborni	9	7	14	12	15	8	1	13	6
Vespadelus troughtoni	1						6		
Miniopterus australis	26	3	2	11	5	4	5	6	2
Miniopterus schreibersii	3	7	35	34	3	1	3		4
Tadarida australis			2	79	12	8	31	7	74
Chaerephon jobensis			1			4		4	5
Mormopterus beccarii				167	1	2		6	1
Mormopterus species 2	34	5	5	120	12	25	11	17	20
Saccolaimus flaviventris									

Appendix 1. Relative activity levels of microbats (number of calls positively identified) at the Mt Emerald Wind Farm site during February 2013.

Detector:	Bat4 rps010382								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	107	153	77	193	67	88	188	68	83
No. calls identified:	91	144	76	190	35	81	183	56	75
SPECIES									
Chalinolobus gouldii	4			8	1	13	1	3	
Chalinolobus nigrogriseus				7	2	4	12	4	1
Nyctophilus sp.									
Scotorepens sanborni	65	124	62	79	16	29	19	5	6
Vespadelus troughtoni				2			1		1
Miniopterus australis	3	3	4	3		3	10	2	3
Miniopterus schreibersii	2		1	17	4	3	7	5	2
Tadarida australis	1					2	5		5
Chaerephon jobensis				4		1	12	1	3
Mormopterus beccarii		2		2		3	4	1	1
Mormopterus species 2	2	2	1	2		6	6	12	9
Saccolaimus flaviventris							1	1	

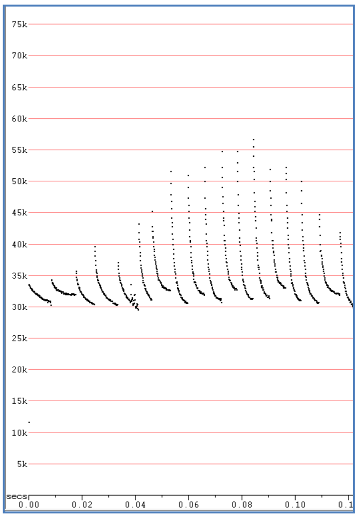
Detector:	BAT5 rps010386								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	444	225	417	152	199	180	151	66	115
No. calls identified:	408	1	370	140	92	172	145	58	74
SPECIES									
Chalinolobus gouldii	44		24	16	6	33	2	11	4
Chalinolobus nigrogriseus	3		1	1		1	1	1	
Nyctophilus sp.									
Scotorepens sanborni	54		37	26	10	4	7	1	6
Vespadelus troughtoni			1				2	1	
Miniopterus australis	16		4	4	3	5	5	4	3
Miniopterus schreibersii	3		1	1	1	2	1	1	
Tadarida australis			3		1		1		11
Chaerephon jobensis						2	12		2
Mormopterus beccarii	3		3	21		3	1	2	7
Mormopterus species 2	5		21	10	6	12	21	4	13
Saccolaimus flaviventris								2	

Appendix 1. Relative activity levels of microbats (number of calls positively identified) at the Mt Emerald Wind Farm site during February 2013.

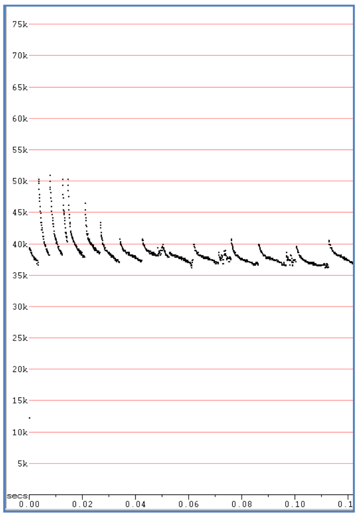
Detector:	BAT6 rps010327								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	67	97	51	38	43	37	61	33	66
No. calls identified:	61	85	44	39	35	37	58	32	59
SPECIES									
Chalinolobus gouldii	6	2	1	2	7	2	1		1
Chalinolobus nigrogriseus		1	1		1	1	1		
Nyctophilus sp.				1					
Scotorepens sanborni	11	25	2	5	10	1	14	15	12
Vespadelus troughtoni									
Miniopterus australis	3	3	2	2		1	2		4
Miniopterus schreibersii	3	6		14			1	1	5
Tadarida australis				2		1	10		5
Chaerephon jobensis	1	1	1	4		2	5		1
Mormopterus beccarii	4	4			1	12	4		
Mormopterus species 2					2			1	1
Saccolaimus flaviventris							2		1

Detector:	BAT7 rps010360								
Date:	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Total sequence files:	3	2	2	11	5	9	4	6	13
No. calls identified:	3	0	2	9	5	8	4	6	14
SPECIES									
Chalinolobus gouldii									
Chalinolobus nigrogriseus									
Nyctophilus sp.									
Scotorepens sanborni				1				2	
Vespadelus troughtoni									
Miniopterus australis									
Miniopterus schreibersii					1	1			1
Tadarida australis				1			2	2	11
Chaerephon jobensis			1			1	1		
Mormopterus beccarii				3		1		2	
Mormopterus species 2					2	3			
Saccolaimus flaviventris									

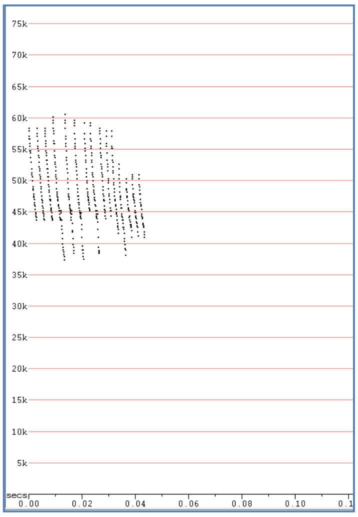
Appendix 2. Representative Anabat call sequences recorded at Mt Emerald, February 2013.
(10msec per tick; time between pulses removed)



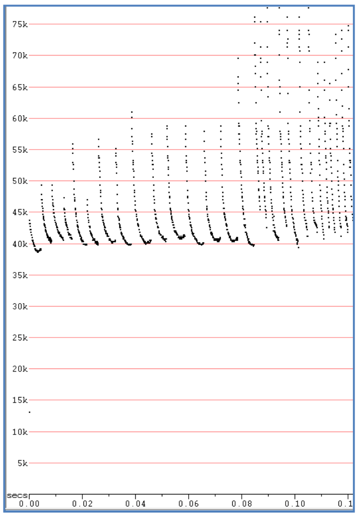
Chalinolobus gouldii



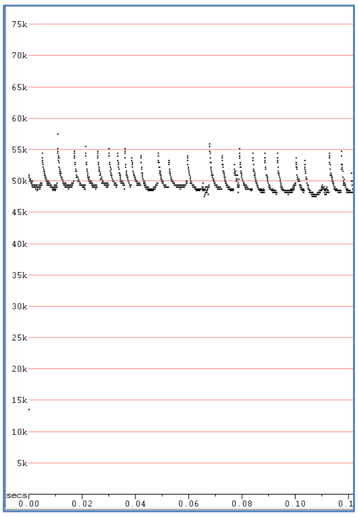
Chalinolobus nigrogriseus



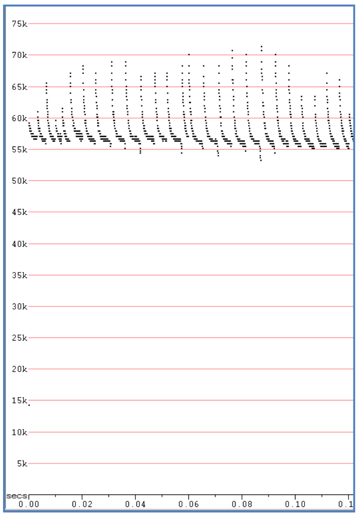
Nyctophilus species



Scotorepens sanborni

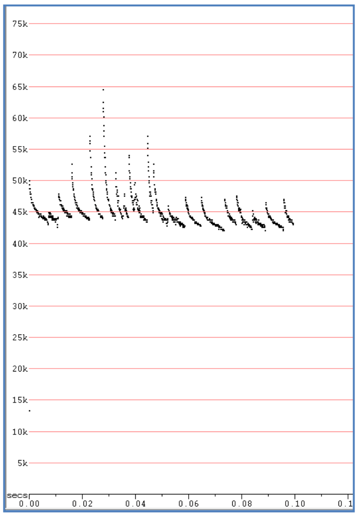


Vespadelus troughtoni

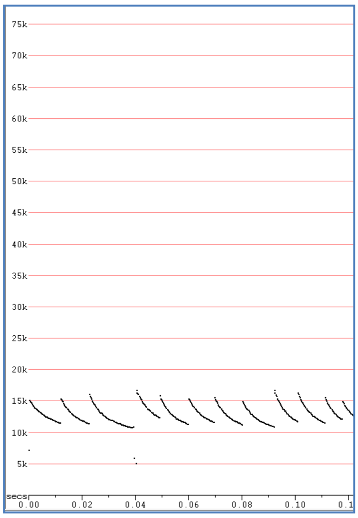


Miniopterus australis

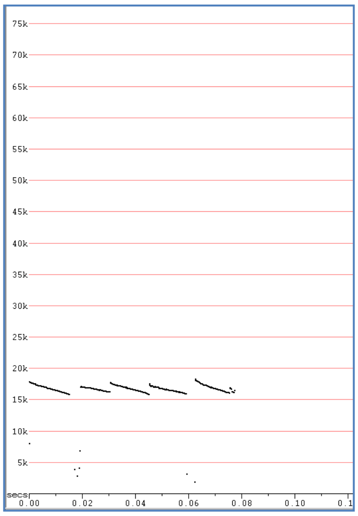
Appendix 2. Representative Anabat call sequences recorded at Mt Emerald, February 2013.
(10msec per tick; time between pulses removed)



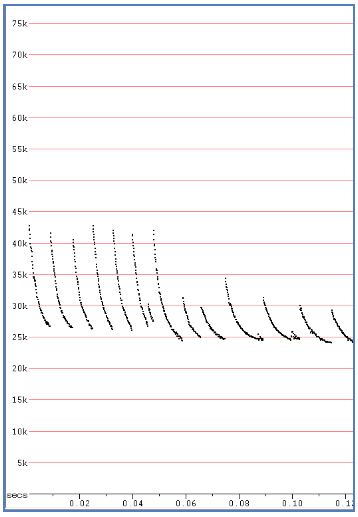
Miniopterus schreibersii



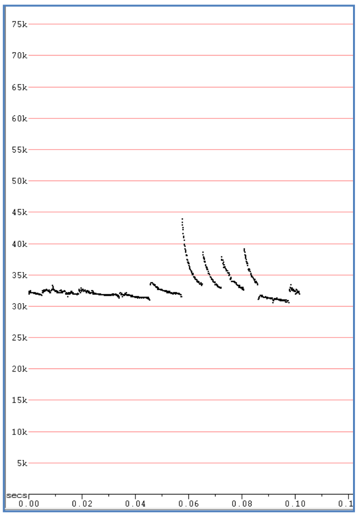
Tadarida australis



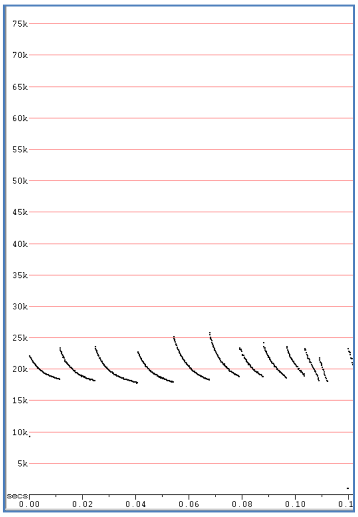
Chaerephon jobensis



Mormopterus beccarii

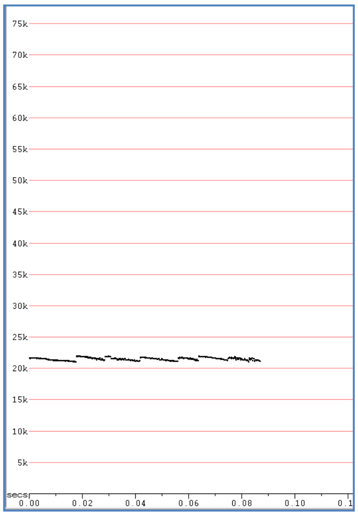


Mormopterus sp. 2

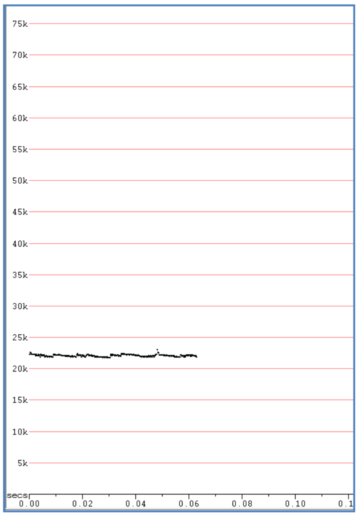


Saccolaimus flaviventris

Appendix 2. Representative Anabat call sequences recorded at Mt Emerald, February 2013.
(10msec per tick; time between pulses removed)



Possibly *Saccolaimus saccolaimus*



Possibly *Taphozous georgianus*

MEWF Data Summaries

Detector	ARU 12 + BAT 010342																																	
Date	17/12/2012	30/12/2012	31/12/2012	1/01/2013	2/01/2013	8/02/2013	9/02/2013	10/02/2013	11/02/2013	12/02/2013	13/02/2013	14/02/2013	15/02/2013	16/02/2013	17/02/2013	18/02/2013	19/02/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	24/04/2013	25/04/2013	26/04/2013	27/04/2013	28/04/2013	29/04/2013	22/05/2013	23/05/2013	24/05/2013	26/05/2013	ARU 12 Total
Total calls identified	1	3	6	18	22	2	7	7	5	3	6	6	3	38	22	33	18	38	34	53	34	41	28	34	32	11	24	30	2	31	13	11	1	617
POSITIVELY IDENTIFIED CALLS																																		
Rhinolophus megaphyllus																					1	1	2	1										5
Chalinolobus gouldii							2																											2
Nyctophilus sp																					1		1											2
Vespadelus troughtoni																																		
Miniopterus australis		1		3	2		1		1		1	1	2	6	1	6	7	8	13	5	8	14	6	8	7					1	2	7		111
Miniopterus oceanensis				3	2	2	3	4	1	1	2	2		6	3	3		5	8	6	3	8	5	1	5	5	2	1	2	2	2	3	1	91
Austronomus australis											1		1	1		1		4	1	1	5	4		1				5		3	4			32
Chaerephon jobensis																														2	2			4
Mormopterus beccarii	1			3	5									2	6		1	1	1	11	2							2		3				38
Mormopterus ridei					4									17		1		1	4	17	1	1	1	2				1						50
Saccolaimus flaviventris																				3														3
***Saccolaimus saccolaimus* (high confidence)**																																		
***Saccolaimus saccolaimus* (low confidence)**																																		
CALLS NOT POSITIVELY IDENTIFIED																																		
Chalinolobus nigrogriseus or *Scotorepens sanborni*		2	5	3	6		1	1	1	2	2	2		5	4	13	8	19	6	2	12	10	10	21	19	6	20	18		4	3	1		206
V. troughtoni or *M. oceanensis*														1		1																		2
M. oceanensis or *Pipistrellus adamsi*																																		
C. jobensis or *M. beccarii*																																		
M. ridei or *C. gouldii*																					1		1							3				5
M. ridei or *C. nigrogriseus* or *S. sanborni*																																		
S. flaviventris or *C. jobensis*				1																1			2				2	3						9
S. flaviventris or *M. beccarii*				2	2							1			3					1										3				12
S. saccolaimus or *M. beccarii*			1	3	1			2	2						2	7	2		1	6		3			1					7				38
Taphozous troughtoni or *M. beccarii*															3	1														3				7

MEWF Data Summaries

Detector	ARU 6 + BAT 010379																													
Date	12/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	22/12/2012	24/12/2012	25/12/2012	26/12/2012	27/12/2012	28/12/2012	29/12/2012	30/12/2012	31/12/2012	1/01/2013	2/01/2013	3/01/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	24/04/2013	25/04/2013	26/04/2013
Total calls identified	3	1	1	5	9	13	7	10	3	1	4	5	8	13	20	8	2	4	12	4	8	1	38	42	56	35	48	32	28	12	2
POSITIVELY IDENTIFIED CALLS																															
Rhinolophus megaphyllus																								2		1		1			
Chalinolobus gouldii								1														1				1		1			
Nyctophilus sp																															
Vespadelus troughtoni																															
Miniopterus australis	2			1	1	3	1		1		1			1						1	1		2	2	4	4	1	2	2	1	
Miniopterus oceanensis		1	1	2	7	2	2	3		1	1	3	3	1	2			1	1	2	1		5	8	1	1	8	5	11	7	
Austronomus australis								1										2					3		3		4	2		1	2
Chaerephon jobensis																							5	9	6	7	6	6	10		
Mormopterus beccarii						3	1				1	2	1	8	10		1		2	1			2	3	6	2	6	3			
Mormopterus ridei															1								3	5	4	1	3	1	1		
Saccolaimus flaviventris																															
***Saccolaimus saccolaimus* (high confidence)**																															
***Saccolaimus saccolaimus* (low confidence)**										**1**													**4**	**3**	**1**						
CALLS NOT POSITIVELY IDENTIFIED																															
Chalinolobus nigrogriseus or *Scotorepens sanborni*	1				1		1	1			1		1	2	1	6	1						5	6	21	13	4	6	4	3	
V. troughtoni or *M. oceanensis*																					2										
M. oceanensis or *Pipistrellus adamsi*																												1			
C. jobensis or *M. beccarii*																											5				
M. ridei or *C. gouldii*																												1			
M. ridei or *C. nigrogriseus* or *S. sanborni*																															
S. flaviventris or *C. jobensis*							2	2	1						1				2				3								
S. flaviventris or *M. beccarii*				1		5		2					3		3	1		1	6		4			1		1					
S. saccolaimus or *M. beccarii*				1										1	2	1			1				9	6	10	4	11	3			
Taphozous troughtoni or *M. beccarii*									1														1		1						

Detector	ARU 6 + BAT 010379																														
Date	27/04/2013	28/04/2013	29/04/2013	30/04/2013	1/05/2013	2/05/2013	3/05/2013	4/05/2013	5/05/2013	6/05/2013	7/05/2013	8/05/2013	9/05/2013	10/05/2013	12/05/2013	13/05/2013	14/05/2013	15/05/2013	16/05/2013	17/05/2013	18/05/2013	19/05/2013	20/05/2013	21/05/2013	22/05/2013	23/05/2013	24/05/2013	25/05/2013	26/05/2013	27/05/2013	28/05/2013	ARU 6 Total
Total calls identified	8	23	18	5	5	6	9	3	8	5	13	3	5	4	18	13	23	22	22	17	9	8	5	21	60	63	3	4	3	1	2	844
POSITIVELY IDENTIFIED CALLS																																
Rhinolophus megaphyllus		1																			1					1						7
Chalinolobus gouldii							1		1					2		1	1		1							1						12
Nyctophilus sp																																
Vespadelus troughtoni																																
Miniopterus australis	1							1									2			1	5			1	1	2					1	46
Miniopterus oceanensis	2	4	13	3	2	2	4	2	4	1	11	3	1	2	12	8	8	3	2	5		4	1	2		3		3	1		1	187
Austronomus australis	3	17					2		2	1					3			1		6	1				3	13				1		71
Chaerephon jobensis	1	1	4	2	3	2				2	1		2		2		1		2	1			1	4	9	25						112
Mormopterus beccarii															1	2	1	2	3				1	2	4	1						69
Mormopterus ridei																																19
Saccolaimus flaviventris																									4	3						7
***Saccolaimus saccolaimus* (high confidence)**																									**1**							**1**
***Saccolaimus saccolaimus* (low confidence)**																	**1**							**1**								**11**
CALLS NOT POSITIVELY IDENTIFIED																																
Chalinolobus nigrogriseus or *Scotorepens sanborni*	1		1			1	2			1	1					1	4	7	9	4	2	4	1	3	21	8	2	1				152
V. troughtoni or *M. oceanensis*																																2
M. oceanensis or *Pipistrellus adamsi*									1																							2
C. jobensis or *M. beccarii*																																5
M. ridei or *C. gouldii*													2						1							1			2			7
M. ridei or *C. nigrogriseus* or *S. sanborni*																																
S. flaviventris or *C. jobensis*																										2						13
S. flaviventris or *M. beccarii*																									4	1						33
S. saccolaimus or *M. beccarii*						1										1	5	7	3					5	12	2	1					86
Taphozous troughtoni or *M. beccarii*																	1	2	1				1	4	2							14

MEWF Data Summaries

Detector	BAT 1 010388																		
Date	11/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	17/04/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	26/04/2013	30/04/2013	3/05/2013	BAT 1 Total
Total calls identified	2	1	3	21	39	5	16	1	2	3	19	38	9	6	4	1	1	1	172
POSITIVELY IDENTIFIED CALLS																			
Rhinolophus megaphyllus																			
Chalinolobus gouldii																			
Nyctophilus sp					1														1
Vespadelus troughtoni				1															1
Miniopterus australis		1			3						1	2		2					9
Miniopterus oceanensis				1	3	1	1				3	18		1	1		1	1	31
Austronomus australis										2	4	4	1	2	2				15
Chaerephon jobensis									1	1	4	2							8
Mormopterus beccarii				3	6		2					3	2						16
Mormopterus ridei				5	9		4	1							1				20
Saccolaimus flaviventris			1																1
Saccolaimus saccolaimus **(high confidence)**																			
Saccolaimus saccolaimus **(low confidence)**																			
CALLS NOT POSITIVELY IDENTIFIED																			
Chalinolobus nigrogriseus or *Scotorepens sanborni*	1			2	4		5		1		6	1	3	1		1			25
V. troughtoni or *M. oceanensis*																			
M. oceanensis or *Pipistrellus adamsi*				1									1						2
C. jobensis or *M. beccarii*												1							1
M. ridei or *C. gouldii*																			
M. ridei or *C. nigrogriseus* or *S. sanborni*																			
S. flaviventris or *C. jobensis*			2	2			2												6
S. flaviventris or *M. beccarii*				1															1
S. saccolaimus or *M. beccarii*	1			5	13	3	2				1	4	2						31
Taphozous troughtoni or *M. beccarii*						1						3							4

MEWF Data Summaries

Detector	BAT 2 010375																									BAT 2 Total
Date	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	17/04/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	25/04/2013	13/05/2013	14/05/2013	15/05/2013	16/05/2013	17/05/2013	18/05/2013	19/05/2013	20/05/2013	21/05/2013	22/05/2013	
Total calls identified	3	8	44	61	4	7	6	13	27	25	65	10	25	27	2	4	43	5	7	1	5	1	1	2	31	427
POSITIVELY IDENTIFIED CALLS																										
Rhinolophus megaphyllus																										
Chalinolobus gouldii							4				2			1		2		1								10
Nyctophilus sp																										
Vespadelus troughtoni									1	1																2
Miniopterus australis			1							1	2															4
Miniopterus oceanensis	1							3			2		4	14						1						25
Austronomus australis								1		3	11	2	5	2					1		1			1	10	37
Chaerephon jobensis										6	5	1	8								1	1	1		1	24
Mormopterus beccarii	1	4	3	3		5		3	2	2	7	4					2									36
Mormopterus ridei		2	1						3		5		3				13									27
Saccolaimus flaviventris								2							1											3
***Saccolaimus saccolaimus* (high confidence)**																										
***Saccolaimus saccolaimus* (low confidence)**																										
CALLS NOT POSITIVELY IDENTIFIED																										
Chalinolobus nigrogriseus or *Scotorepens sanborni*								2	2	1	10	1	1	5			2	2			1			1	1	29
V. troughtoni or *M. oceanensis*										4	1			2		1					2					10
M. oceanensis or *Pipistrellus adamsi*										1																1
C. jobensis or *M. beccarii*																									1	1
M. ridei or *C. gouldii*					1			1						1			1									4
M. ridei or *C. nigrogriseus* or *S. sanborni*																										
S. flaviventris or *C. jobensis*	1	1	37	57	2	2																				100
S. flaviventris or *M. beccarii*							2		1	1	2		1		1											8
S. saccolaimus or *M. beccarii*		1	1	1	1			1	18	4	15	2	2	2		1	25	2	6						18	100
Taphozous troughtoni or *M. beccarii*			1							1	2		1													5

MEWF Data Summaries

Detector	BAT 3 010359																													
Date	11/12/2012	12/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	22/12/2012	23/12/2012	24/12/2012	25/12/2012	26/12/2012	27/12/2012	28/12/2012	30/12/2012	17/04/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	24/04/2013	25/04/2013	28/04/2013	2/05/2013	BAT 3 Total
Total calls identified	1	1	2	154	24	20	53	15	6	2	1	3	17	19	23	13	11	1	45	121	136	88	75	253	105	8	4	7	1	1209
POSITIVELY IDENTIFIED CALLS																														
Rhinolophus megaphyllus																														
Chalinolobus gouldii																						1	1	8	6					16
Nyctophilus sp																														
Vespadelus troughtoni																					1				3					4
Miniopterus australis			1	2		1	1		1			1	1		3		2		1			5	2	3						24
Miniopterus oceanensis			1	1	4	1	5	8		1		2	6	9	10	3			15	2	4	5	4	40	20	3	2	1		147
Austronomus australis	1						1	1	3				2	2	2				13	9	7	1	4	42	9	2		3		102
Chaerephon jobensis																			1	1	8	5	2	11	35					63
Mormopterus beccarii				11	4	3							3	1	6	1	2	1	1	12	28	2	6	17	6		1			105
Mormopterus ridei				6	12	6	5	3					2		1	4	3			39	15	14	5	28			1			144
Saccolaimus flaviventris																						7	14	1						22
***Saccolaimus saccolaimus* (high confidence)**																				**1**	**1**	**19**	**2**							**23**
***Saccolaimus saccolaimus* (low confidence)**																						**2**	**1**							**3**
CALLS NOT POSITIVELY IDENTIFIED																														
Chalinolobus nigrogriseus or *Scotorepens sanborni*		1		128		2	29		1					5		5	3		13	2	21	7	16	66	14	3				316
V. troughtoni or *M. oceanensis*							12																							12
M. oceanensis or *Pipistrellus adamsi*																				2										2
C. jobensis or *M. beccarii*																				3			1	4						8
M. ridei or *C. gouldii*																				3	4		1	10	8					26
M. ridei or *C. nigrogriseus* or *S. sanborni*																														
S. flaviventris or *C. jobensis*						3		1	1				3																	8
S. flaviventris or *M. beccarii*								2		1	1			2	1		1			1	1		3	1	4					18
S. saccolaimus or *M. beccarii*				6	4	3													1	45	43	39	16	21				3	1	182
Taphozous troughtoni or *M. beccarii*						1														2	4	2		1						10

MEWF Data Summaries

Detector	BAT 4 010382																												
Date	11/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	24/04/2013	25/04/2013	27/04/2013	28/04/2013	29/04/2013	30/04/2013	1/05/2013	2/05/2013	4/05/2013	5/05/2013	6/05/2013	7/05/2013	BAT 4 Total
Total calls identified	4	2	15	89	32	241	69	71	15	27	72	70	179	98	71	39	10	2	4	10	3	3	1	16	4	1	1	4	1153
POSITIVELY IDENTIFIED CALLS																													
Rhinolophus megaphyllus																													
Chalinolobus gouldii						1										3													4
Nyctophilus sp																													
Vespadelus troughtoni																													
Miniopterus australis	1		1	2				1			2	2	5		4	1	2							1	1				23
Miniopterus oceanensis			14	2	1					1	2	1		9	7	1	2	1	2	1	3			1		1	1	1	51
Austronomus australis						1		1			4		14	26	9	5						3						2	65
Chaerephon jobensis											9	2	9	4	7	11		1						2					45
Mormopterus beccarii					1	12	1				8	6	16	8	5	1							1						59
Mormopterus ridei						7					20	14	20	4	4	1													70
Saccolaimus flaviventris													13	2															15
***Saccolaimus saccolaimus* (high confidence)**																													
***Saccolaimus saccolaimus* (low confidence)**																													
CALLS NOT POSITIVELY IDENTIFIED																													
Chalinolobus nigrogriseus or *Scotorepens sanborni*	3	2		84	30	197	66	65	12	26	4	33	64	25	16	10	5		1	9				11	2				665
V. troughtoni or *M. oceanensis*												1							1										2
M. oceanensis or *Pipistrellus adamsi*																													
C. jobensis or *M. beccarii*												1	1			1	1												4
M. ridei or *C. gouldii*												2																	2
M. ridei or *C. nigrogriseus* or *S. sanborni*																													
S. flaviventris or *C. jobensis*				1			2	1	1																				5
S. flaviventris or *M. beccarii*								1	2		2	1	13	7	2	1									1				30
S. saccolaimus or *M. beccarii*						23		2			21	7	24	13	17	4								1				1	113
Taphozous troughtoni or *M. beccarii*																													

MEWF Data Summaries

Detector	BAT 5 010386																						
Date	11/12/2012	12/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	22/12/2012	23/12/2012	24/12/2012	16/04/2013	17/04/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013	BAT 5 Total
Total calls identified	64	9	2	23	276	549	137	365	183	170	19	4	60	32	221	66	54	202	113	129	121	21	2820
POSITIVELY IDENTIFIED CALLS																							
Rhinolophus megaphyllus																							
Chalinolobus gouldii	34			5	81	406	26	279	99	86	12	1	4	8		2	4	4	7		1		1059
Nyctophilus sp																							
Vespadelus troughtoni																				1			1
Miniopterus australis			1	2		1	4	3	4					1	1	3	1	4	3	5	2		35
Miniopterus oceanensis			1		20	7	6	5							6	4	1	1	4	1	12	3	71
Austronomus australis															12	2	2	2	3	2	14		37
Chaerephon jobensis																2	2	6	1	2	5	2	20
Mormopterus beccarii		1			7	6	78	4	8			1	2	1	9	7	4	3	4	3		5	143
Mormopterus ridei									1						4	14	8	20	17	3	3		70
Saccolaimus flaviventris																1			3	2			6
***Saccolaimus saccolaimus* (high confidence)**																							
***Saccolaimus saccolaimus* (low confidence)**																**1**							**1**
CALLS NOT POSITIVELY IDENTIFIED																							
Chalinolobus nigrogriseus or *Scotorepens sanborni*	30	7		16	160	124	21	69	68	83	6	2	52	22	163	9	12	74	22	101	76	8	1125
V. troughtoni or *M. oceanensis*																1							1
M. oceanensis or *Pipistrellus adamsi*															1								1
C. jobensis or *M. beccarii*																					1		1
M. ridei or *C. gouldii*						2		2		1	1				9	1	2	1	6		4		29
M. ridei or *C. nigrogriseus* or *S. sanborni*																		82	25	2	2	1	112
S. flaviventris or *C. jobensis*					1			1					2										4
S. flaviventris or *M. beccarii*		1			4										1	1	4	1	2	4			18
S. saccolaimus or *M. beccarii*					3	3	2	2	3						15	19	14	3	16	2		1	83
Taphozous troughtoni or *M. beccarii*																				1	1	1	3

MEWF Data Summaries

Detector	BAT 6 010327																			
Date	11/12/2012	12/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	21/12/2012	22/12/2012	23/12/2012	17/04/2013	18/04/2013	19/04/2013	20/04/2013	21/04/2013	22/04/2013	23/04/2013
Total calls identified	3	3	1	3	13	7	64	24	8	3	3	2	8	97	69	58	119	27	15	8
POSITIVELY IDENTIFIED CALLS																				
Rhinolophus megaphyllus																				
Chalinolobus gouldii					1	2					2		4							
Nyctophilus sp																				
Vespadelus troughtoni															1					
Miniopterus australis	2			2			1			1	1	1	1			1		1	2	1
Miniopterus oceanensis		2		1		2	3			1				1	3	2	5			
Austronomus australis							1			1				20	27	4	4	4	2	3
Chaerephon jobensis														1	1	4	2	1	2	
Mormopterus beccarii	1		1		2	2	5	3	4					7	11	2	3	1	5	1
Mormopterus ridei													1	28	5	13	2		1	
Saccolaimus flaviventris																	4			
***Saccolaimus saccolaimus* (high confidence)**					**1**	**2**												**1**		
***Saccolaimus saccolaimus* (low confidence)**														**1**					**1**	
CALLS NOT POSITIVELY IDENTIFIED																				
Chalinolobus nigrogriseus or *Scotorepens sanborni*		1					42	6	1				1	6	1	17	57	8		1
V. troughtoni or *M. oceanensis*																				
M. oceanensis or *Pipistrellus adamsi*														1	1	7	3			
C. jobensis or *M. beccarii*															3	1		1		
M. ridei or *C. gouldii*															1	1	5	4		
M. ridei or *C. nigrogriseus* or *S. sanborni*															1		1			
S. flaviventris or *C. jobensis*					1		12	11				1			2		4			
S. flaviventris or *M. beccarii*								1	2						2	1	7			
S. saccolaimus or *M. beccarii*					6	1		3	1				1	33	10	5	22	2	3	2
Taphozous troughtoni or *M. beccarii*					3													5		

Detector	BAT 6 010327																				
Date	24/04/2013	25/04/2013	26/04/2013	27/04/2013	28/04/2013	29/04/2013	1/05/2013	2/05/2013	3/05/2013	5/05/2013	6/05/2013	7/05/2013	8/05/2013	9/05/2013	11/05/2013	12/05/2013	13/05/2013	14/05/2013	15/05/2013	16/05/2013	BAT 6 Total
Total calls identified	17	7	5	3	5	4	7	6	3	4	2	1	1	2	4	5	7	13	17	3	651
POSITIVELY IDENTIFIED CALLS																					
Rhinolophus megaphyllus																					
Chalinolobus gouldii																					9
Nyctophilus sp																					
Vespadelus troughtoni	1																				2
Miniopterus australis				1		2				2							1				20
Miniopterus oceanensis				1	2		3	4	3	2	1		1			4	1	1			43
Austronomus australis	2		5	1		1						1						2	3		81
Chaerephon jobensis	1																1		1		14
Mormopterus beccarii					2		4											2	5	3	64
Mormopterus ridei															1		1				52
Saccolaimus flaviventris		3																			7
***Saccolaimus saccolaimus* (high confidence)**																					**4**
***Saccolaimus saccolaimus* (low confidence)**																					**2**
CALLS NOT POSITIVELY IDENTIFIED																					
Chalinolobus nigrogriseus or *Scotorepens sanborni*	11	2			1										1	1	1	1			159
V. troughtoni or *M. oceanensis*																					
M. oceanensis or *Pipistrellus adamsi*		2															1				15
C. jobensis or *M. beccarii*																					5
M. ridei or *C. gouldii*	1							1													13
M. ridei or *C. nigrogriseus* or *S. sanborni*																	1				3
S. flaviventris or *C. jobensis*																					31
S. flaviventris or *M. beccarii*														1					3		17
S. saccolaimus or *M. beccarii*						1		1			1			1	2			7	5		107
Taphozous troughtoni or *M. beccarii*	1																				9

MEWF Data Summaries

Detector	BAT 7 010360													
Date	11/12/2012	12/12/2012	13/12/2012	14/12/2012	15/12/2012	16/12/2012	19/12/2012	20/12/2012	16/04/2013	19/04/2013	20/04/2013	21/04/2013	23/04/2013	BAT 7 Total
Total calls identified	13	16	20	9	4	6	20	8	1	1	1	1	1	101
POSITIVELY IDENTIFIED CALLS														
Rhinolophus megaphyllus														
Chalinolobus gouldii														
Nyctophilus sp														
Vespadelus troughtoni														
Miniopterus australis	2	1	2	2	1		4	2						14
Miniopterus oceanensis	6	14	16	6	1		6	1						50
Austronomus australis	4					3	1	2						10
Chaerephon jobensis														
Mormopterus beccarii					1	1								2
Mormopterus ridei														
Saccolaimus flaviventris														
***Saccolaimus saccolaimus* (high confidence)**			**1**					**1**						**2**
***Saccolaimus saccolaimus* (low confidence)**														
CALLS NOT POSITIVELY IDENTIFIED														
Chalinolobus nigrogriseus or *Scotorepens sanborni*		1		1		2	1							5
V. troughtoni or *M. oceanensis*														
M. oceanensis or *Pipistrellus adamsi*														
C. jobensis or *M. beccarii*														
M. ridei or *C. gouldii*														
M. ridei or *C. nigrogriseus* or *S. sanborni*														
S. flaviventris or *C. jobensis*			1				6	3						10
S. flaviventris or *M. beccarii*	1				1		1							3
S. saccolaimus or *M. beccarii*			1				1		1	1	1	1	1	7
Taphozous troughtoni or *M. beccarii*														

MEWF Data Summaries

Detector	BAT 8 010387									
Date	14/12/2012	15/12/2012	16/12/2012	17/12/2012	18/12/2012	19/12/2012	20/12/2012	22/12/2012	23/12/2012	BAT 8 Total
Total calls identified	1	10	14	16	33	5	2	2	1	84
POSITIVELY IDENTIFIED CALLS										
Rhinolophus megaphyllus										
Chalinolobus gouldii					12		1			13
Nyctophilus sp										
Vespadelus troughtoni										
Miniopterus australis		1			1	1	1	2	1	7
Miniopterus oceanensis	1	3	1	1	3					9
Austronomus australis			2							2
Chaerephon jobensis										
Mormopterus beccarii		4	3	5	1	3				16
Mormopterus ridei			3	5	4					12
Saccolaimus flaviventris										
Saccolaimus saccolaimus **(high confidence)**										
Saccolaimus saccolaimus **(low confidence)**										
CALLS NOT POSITIVELY IDENTIFIED										
Chalinolobus nigrogriseus or *Scotorepens sanborni*		1	4	5	6	1				17
V. troughtoni or *M. oceanensis*										
M. oceanensis or *Pipistrellus adamsi*										
C. jobensis or *M. beccarii*										
M. ridei or *C. gouldii*										
M. ridei or *C. nigrogriseus* or *S. sanborni*										
S. flaviventris or *C. jobensis*					1					1
S. flaviventris or *M. beccarii*					1					1
S. saccolaimus or *M. beccarii*		1	1		4					6
Taphozous troughtoni or *M. beccarii*										

MEWF Data Summaries

Detector	ARU 12 Total	ARU 6 Total	BAT 1 Total	BAT 2 Total	BAT 3 Total	BAT 4 Total	BAT 5 Total	BAT 6 Total	BAT 7 Total	BAT 8 Total	**Grand Total**
Total calls identified	617	844	172	427	1209	1153	2820	651	101	84	**8078**
POSITIVELY IDENTIFIED CALLS											
Rhinolophus megaphyllus	5	7									**12**
Chalinolobus gouldii	2	12		10	16	4	1059	9		13	**1125**
Nyctophilus sp	2		1								**3**
Vespadelus troughtoni			1	2	4		1	2			**10**
Miniopterus australis	111	46	9	4	24	23	35	20	14	7	**293**
Miniopterus oceanensis	91	187	31	25	147	51	71	43	50	9	**705**
Austronomus australis	32	71	15	37	102	65	37	81	10	2	**452**
Chaerephon jobensis	4	112	8	24	63	45	20	14			**290**
Mormopterus beccarii	38	69	16	36	105	59	143	64	2	16	**548**
Mormopterus ridei	50	19	20	27	144	70	70	52		12	**464**
Saccolaimus flaviventris	3	7	1	3	22	15	6	7			**64**
***Saccolaimus saccolaimus* (high confidence)**		**1**			**23**			**4**	**2**		**30**
***Saccolaimus saccolaimus* (low confidence)**		**11**			**3**		**1**	**2**			**17**
CALLS NOT POSITIVELY IDENTIFIED											
Chalinolobus nigrogriseus or *Scotorepens sanborni*	206	152	25	29	316	665	1125	159	5	17	**2699**
V. troughtoni or *M. oceanensis*	2	2		10	12	2	1				**29**
M. oceanensis or *Pipistrellus adamsi*		2	2	1	2		1	15			**23**
C. jobensis or *M. beccarii*		5	1	1	8	4	1	5			**25**
M. ridei or *C. gouldii*	5	7		4	26	2	29	13			**86**
M. ridei or *C. nigrogriseus* or *S. sanborni*							112	3			**115**
S. flaviventris or *C. jobensis*	9	13	6	100	8	5	4	31	10	1	**187**
S. flaviventris or *M. beccarii*	12	33	1	8	18	30	18	17	3	1	**141**
S. saccolaimus or *M. beccarii*	38	86	31	100	182	113	83	107	7	6	**753**
Taphozous troughtoni or *M. beccarii*	7	14	4	5	10		3	9			**52**

Appendix 25

Mount Emerald Wind Farm – An Assessment of Utilisation Patterns of Spectacled Flying-fox.

Prepared by RPS

Mount Emerald Wind Farm

An Assessment of Utilisation Patterns of Spectacled Flying-fox on the Proposed Mount Emerald Wind Farm Site

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Document Status

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D Finney		28/11/2013

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1.0 Introduction

1.1 Project Summary

RACL proposes to construct the Mt Emerald Wind Farm (MEWF) on elevated land located approximately 20 km SSW of the town of Mareeba on the Atherton Tablelands in north Queensland. The project site occupies a total area of 2422 ha.

The wind farm's electrical energy generation facility and infrastructure will comprise 63 wind turbines and associated tracks for underground cabling and access between the turbine arrays (**Figure 1**). An electricity substation is also proposed and will feed energy generated from the wind farm into the existing Chalumbin to Woree 275 kV transmission line. A conspicuous section of this transmission line more or less dissects the site and closely corresponds with bioregional boundaries.

The wind farm site occurs at the northern extent of the Herberton Range and includes the prominent landmark of Walsh Bluff at the most northern end. Mount Emerald (proper) is located off the site at the southern boundary. The undisturbed landform and vegetation is contiguous with Mt Emerald. Land to the north, east and west is characterised by agriculture and is generally cleared and modified.

1.2 Landscape Features

The proposed MEWF site is situated over mountainous terrain coinciding with the northern extent of the Herberton Range. The site is broadly divided in terms of the degree of surface relief. This has bearing on the landforms, vegetation types and ultimately, the constructability of the project. To the south of the Chalumbin to Woree 275 kV transmission line the land is conspicuously dissected, rugged and characterised by narrow, high ridges and in some instances, precipitous slopes. Heath vegetation and low, windswept sparse woodlands characterise this landform. This area falls into the Wet Tropics bioregion section of the site and corresponds with the highest level of biodiversity in terms of vegetation and conservation significant flora, as well as being the least disturbed. It is a contiguous tract of land with Mt Emerald on the southern boundary and holds high levels of environmental integrity.

The land to the north of the transmission line exhibits less surface relief, dissected ridges and steep slopes become far less frequent, and the landform generally becomes more undulating. Consequently, different vegetation types are hosted; where woodlands are generally taller, more widely represented on a regional basis, and conspicuously fewer conservation significant plants are present. This part of the site corresponds with the Einasleigh Uplands bioregion section of the site, and holds lower environmental values than the Wet Tropics section. From a constructability viewpoint, the Einasleigh Uplands section is least constrained and offers the most opportunities with the potential for notably reduced environmental impacts on important plant habitats and conservation significant plant species.

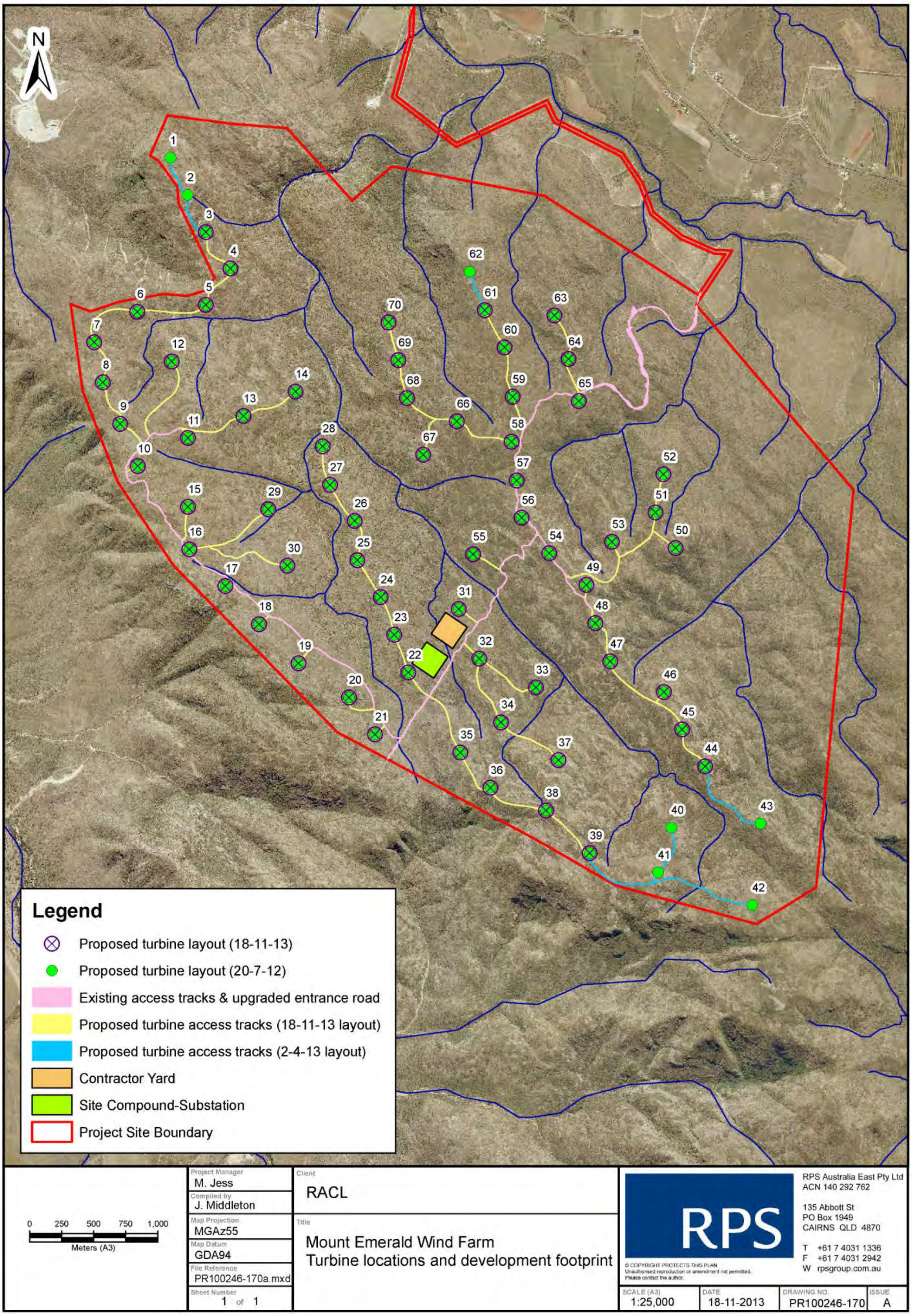

Figure 1 Turbine Locations and Development Footprint

1.3 Assessment of Utilisation Patterns

The high likelihood of the vulnerable EPBC-listed Spectacled Flying-fox (*Pteropus conspicillatus*) occurring on the proposed Mt Emerald Wind Farm (MEWF) site (RPS, 2011) is likely to have been one of the key factors in the project being assessed as a **controlled action** under the EPBC. In particular, the potential for the project to have significant impacts on values of the Wet Tropics World Heritage Area (WTWHA) are most likely related to the potential impacts on the Spectacled Flying-fox, which has been identified as contributing to the World Heritage values of the WTWHA intrinsically.

The Spectacled Flying-fox contributes to the WTWHA values by assisting the maintenance the ecological integrity of the area (ACTFR, 2001), by pollinating flowers and dispersing fruits of rainforest trees (WTMA, 2000 in ACTFR, 2001).

The DotE (formerly SEWPaC) EIS Guidelines for the proposed MEWF request a detailed assessment of the nature, extent, likelihood and consequence of the short-term and long-term impacts of collision risk and barotrauma from turbines on Matters of National Environmental Significance (MNES) fauna species (Section 5.10), including the Spectacled Flying-fox (*Pteropus conspicillatus*). Numerical collision modelling is recognised as the preferred method of assessing risk where sufficient information on the species abundance and number of at risk flights per annum is obtainable (EPHC, 2010).

Various numerical collision risk models have been previously used in wind farm assessments in Europe and North America for birds, for example the Scottish Natural Heritage Collision Risk Model (Band Model) (Band et al., 2007). In Australia, the BIOSIS model (Smales et al., 2013) has been used to model predicted wind turbine numerical collision risk for the following EPBC listed threatened and migratory species:

- Orange-bellied Parrot (Smales et al., 2005),
- Swift Parrot (Smales, 2005a),
- Tasmanian Wedge-tailed Eagle subspecies (Smales and Muir, 2005)
- White-bellied Sea (Smales, 2005b).

There have been few attempts to conduct numerical wind turbine collision risk modelling for any nocturnally active bat species, either microbat or flying-fox, anywhere in the world, due to the difficulties in obtaining the specific input data, particularly flight heights. The only numerical collision risk modelling that has been conducted (to date) anywhere in the world for any flying-fox species is for the Butoni Wind Farm in Fiji (Smales, 2005c).

Two species of flying-fox, the Pacific Flying-fox (*Pteropus tonganus*) and Samoan Flying-fox (*Pteropus samoensis*) were identified as potentially occurring in the vicinity of the wind farm (Smales, 2005c). *P. tonganus* is known to forage during both the day and night, while *P. samoensis* is totally nocturnal. A total of 86 records of *P. tonganus* were recorded during the study within or immediately adjacent to the wind farm site (Smales, 2005c). The surveys were only conducted during diurnal and dusk hours and therefore the survey results are highly likely to have underestimated the activity of the species. On the basis of a four day survey (62 ten-minute point counts made at six locations), the turbine collision risk to *P. tonganus* was determined to be low (<1.1 flights at risk per annum, assuming an avoidance rate of between 98-99%) EPHC (2010) state that the flight behaviours of fruit bats are more similar to that of crepuscular bats and nocturnal birds than other bat taxa and therefore, it may be feasible to obtain data suitable for collision risk modelling using standard point count survey methods typically used for assessing wind farm bird utilisation.

To date, only two wind farms have been constructed within the range of the Spectacled Flying-fox: Windy Hill (near Ravenshoe) and Thursday Island (in the Torres Strait). No systematic long-term mortality monitoring has been undertaken at either location (Terry Johannesen, pers. com.) and, as such, their impact on

P. conspicillatus is not currently known. DoE approval has been granted for Stage 1 of the proposed High Road Wind Farm (near Ravenshoe), in cleared agricultural land adjacent to the extensive wet and dry sclerophyll woodland and forests of the Bluff State Forest. The EPBC referral submitted for the project concluded that there was a low likelihood of *P. conspicillatus* occurring on the site due to the absence of closed rainforest roosting habitat (RPS, 2009). However, *P. conspicillatus* is now known to forage extensively in other vegetation communities such as eucalypt and *Melaleuca* forests (Curtis et al., 2012) including the wet and dry sclerophyll habitats of the Herberton Range adjacent to the proposed High Road and MEWF wind farms (D. Westcott, pers. comm.) and is also known to forage on the fruits of Wild Tobacco (*Solanum mauritianum*) (Eggert, 1994, Spencer et al., 1992), which is an abundant introduced plant occurring in disturbed habitats on the Atherton Tablelands. Several wind farms in Australia have been constructed or are proposed within the distribution range of Grey-headed Flying-fox (similar ecology to the SFF) e.g. Dundonell Wind Farm (Vic) and Capital Wind Farm (NSW). These projects have been assessed as posing low risk to this species as the habitats are not considered to be suitable and no numerical risk modelling was conducted (or required) as part of these assessments (Richards, 2005; BLA, 2010)

Wind turbine collision risk assessment for nocturnally active flying fauna in the US and Europe typically utilises marine radar to obtain accurate data on abundance, flight tracks and flight heights. The only successful use of radar in the southern hemisphere for wind farm bird assessments was conducted at Taharoa Wind Farm in New Zealand (Fuller *et al*., 2009). The cost of the commercially available systems, capable of tracking small to large-sized targets in three dimensions (e.g. Detect Inc. bird and bat radar system), is in the order of at least $1million for purchase and/or $374,000 for a one-year lease (**Attachment A** – Detect quote).

Thermal imaging video and image enhancing night vision devices (binoculars, goggles and scopes) have been previously used in ecological studies of nocturnally active flying-foxes and microbats. Examples of thermal imaging video cameras and/or night-vision devices previously used in survey are;

- to count microbats emerging from cave roosts (Sabol & Hudson, 1995; Betke *et al*., 2008);
- counting roosting Mariana Fruit Bat (*Pteropus marianus marianus*) from vantage points (USGS, 2010);
- to determine the 3D flight trajectory of microbats (Theriault *et al.*, 2010; Hristov *et al.*, 2008);
- nocturnal bird migration (Fortin *et al.,* 1999; Zehender *et al.,2001;* Ahlen 2003, Desholm, 2003; Desholm *et al.,* 2006*,* Gauthreaux and Livingston 2006);
- to assess flight patterns and mortality of microbats around operating wind turbines (Desohlm *et al.,* 2003; Horn *et al.,* 2008).

Although thermal imaging and night-vision devices are still relatively expensive (~$40K for high resolution and capture rate thermal imaging video, $2-4 K for night vision device), they are significantly cheaper than commercially available bird and bat radar systems. Both methods are mentioned in the Australian D*raft National Wind Farm Development Guidelines* as being suitable for monitoring bat movements (EPHC, 2010).

It is difficult to determine the height or altitude at which bats fly because of their nocturnal behaviour (Parsons *et al*., 2008). The only study that provides indirect data on the flight heights of Australian flying foxes was conducted by Parsons *et al*. (2008), who conducted an analysis of the altitudes of aircraft bat strikes from Australia in the period 1996-2006 using data obtained from the Australian Transport Safety Bureau. Parsons *et al.* (2008) suggested that the majority of the collisions identified as bats are likely to be flying-foxes (>500g) as smaller microbats are not likely to cause damage to aircraft. Parsons *et al*. (2008) found the majority of collisions with flying-foxes occurred at approximately 150 m above the ground with only a few collisions occurring at higher elevations up to 1500 m (Parsons *et al.,* 2008). Interpretation of this data should consider the small sample size of 75 bat collisions and that Australian aircraft spend only a very small proportion of their total flight time at low elevations (<300 m).

Some studies have attempted to estimate flight height of migrating birds by using the relationship between the silhouette sizes of the targets images captured with light-enhancing night vision goggles or thermal imaging devices and the flight altitude (Fortin *et al*., 1999; Leichti *et al*., 1995).

To make an informed assessment of the impacts of collision risk from turbines on Spectacled Flying-fox habitat utilisation surveys were necessary. As identified above a variety of methods have been trialled on bats internationally but few have provided the necessary information.

The aims of the study were:

- To confirm the presence of *Pteropus conspicillatus* on the site;
- To examine spatial and temporal utilisation patterns of the species; and
- To collect data suitable for inclusion in a collision risk model such as abundance and flight height.

2.0 Methodology

All opportunistic observations of *Pteropus spp.* on the site during the course of all field work were recorded and relevant information noted (e.g. actively foraging, flying over-head, flight height etc).

2.1 Night Vision Goggle Surveys

A total of 21 survey locations (**Figure 2**) were identified across the site to sample as much of the variation in ridge habitats across the site as was possible given limitations associated with access and safety (i.e. locations were limited to areas within one hours walk of the nearest vehicle access and within mobile phone coverage range). Survey locations were selected to provide unobstructed 360 degree views (where possible) and were located predominately along rocky ridges with low shrubs and few trees. At each site, visual observations were conducted continuously between approximately 30 minutes after sunset to 30 minutes before sunrise by two observers alternating over three hour shifts to minimise fatigue. Each observer was equipped with a pair of NVA 7 HP dual-eyepiece, single lens, helmet mounted night vision goggles with 1 x magnification and a 40° field of view, and a 100W hand-held spotlight fitted with an infra-red filter(to assist with species identification). The survey dates are shown in **Table 1**. Using the methodology of Biosis (2013), once a target was observed, the estimated distance from observers and height of target at first sight was recorded. Where possible, targets were identified to species or if this was not possible into the broader taxonomic groups e.g. waterbird, small to medium sized bird, microbat, etc. Surveys were conducted during periods of high ambient moonlight to aid detection. Surveys were conducted during periods without sustained rain or drizzle to ensure high levels of detectability. All sites, except for NVG 20, were sampled on only one occasion (**Table 1**). A total of 11 observers were used to conduct the surveys. It is accepted that observer biases associated with varying levels of experience was an unquantifiable variable during the surveys.

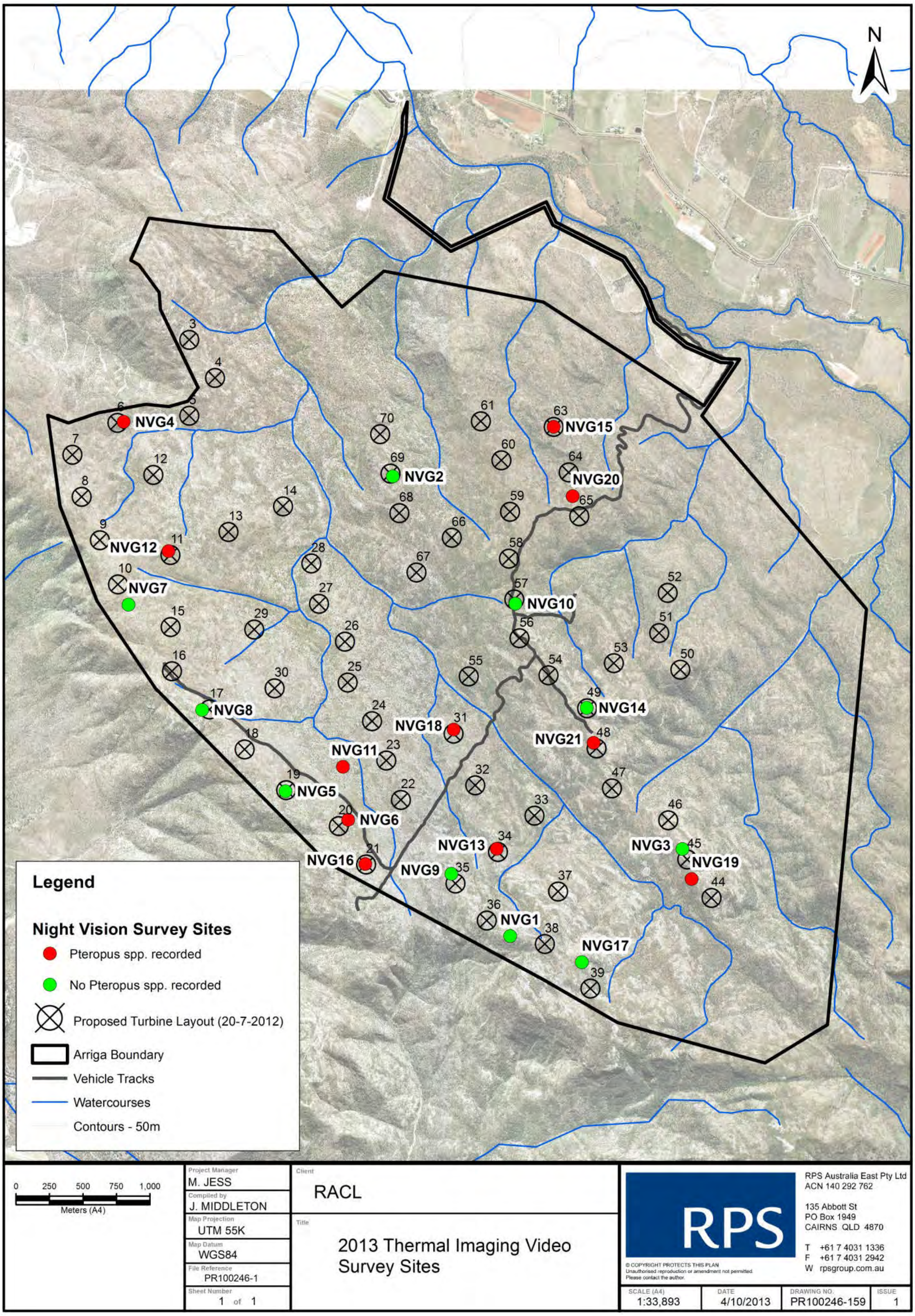

Figure 2 Night Vision Goggle Survey Site Locations

2.2 Thermal Imaging Video Surveys

The thermal imaging video system consisted of:

- a FLIR A615 thermal camera (640 x 480 pixel resolution @ 50 HZ; 25° horizontal x 19° vertical field of view; spatial resolution = 0.68 mrad) in a weatherproof housing set up on a tripod with the video facing directly vertical and with the top of the lens oriented towards north;
- an Adlink Matrix Industrial PC and two Buffalo 4TB USB 3.0 external hard drives housed in a IP67 rated Pelican 1600 case; and
- an external 12v 20A power supply consisting of 4 x 80 Ah seal gel-cell lead-acid batteries, weighing a total of approximately 60 kg.

Figure 3 shows the three sites where thermal imaging survey were conducted. Sampling was conducted for one continuous evening (from approximately sunset to 0800 hrs) at each of the sites between 12 and 15 February 2013. The footage was saved as 13 one-hour segments (FLIR sequence files) of approximately 66GB of memory each. Analysis of the recorded footage was conducted in the FLIR Research IR Version 3.4.13039.1003 software (FLIR, 2011). A plot of maximum pixel temperature versus time was examined to enable more time-efficient identification of flying fauna. Warm-blooded flying targets were typically visible on the plot as peaks, particularly during periods of no cloud cover when the contrast between the warm targets and the cold sky was most pronounced (**Plate 1).**

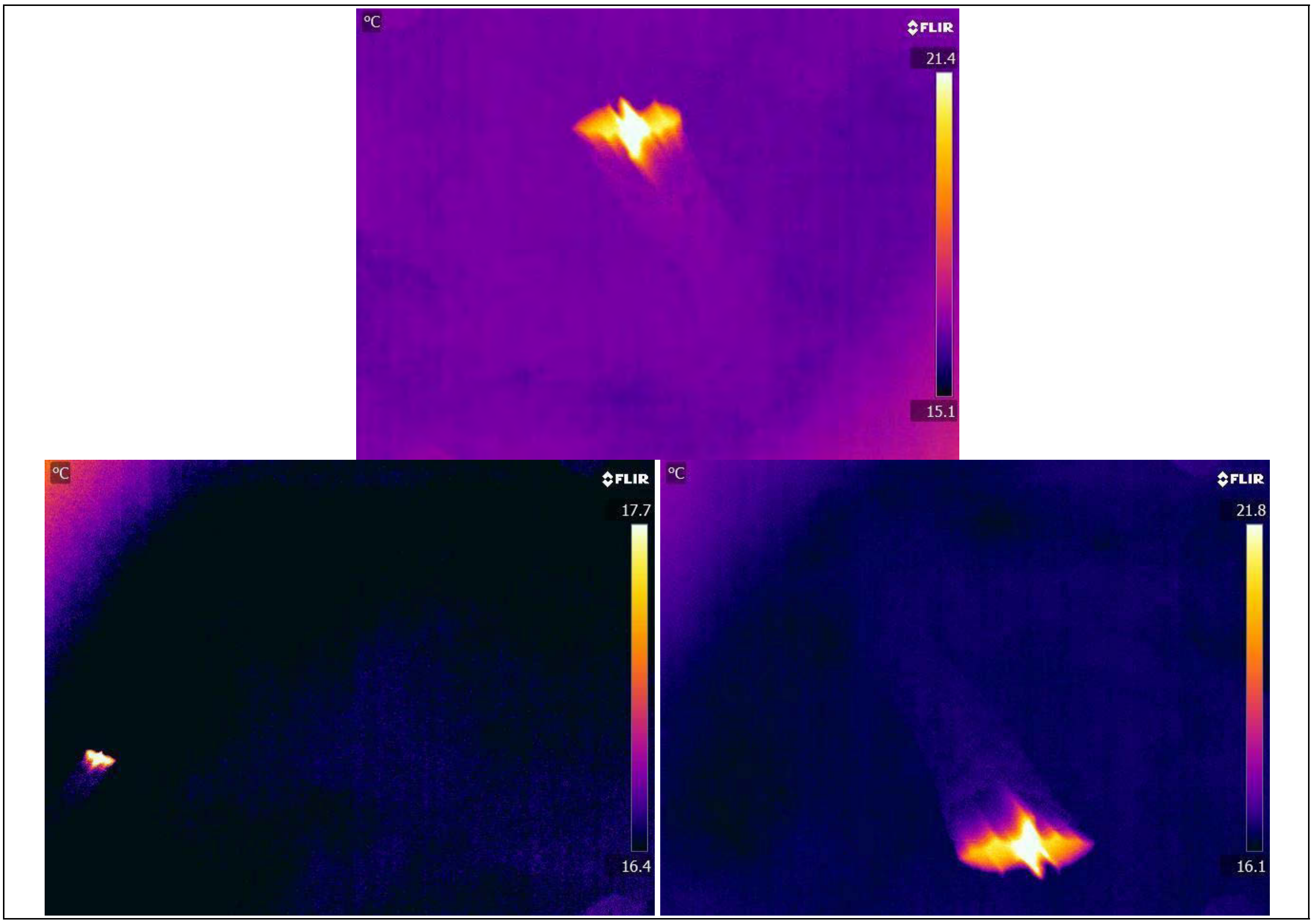

Plate 1 Potential Pteropus spp. FLIR Images

For each flying fauna target identified on the video footage, the following data was recorded:

- Time first visible (hh:mm:ss.000 format),

- Time last visible,
- Flight direction relative to screen (e.g. top middle to bottom right),
- Faunal group identification categorized according to a set of qualitative criteria as a bat, insect, bird, aircraft, or unknown (unidentifiable) object.

Identification criteria included object size, object morphology, estimations of inertia and velocity, evaluation of flight manoeuvres and behaviours and wing-beat frequency. In an effort to reduce false positive identification and observer biases, a highly conservative approach was used when classifying objects, categorizing many objects as “unknown”. The apparent size of the flying targets (with respect to the member of pixels) as viewed with the FLIR Research IR software was highly dependent upon the temperature scale that was selected for the optimal identification of targets. The size of the object decreased as the upper bound of the temperature scale was increased. All analyses were conducted by the same scientist to avoid classification biases.

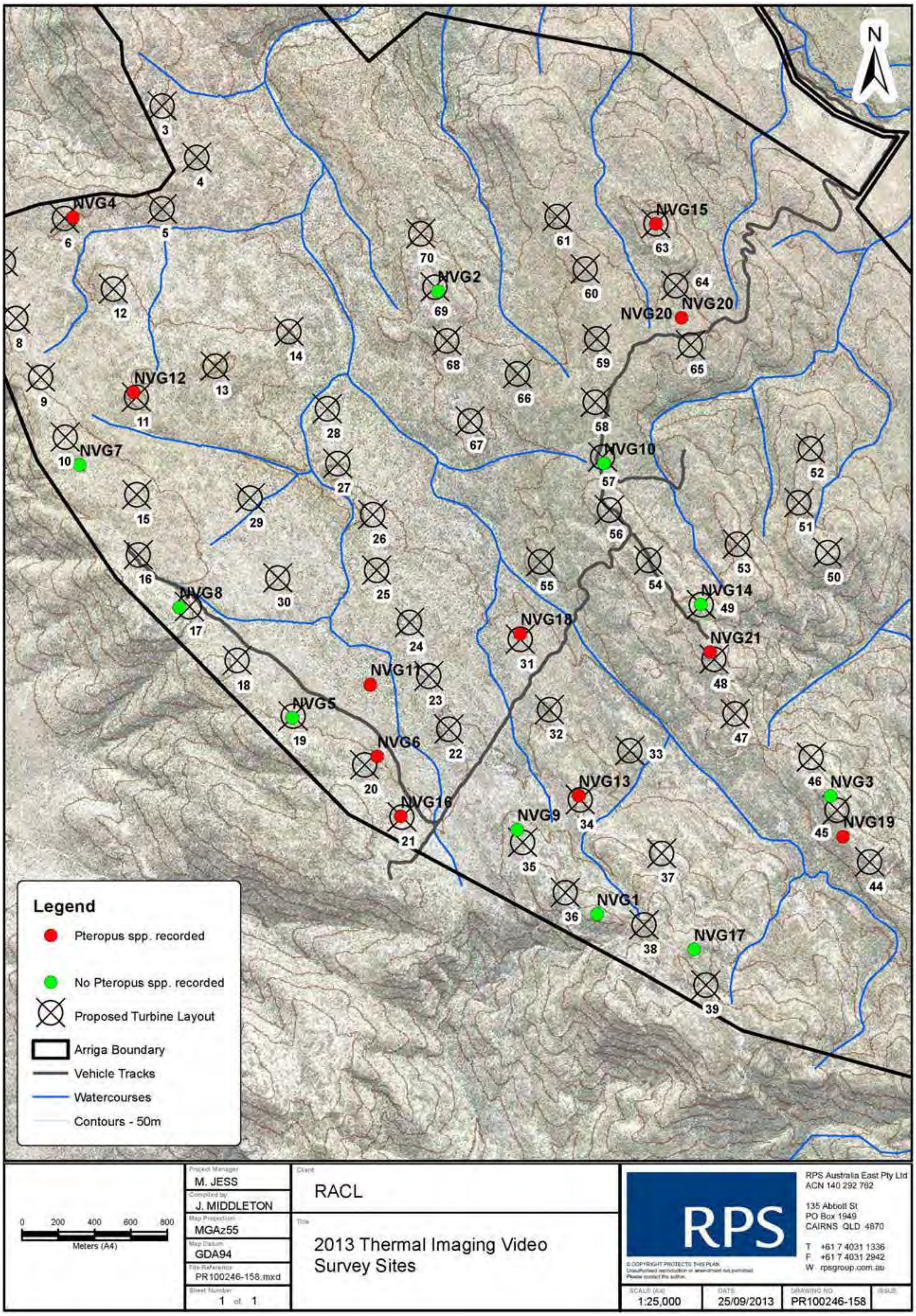

Figure 3 Location of Thermal Imaging Video Survey Sites

3.0 Results

3.1 MEWF Incidental Flying-fox Observations

Two species of flying-foxes were confirmed to occur within the MEWF site. On the 19/3/13 at 2322 hrs, a single Spectacled Flying-fox individual was observed foraging in a flowering *Melaleuca viridiflora* tree ~3m above the ground with a hand-held LED spotlight at c. 326469E 8100237N (UTM WGS 84 55K). The animal flew off when disturbed and flew to a height of ~30-50 m above the ground heading south.

A single freshly dead Little Red Flying-fox (*Pteropus scapullatus)* male was located at c. 328543E 8100734N along the power line access track at 19/12/12 at 0718 hrs. The animal showed no signs of predation (e.g. puncture, tear or bite wounds) and may have collided with the high tension power lines (40m) directly above the animal.

3.2 MEWF Night Vision Surveys

Preliminary observations of flying-foxes alighting from the canopy at the Tolga Scrub roost using the night-vision goggles in October 2012 demonstrated that animals were able to be observed at distances of up to ~150 m under full-moon light conditions with no cloud cover. However, it was not possible to distinguish between *P. conspicillatus* from *P. scapulatus* with any confidence and both species were confirmed to be present during daylight hours.

These observations presented adequate information to continue with night vision goggles as an assessment tool to determine presence/absence of flying foxes on the proposed MEWF, and to attempt to provide estimates of horizontal and vertical distances during surveys.

Pteropus spp. individuals were recorded at 12 of the 21 survey sites (**Figure 2**). A total of 67 individual *Pteropus* spp. were recorded during the surveys, of which only two individuals could be confidently identified as *P. conspicillatus* (**Table 1**). Both of the two positively identified *P. conspicillatus* individuals were observed from very close range (as confirmed by second observer without night vision goggles) and were illuminated with a 30W infrared spotlight so that the distinctive pale eye rings and patches on the head and shoulders were visible with the night vision goggles.

Table 1 Summary of Night Vision Goggle (NVG) Survey Data

Date	Site	Easting	Northing	Number of Individuals Recorded							Total
				Grus spp.	Microbat	*Pteropus* sp.	Spectacled Flying Fox	Duck	Unidentified Bird	Unknown target	
2/10/2012	NVG1	328467	8098753	0	0	0	0	0	0	0	**0**
2/10/2012	NVG2	327591	8102189	0	0	0	0	0	0	0	**0**
2/10/2012	NVG3	329754	8099405	0	0	0	2	0	0	0	**2**
2/10/2012	NVG4	325581	8102596	0	10	2	0	0	0	1	**13**
29/10/2012	NVG5	326789	8099837	10	0	0	0	0	0	0	**10**
29/10/2012	NVG6	327258	8099624	0	0	3	0	0	0	0	**3**
29/10/2012	NVG7	325617	8101231	0	3	0	0	0	0	0	**3**
30/10/2012	NVG10	328506	8101239	0	0	0	0	0	0	0	**0**
30/10/2012	NVG11	327218	8100019	0	1	11	0	0	0	0	**12**
30/10/2012	NVG8	326167	8100444	0	0	0	0	0	2	0	**2**
30/10/2012	NVG9	328029	8099220	0	13	0	0	0	0	0	**13**
26/11/2012	NVG12	325916	8101631	0	2	1	0	0	0	0	**3**
26/11/2012	NVG13	328367	8099407	0	1	4	0	2	0	0	**7**
26/11/2012	NVG14	329040	8100460	1	0	0	0	0	0	0	**1**
26/11/2012	NVG15	328792	8102560	0	0	2	0	0	0	0	**2**
27/11/2012	NVG16	327386	8099294	0	1	4	0	0	1	0	**6**
27/11/2012	NVG17	329002	8098559	0	0	0	0	0	0	0	**0**
27/11/2012	NVG18	328046	8100298	0	0	5	0	0	0	0	**5**
27/11/2012	NVG19	329823	8099182	0	2	4	0	0	0	0	**6**
26/02/2013	NVG20	328934	8102042	0	13	20	0	0	0	2	**35**
27/02/2013	NVG21	329091	8100198	0	7	8	0	0	0	0	**15**
28/05/2013	NVG20	328934	8102042	0	2	1	0	0	0	0	**3**

The abundance of *Pteropus* spp. individuals increased from dusk onwards, peaking between 2000 -2200 hr and then declined gradually towards dawn (**Figure 4**).

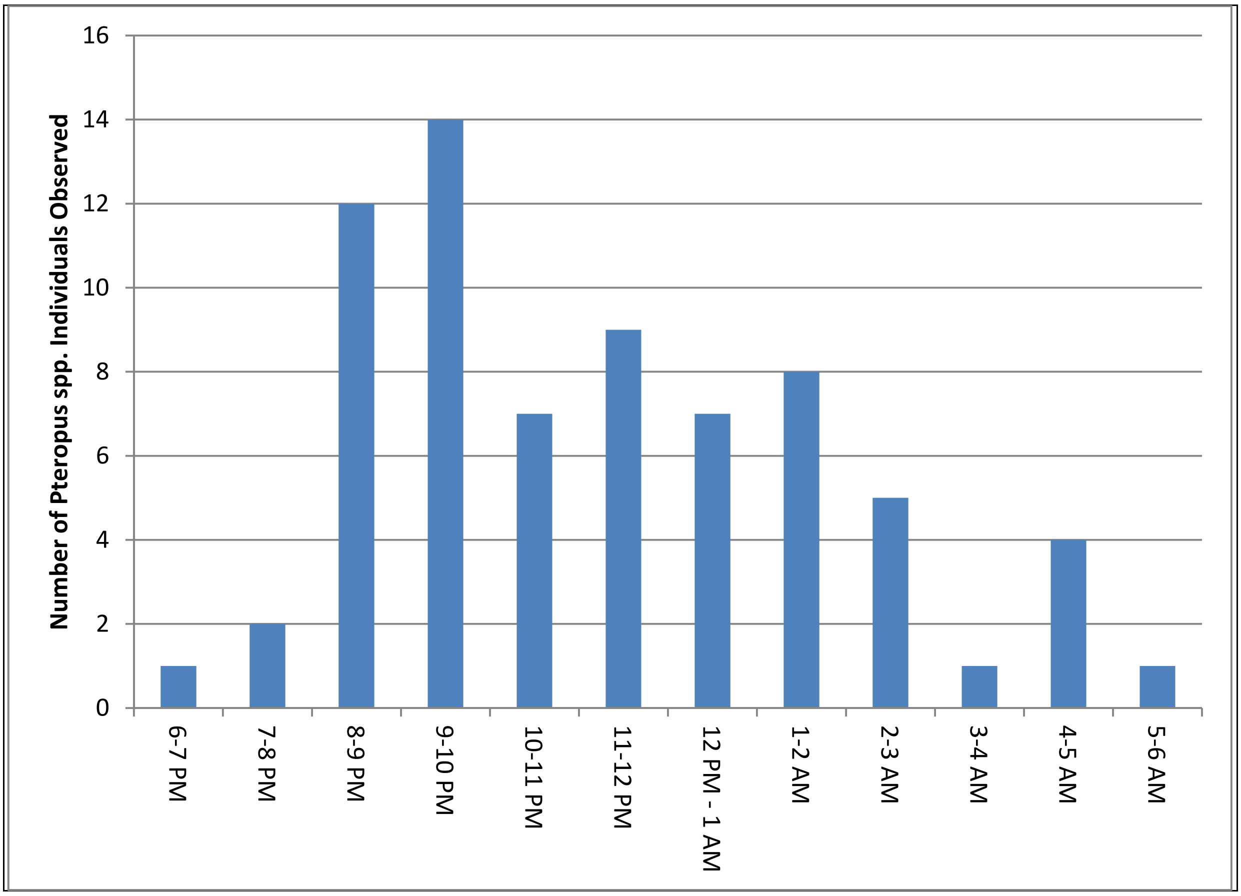

Figure 4 *Pteropus* spp. Abundances Observed during Hourly Time Periods for all Night Vision Surveys Combined

3.3 Thermal Imaging Video Surveys

A total of 111 targets were classified as potentially being *Pteropus* spp. at each of the three sites during the February 2013 surveys (**Table 2**).

A comparison of NVG results to those of Thermal Imaging at the same date, time and location support this method with the same level of classification applied to NVG targets at same data point.

Table 2 Number of Targets Provisionally Classified as *Pteropus* spp.

Site Name	Survey Night Date	Total No. Potential *Pteropus* spp. Identified
FLIR 1	12/02/13	42
FLIR 2	13/02/13	23
FLIR 3	14/02/13	46

Examples screen shots of targets that were considered to represent *Pteropus* spp. are shown in **Plate 2**.

4.0 Discussion

4.1 Spatial and Temporal Utilisation Patterns

Pteropus spp were identified across the MEWF site at more than half of the survey locations between October 2012 and May 2013. Individuals were observed in both the Wet Tropics Bioregion and the Einasleigh Uplands Bioregions of the site. More specifically, Spectacled Flying-foxes were confirmed to occur on the site on two separate occasions (late dry season and late wet season) during the entire period of our ecological surveys on the site between 2010 and 2013.

Our attempts to examine the species spatial and temporal utilisation patterns on the site using thermal imaging video and night vision goggles were unsuccessful due predominately to the difficulties in reliably obtaining positive species identifications with either of these devices.

Significant effort was placed in the development and conduct of the methodologies with the understanding this was a novel approach, untested in Australia, on a species that has been understudied due to the challenges in obtaining sufficient ecological data. This was recognised as a risk, however every effort was undertaken to provide information to the DoE on the species, and these methods were selected for trial as they were the only affordable method with any potential to obtain the required data. At the time of developing the survey methodologies, commercially available bat and avian radar systems, which were assessed as having the best potential to gather the required data, were deemed not cost effective (in the order of $1million) and research suggested that cheaper, marine radar systems would not be suitable.

The tested methods proved suitable for collection of presence/absence data on site; however detailed abundance and flight height data proved difficult and were ultimately also not cost effective. The ruggedness of the survey site meant that observers could only travel to a tower location before dusk carrying all equipment on foot (thermal imaging totalled 100kg). Due to the site relief (greater than 15^{o}- 30^{o} over 83% of the site) and the hazardous groundlayer it was not possible to conduct surveys in multiple locations on each night. This limited replication and increased the number of field staff required to assist.

There are several sources of potential variation associated with the night-vision goggle survey data including environmental conditions and observer bias.

- The night vision goggles that were used had a limited field of view of ~40° compared to between 124°-208° for the human eye, therefore only a small proportion of the total potential detection volume around each observer (~0.005 km^3) could be sampled at any one time.
- The need to scan continuously for long-periods was physically and mentally demanding for the observers and it is likely that detectability was not constant during the 3 hour shifts, particularly in the early morning due to observer fatigue.

The night vision goggles surveys were restricted to periods of high lunar illumination to facilitate the detection and identification of *P. conspicillatus*. The influence of moon phase on the activity of any *P. conspicillatus* or other Australian *Pteropus* spp. is not currently understood. Many studies have shown a pronounced *luna phobia* effect in bats. For example, a meta-analysis conducted by Saldaña-Vázquez & Munguía-Rosas (2012), found that the relationship between moonlight intensity and bat activity is negative and significant. Latitude was also found to be positively correlated with *luna phobia* in bats (Saldaña-Vázquez & Munguía-Rosas, 2012). Many species of New World phyllostomatid bats have been shown to exhibit reduced activity during periods of high lunar lamination (Morrison, 1975; Crespo *et al*., 1972; Gannon & Willig, 1997). Feeding activity of a megachiropteran fruit bat, the Greater Short-nosed Fruit Bat (*Cynopterus sphinx)* on *Calophyllum inophyllum* fruit and leaves of two other plant species was shown to be negatively correlated with the percentage of moonlight each night (Elandgovan & Marimuthu, 2006). This *lunar phobia* effect may be due to increased risk of predation by visually oriented predators (Morrison, 1978) such as owls, as lunar illumination has not been shown to be correlated with resource abundance and distribution or bat social activity (Morrison, 1978). If the Australian *Pteropus spp.* exhibit *luna phobia*, then the abundances recorded during the night vision goggle surveys, which were only conducted during periods of high ambient moonlight to aid detection, may not be representative of "optimum" flying-fox activity across the site, i.e. the counts would be underestimated due to the potential *lunar phobia* phenomenon.

Weather conditions also varied significantly across the site during the surveys, with survey locations above 900 m on the south eastern section of the site often covered in dense low cloud for large periods of the night.

4.2 Effectiveness of NVG and Thermal Imaging Video to Collected Data Suitable for Numerical Collision Risk Modelling Data

Numerical turbine collision risk modelling requires information on the number of individuals that might interact with turbines and the estimated number of their flights that are at risk of collision (EPHC, 2010).

Neither of the methods used in this trial study was determined to be suitable for collecting utilisation data suitable for numerical risk modelling because of

(a) the inability to accurately identify species (as discussed preciously) and

(b) the inability to accurately estimate flight heights of individuals.

These technologies together with a radar system would provide a more holistic approach to data collection.

The night vision goggles that were used did not permit binocular vision to estimate horizontal and vertical distances. All of the *Pteropus* spp. individuals recorded during the night vision goggle surveys were considered likely to have been flying within or below the rotor sweep area (hub height 90 m, blade length 55 m - 35 m to 145 m above the ground) as it was not possible to discriminate flying-foxes at distances greater than ~150 m with the night-vision goggles. Therefore, even assuming sufficient spatial and temporal replication could be obtained, the estimate of the turbine collision risk obtained from the data is likely to overestimate the risk.

The potential for using thermal imaging to estimate the flight height of any *Pteropus* spp. appears to be limited due to the high degree of subjectivity regarding the positive identification of targets and the influence of the temperature scale selected to view the image on the FLIR Research IR software on the apparent size of the target. It is theoretically possible to estimate the flight height of a target of known size by counting the number of pixels its image occupies on the monitor. It was not possible to keep the temperature scale constant while effectively detecting all targets of interest as the relative brightness of the target against the sky background varied depending upon the presence and amount of cloud cover. There is a significant difference in the average wing span of the species of flying-fox which have been confirmed to occur on the site (*Pteropus conspicillatus* ~ 20-40% greater than *P. scapulatus),* which may be a significant source of error in estimating flight heights based on size of the target on the image (number of pixels).

4.3 Recommended Further Research

It is apparent that radar is the only proven methodology (currently available) to collect accurate data on the flight heights of nocturnally flying animals such as flying-foxes. Avian and bat radar systems are the primary method used in the US and Europe to quantify utilisation and assess the environmental risk of wind energy developments on nocturnally flying fauna (birds and bats) (Davenport, 2010, d' Entremont, 2010; Johnson, 2010 and Svedlow, 2011). These radar systems can provide data on the number of targets passing through the radar beam in a set amount of time, the distance to the target from the radar (either elevation or range depending on whether the radar is used in a horizontal or vertical orientation) and trajectory or flight path

(Duberstein *et al*., 2012). However, radar systems used on their own may not be sufficient to enable effective differentiation between insects and fauna of interest (birds and bats) (Addy Borst, Robin Radar, pers. comm.). The simultaneous used of both radar and thermal imaging devices have been used successfully to differentiate nocturnal insects, birds and bats, with radar providing accurate distance measurements and thermal imaging assisting with target differentiation (Gauthreaux & Livingston, 2006).

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Attachment A

DeTect Inc. – Quote for MERLIN ARS System – Avian Survey Configuration

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DeTect Inc.
detection technologies

environmental systems & services

DeTect ARS-SCADA System

Proposal for Ratchaburri Wind Farm

engineering solutions for monitoring the environment

NCS INTERNATIONAL
CERTIFIED
QUALITY
MANAGEMENT SYSTEM
ISO 9001
CERTIFICATION N° 14363

AUSTRALIAN
OWNED AND
OPERATED

MERLIN Avian Radar System

for

Bird Activity Monitoring and Mortality Risk Mitigation
at Ratchaburri's proposed wind farms in North Queensland - Australia

Introduction

DeTect is pleased to provide this proposal to RPS for provision of a MERLIN Avian Radar System for use at Ratchaburri's proposed wind farms in North Queensland, Australia. The goal is to reduce bird and bat mortality risk from possible collision with the windfarms' planned turbines, using DeTect's MERLIN *SCADA* avian risk mitigation technology. MERLIN *SCADA* represents the most advanced active bird mortality risk reduction/mitigation technology available today and is the only system deployed for operational uses for migratory and soaring bird applications.

For proper implementation, the project at the windfarm site will be divided into three phases. The first phase will involve installation of a MERLIN Avian Radar System (ARS) at an area covering the windfarms for the purpose of carrying out an extended avian survey (up to 12+ months may be required) aimed at collecting detailed information regarding the activity levels, behavior and movement patterns of the birds, and at assessing the mortality risk presented by the windfarms to birds. During this phase we will also define the number of radars needed to provide full operational coverage of the windfarms. The survey data is required for the mitigation project design and the data from the survey will be used to define and develop the initial Risk Rules and operational scenarios which can be used to implement automatic Merlin SCADA control of the wind turbines in the second Phase, so as to minimize bird mortality risk.

Figure 1: MERLIN Avian Radar System at Smola Wind Park, Norway (Owner: Staatkraft)

MERLIN SCADA is a unique technology which utilizes the MERLIN ARS as an ‗early warning system' to automatically detect birds approaching the wind farm, determine if they are at risk of collision with the turbines, and automatically activate mitigation responses ranging from issuing operator warnings to automated turbine idling (curtailment), or activation of humane deterrent systems such as LRAD or the laser deterrent unit (LDU). The MERLIN SCADA system is customized for each specific wind farm application via the software GUI interface, with response scenarios programmed based each site's specific issues and requirements. MERLIN SCADA is applicable to mortality risk mitigation for a wide range of scenarios and conditions that include migratory birds, raptors and bats (see attached paper).

Typically, the MERLIN system radars sensors are positioned at points within and/or around the wind farm (see figure 2 below) to meet the operational detection and response requirements. The MERLIN system is connected to the windfarm Supervisory Control and Data Acquisition (SCADA) system via a MODBUS or similar interface to support two-way communication between the MERLIN system, the wind turbines and remote windfarm control centers. The typical operational scenario provides continuous, unattended advance detection of bird movements approaching the wind farm (at ranges out to 4 nautical miles or nm), real-time analysis of bird level, bird altitude, visibility, weather and other variables, mortality risk assessment, and initiation of response actions (automatic, or human-actuated after an alert to operators by the system), and MERLIN includes the capability to automatically restart the turbines after the risk conditions have abated. Ideally, the MERLIN ARS is used for pre-construction survey prior to the wind farm going operational and to support development and testing of the initial MERLIN *SCADA* risk rule sets used for mortality risk assessment and mitigation measure activation.

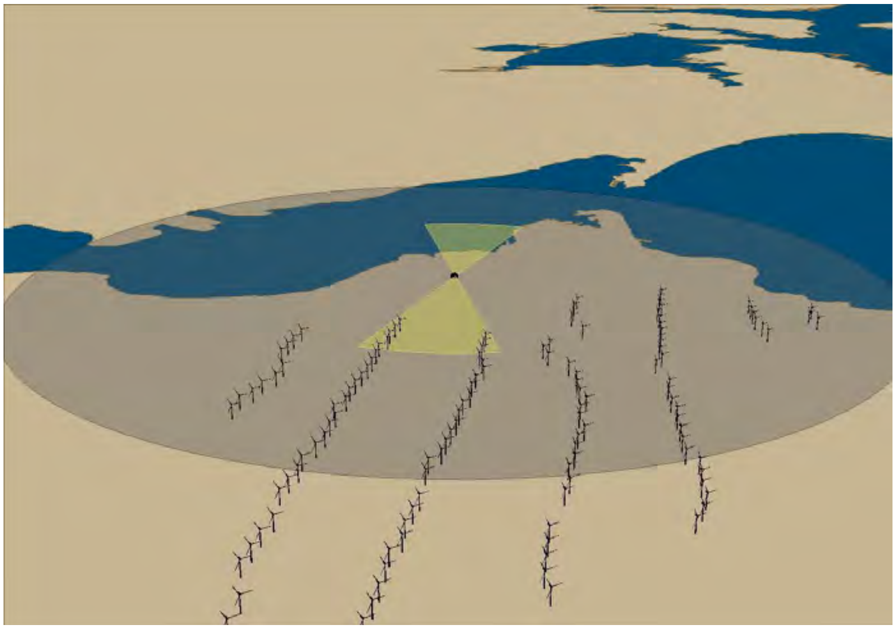


Figure 2: Illustration of MERLIN SCADA deployment at a wind farm providing continuous monitoring of migratory bird movements approaching the windfarm, with horizontal and vertical radar coverage indicated (not to scale).

Wind Farm Bird Mortality Risk Mitigation proposed Scope of Work for Ratchaburri's Windfarms

1. **Understanding of the Project:** RPS has been engaged by Ratchaburri to conduct an assessment of several of their proposed wind farms in North Queensland, Australia. No preconstruction radar data is known to be available. In order for the bird radar system to provide optimal detection and risk management, the proposed system with include solid-state radars with Doppler processing. The most pressing bird and bat issues are:
   - Sarus Cranes (may fly over site in winter)
   - Wetland birds (may fly over site occasionally)
   - Resident raptors
   - Seasonally foraging flying-foxes
   - Resident microbats (including the critically endangered Bare-rumped Sheathtail Bat, Saccolaimus saccolaimus)

2. **Three-Phase Implementation of the MERLIN ARS and MERLIN *SCADA***, as follows:

   a. **Phase One - Survey:** Deliver and install one or two MERLIN XS25200me Avian Radar System (ARS), together with a laser ceilometer and a meteorological visibility sensor, and commence avian survey work (to begin 4-6 months ARO), with the objective of carrying out up to 12 months of 24-7 bird activity data collection and to develop a comprehensive understanding of the windfarm's specific mitigation requirements, and to develop initial Risk Rule Sets for implementation of MERLIN SCADA. One system will provide only partial coverage of the wind farm, so the client should consider buying two systems to cover the entire WRA. , The avian, cloud height & sky cover and visibility data collected will allow rigorous assessment of how best to utilize MERLIN SCADA to minimize bird mortality risk.

      Phase One will also develop detailed radar coverage data for analysis of the windfarm in order to determine the final number of radars needed and placement to satisfy Phase Three operational radar coverage requirements.

      Specific objectives during this initial survey phase include:

      - Define bird flight patterns and area activity levels,
      - Identify precursor risk patterns,
      - Quantify avian mortality risk
      - Define required response times and appropriate mitigation strategy,
      - Determine the operational MERLIN system placement and the eventual number of horizontal and vertical radars required to achieve full coverage of the windfarm,

      Note: This assessment requires a minimum of 3 months of on-site data collection *during periods of highest risk* with confirmatory visual observations. Furthermore, up to 12 months of data collection are typically are needed in order to optimize our understanding of bird behaviors and to fully develop the Risk Rules needed for MERLIN SCADA bird mortality risk mitigation. This proposal assumes that a full 12 month radar survey will be carried out.

   b. **Phase Two – Initial SCADA Implementation:** in this phase DeTect will install and test the initial SCADA system configuration over a period of 6-12 months, using the Risk Rules developed in Phase One. This process will provide intensive operational evaluation in order to optimize the mitigation risk rules and responses for optimal avian mortality risk mitigation.

   c. **Phase Three - ARS Coverage Expansion**, using additional Vertical and/or Horizontal Surveillance Radars (VSR's and HSR's) as needed to provide full windfarm coverage and to implement SCADA control of all turbines using optimized Risk Rules. Full SCADA implementation is expected to be completed within 3-6 months after installation of the additional MERLIN radars. DeTect will provide the client with a report projecting the numbers and types of radars needed for this purpose, at the end of Phase One.

3. Radar Survey Description

The proposed system is widely used for this purpose and is optimal for general avian monitoring for the above referenced project. The general objective of an avian survey of this nature is to develop data on bird activity levels and patterns for the study area. The design of the survey and specific scope of analysis of the radar data collected to be supported by DeTect will be determined through direct discussion with the Client, however the scope will generally be in accordance with DeTect's standard methodology for such surveys and will include the following:

a. Quantifying diurnal and nocturnal bird activity in the area of the survey area to include height distribution, passage rates and composition (target size classes)

b. Assess flight pattern of birds across the proposed area to include flight paths, flight altitudes, flight directions, flight speeds, and conditions (visibility data to be provided by the Client).

The client's biologists and researchers will be operating the system and DeTect will coordinate with the Client to define the study plan prior to delivery and start-up of the radar, to include defining the specific data analysis and data outputs desired. DeTect will also train the Client's staff on system operation and support.

3.1 MERLIN Avian Radar System Characteristics

MERLIN represents the state-of-the-art and is the most advanced and proven system available, with over 60 systems operating worldwide in aviation safety and bird control, however the technology does have limitations in that radar is a line of sight instrument and the current system implementation is not species specific. The MERLIN technology was originally developed and is currently used by the US Air Force and NASA for aircraft-bird strike risk management and includes advanced, military-grade signal processing software. Please refer to the figure below, illustrating a typical ABAR configuration.

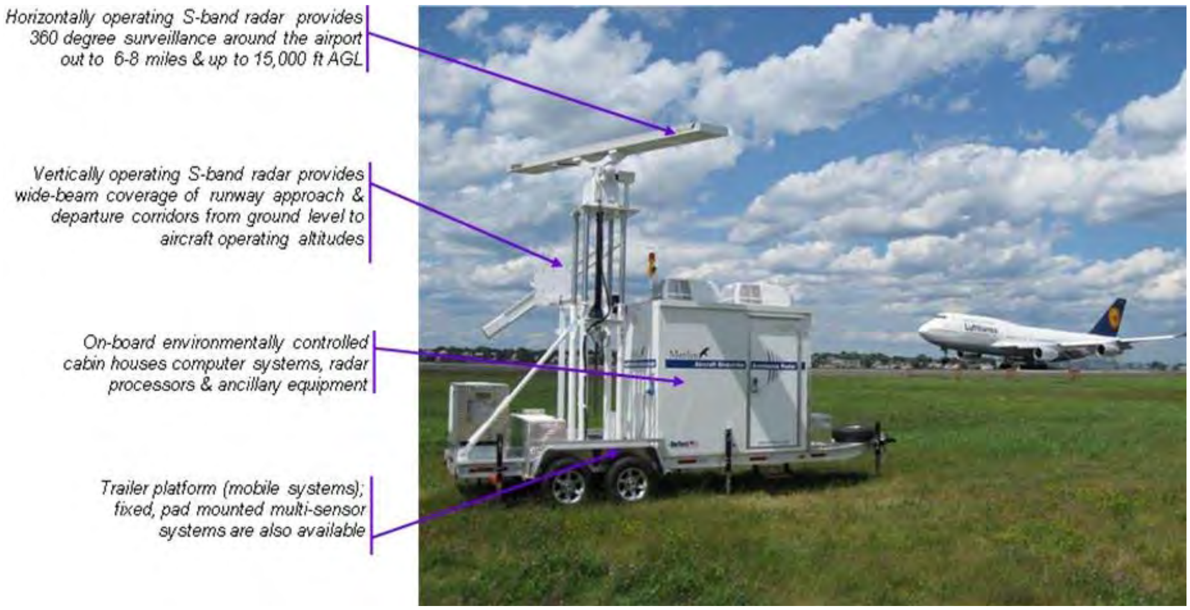


Figure 2: Typical Mobile ABAR Configuration

All radar systems are however susceptible to interference from structures, vegetation, high sea state, and other radars that may limit detection in certain areas and/or environments. The system will require installation in a representative location with a relatively clear line-of-sight of the area of interest and DeTect will assist the client in siting analysis and desktop clutter and coverage modeling as part of its scope of delivery under this proposal.

Data from the X-band (3 cm wavelength, ~22 degree beam angle width in the vertical) vertical scanning radar (VSR) will not generally be available during periods of precipitation. The solid-state S-band (10 cm, ~24 degree beam angle from the horizontal) horizontal surveillance radar (HSR) generally will function in up to moderate precipitation.

The system classifies targets into size classes generally corresponding to small, medium, large and flock size birds, but cannot definitively distinguish species. As such, DeTect recommends that periodic field groundtruthing of the radar system data be conducted by qualified biologists as part of any survey, using the system for data validation and to develop data subsets on species predominant at the survey site (using the MERLIN groundtruth recording feature).

For avian surveys, the recommended range of operation for the vertical scanning radar (VSR) is 0.75-1.0 nautical miles (nm), maximum range is 1.5 nm; and for the horizontal surveillance radar (HSR) recommended range is 1-2 nm (maximum range 3-4 nm).

Table 1: MERLIN Operating Ranges by Application

Radar Type	**General Survey**	**Windfarm Survey**	Comments
VSR (X-Band)	1.0 -1.5 nm *(1.85 – 2.8 km*	0.75-1.0 nm *(1.4 – 1.85 km)*	Determined by survey needs.
HSR (S-Band)	3 – 4 nm *(5.6 – 7.4 km)*	1-2 *nm (1.85 – 3.70 km)*	Determined by survey needs.

The actual siting for the MERLIN ARS will be defined in a pre-delivery survey, either utilizing the customer's GIS data sets, or a formal site visit.

DeTect will provide standard and custom data analysis to support the Client's monitoring activities. The standard analysis queries included with the system are shown in Table 2 below:

Table 2: Standard Survey Project Queries Included with System.

Query	Description	Classification	Format
1	Total number of bird targets AGL under Good visibility conditions	By size as S, M, L or F	Data table and graphically
2	Total number of bird targets AGL under Low visibility conditions	By size as S, M, L or F	Data table and graphically
3	Total number of bird targets per kilometer (km) of front by hour of the day	By size as S, M, L or F	Data table
4	Total number of bird targets per km of front by hour of the day, normalized to all project days	By size as S, M, L or F	Data table
5	Total number of bird targets per km of front by period - day, night or transition (dusk/dawn)		Data table and graphically
6	Total number of bird targets per km of front by period - day, night or transition (dusk/dawn)	By low or high visibility	Data table and graphically
7	Mean altitude/standard deviation of bird targets by period - day, night or transition (dusk/dawn)		Data table and graphically
8	Number of periods with passage rates exceeding the risk threshold by visibility		Tabular
9	Target count below, within and above the Rotor Swept Zones		Data table and graphically
10	Directional histograms by count by period - day, night or transition (dusk/dawn)		Graphically

3. MERLIN XS25200me Avian Radar System (ARS) Deliverables

The initial ARS delivered to satisfy Phases 1 and 2 will be trailer-mounted dual radar system consisting of one Vertically Scanning Radar (VSR) and one Horizontally Scanning Radar (HSR). The ARS deliverables will include:

3.1 One (1) MERLIN XS25200me Avian Radar System (minimum), to include:

a. Fully self-contained, CE certified trailer mounted system functional at delivery, including Doppler processing, Visibility Sensor, and Laser Ceilometer.

b. Country-of-delivery compliant marine-grade aluminum trailer system and equipment platform.

c. Commercial power plug in and 100 ft cable (110/220 vAC, 60/30 amp service required) with on-board diesel 6 kilowatt (kW) power generator system with extended run fuel tank (supports about 10 24-hour days of operation; oil and filter change required every 250 hours), Uninterruptible Power Supply (UPS) back-ups, and automatic commercial/generator power transfer switch that will start the generator should commercial power fail.

Note: Dual, auto-switch generator systems with high capacity fuel tanks are available as an option for extended runtimes (500 hours) between service.

d. Dual radar sensor system:

   i. 200 watt horizontally-operating solid state S-band radar with Doppler processing with 7° tilt-up and ~24 degree beamwidth, mounted on an extendable radar tower.

   ii. 25kW vertically-operating magnetron X-band with tower and slide-out separator (~22 degree beam width angle).

e. Environmentally-controlled on-board operator/equipment SIP cabin (~8 x 6 x 6 ft, l x w x h) with window and coded (keypunch) door lockset.

f. On-board vibration dampered, rack-mounted data processing computer system and network (MS Windows operating system, English version is standard, foreign language versions available at extra cost). Delivery includes radar interface and processor computers for each radar, a network switch, MERLIN WAAS enabled GPS/Compass geo-referenced datum system, and ancillary components.

g. MERLIN radar operating and processing software to include one (1) full MERLIN system license for MERLIN Administrator, Processor, Display, Remote (remote control and display software), MerlinChart™ and TrackPlot™, and one (1) remote, limited-use system license for MERLIN Administrator, Processor, Display, MerlinChart™ and TrackPlot™ for offsite data analysis.

   The MERLIN data processing package Includes raw radar stream recorder for both the HSR and VSR, which allows recording of high resolution, unprocessed (raw) radar datastream for detailed offsite analysis and QA/QC.

h. MERLIN/SQL data system for archiving and reporting of processed bird track data at the site.

i. Cellular WWAN uplink system (connectivity service provided by client).

j. Local wireless network (50-100 ft range) and wireless notebook display computer for recording biologist groundtruth visual data direct to the MERLIN system database.

k. Ancillary support equipment including a weather station (Davis Weather Wizard), spare tire, wheel chocks, lightning protection, tie-downs and ground anchors, tools and equipment storage box, safety equipment (first aid and Halotron™ fire extinguishers), and safety signage.

l. All-white, powder coat paint scheme on key components with standard system markings.

m. Pre-delivery scoping site visit and meeting to occur within 45 days of receipt of order.

n. Two (2) reproducible digital copies of User Operations & Maintenance (O&M) Manuals (user and technical; one to be installed on main system).

o. Delivery: CIF, to be shipped to nearest major seaport in client's country. Client pays in-country Inland freight charges, as well as any import duties and related taxes and fees.

p. System installation support, start-up, initial groundtruthing and user training.

q. Daily remote QA system check and remote diagnostics with MERLIN FileWatcher

r. Quarterly site visits by DeTect radar ornithologist/biologist for the first calendar year after start-up to coincide with expected peak activity periods for each season; 3 days per visit to include system inspection and radar groundtruthing

s. One (1) year data processing and analysis support to include daily monitoring of the system with daily remote system checks and data file downloads via the internet (requires satellite or cellular connectivity).

   Report and data products to include tabular, graphical and plot output products to meet the study objectives for bird passage rates, altitudes, flow patterns and quantitative assessment of mortality risk

   (Out year data processing is available on a fee contract basis)

t. One (1) year 24-7 telephone and internet technical support

u. Attendance at MERLIN Certification/User Training classes held 2-3 per year in Panama City, Florida, USA (space availability is based on first-booked basis)

v. One year full parts and labor warranty

w. Three (3) years MERLIN software upgrades

Additional information:

- The system requires installation on a firm, level surface (pavement or gravel pad recommended) and will be anchored with lightning protection installed by at installation.
- The system is designed for unattended, environmental use however in the event of high winds (> 50 mph) may require additional securing and/or temporary removal from the site.

4. MERLIN ARS Coverage Plan

The actual siting for the Phase One MERLIN ARS will defined in a pre-delivery survey, either utilizing the customer‘s GIS data sets, or a formal site visit. A preliminary and hypothetical best-estimate of the radar requirements for full coverage of the proposed windfarms (to be determined after completion of Phases 1 and 2), is shown in Figure 4a below, and assumes a MERLIN SCADA layout based on at least 2 MERLIN XS25200me trailer-mounted systems, each consisting of 1 HSR and 1 VSR. As part of Phases 1 and 2, DeTect will conduct a detailed requirements review, based on data analysis, field work and GIS analysis. This information, as well as the 12 month avian survey data, will allow us to characterize and understand bird flight patterns and general use of the environment, and recommend a suitable final operational radar network solution. DeTect has provided a base quotation for additional VSR radars, if needed, to be able to provide total coverage and SCADA implementation.

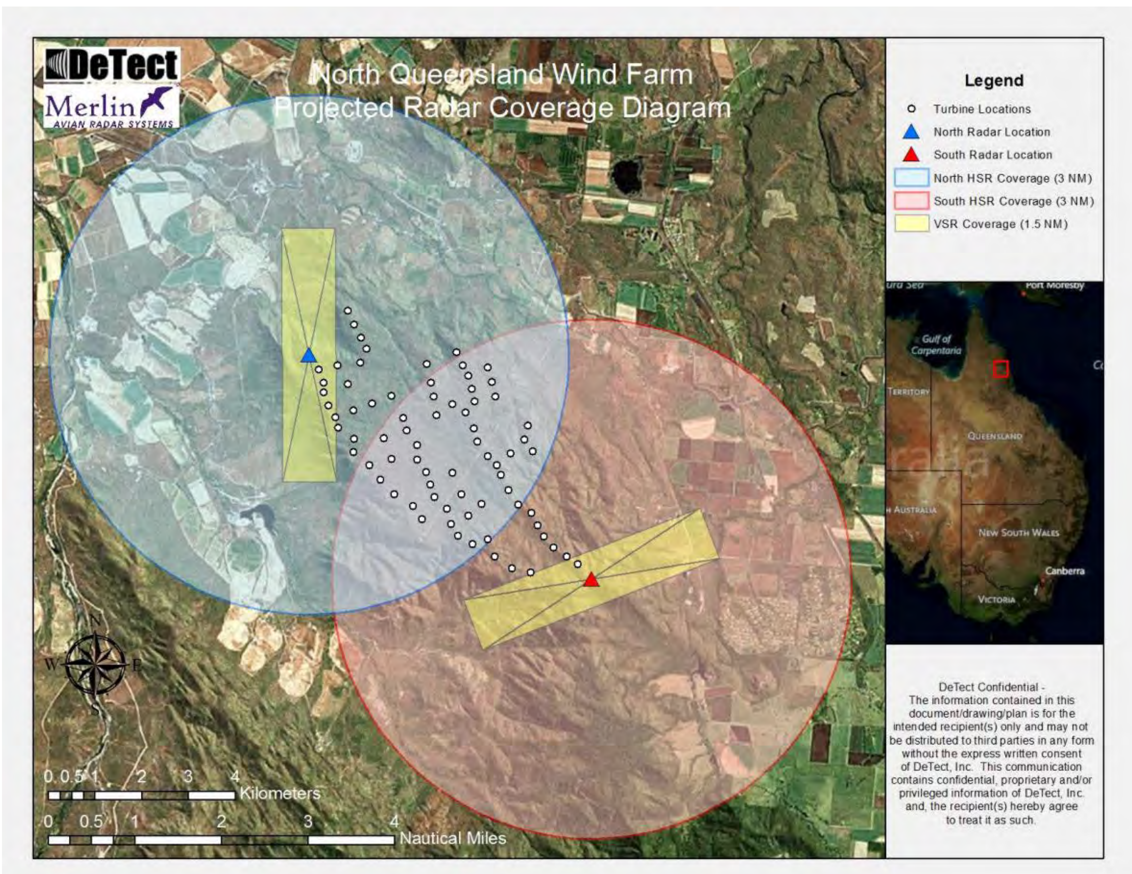


Figure 4a: *Conceptual Initial MERLIN ARS Deployment Plan for full coverage of Ratchaburri's Proposed Windfarms (Not to Scale)*

5. MERLIN SCADA

The MERLIN SCADA sub-system is an advanced ARS application designed to continuously analyze bird density, altitude, visibility, weather and other key relevant risk factors and automatically idle wind turbines and/or activate bird deterrent devices so as to reduce mortality risk to birds. (Note: up to 12 months of MERLIN avian survey data are typically needed to define the Risk Thresholds used to define the SCADA risk rules for each site). General performance characteristics for the MERLIN system are as follows:

- **a.** MERLIN horizontal scanning radars (HSR) provide 360° degree horizontal (x-y) detection of approaching bird movements out to 2-3 miles and up to 10,000 feet within line-of-sight.
- **b.** The vertically scanning radars (VSR) provide vertical detection (y-z) of bird activity out to 1-2 miles within line of sight.
- **c.** Based on programmed Risk Thresholds, the MERLIN SCADA software will continually analyze the defined risk factors and environmental conditions, initiating full or partial turbine idling and/or deterrent device activation until the risk abates (passes).

6. Terms, Conditions & Qualifiers

a. All pricing is in U.S. Dollars and the client assumes all foreign exchange risk.

b. Payment Terms:

- 30% of contract with order and executed contract
- 15% payment due 30 days after contract
- 15% payment due 60 days after contract
- 15% payment due 90 days after contract
- 15% payment due prior to shipment
- Balance in equal payments to be invoiced monthly with 5% due at start-up and the final 5% due within 60 days after startup

c. Payments are to be made within twenty (20) days of invoice date. Failure to make payments in accordance with the terms and schedule may result in extension of delivery.

d. The price proposed is exclusive any and all applicable sales taxes, fees, licenses, duties (import or other), operating permits and other costs resulting from the sale, delivery, transfer, installation, and operation of the system and the buyer will be responsible for obtaining and costs related to such items. DeTect will provide available information for applications, permits and licenses as required by the buyer.

e. Title to the equipment will be transferred to the buyer upon receipt of all payments due from the buyer to DeTect under this proposal and any subsequent contract.

f. Delivery quoted is CIF nearest major port (customer to arrange customs clearance, transport to project and installation sites).

g. Start-up to occur upon delivery, and system set-up.

h. Proposal is valid for 90 days from the date of issue.

i. Radar is a line of sight instrument and will not detect targets obstructed by structures, terrain, etc.

j. Specifications are subject to change without notice. Systems will be delivered in general accordance with specifications and design currently in effect at time of order.

k. DeTect provides a one (1) year full parts and labor warranty that includes repair or replacement of any defective parts for the term of the warranty, exclusive of wear parts. Wear parts are parts which degrade under normal use and include, but are not limited to, motor brushes, tires, and other such components, or parts that fails due to deterioration from adverse environments or chemical exposure. Extended warranty coverage is available at additional cost.

l. Purchase and delivery the system may be subject to the United States International Traffic in Arms Regulations (ITARs). Non-US government buyers at purchase will be required to execute an agreement acknowledging that: (i) DeTect's MERLIN system (defined as technology, hardware and software) may be governed by the United States ITARs; (ii) the system will be used solely for the intended commercial purpose and will be used in strict compliance with ITARs; (iii) he will implement procedures for restricting access to said system and agrees not to sell, rent, lease or in any manner transfer the system or any component to any country or individual to which such access or transfer is restricted; (iv) will not to export or transfer the equipment outside of the U.S. except as permitted by ITARs and with the express written approval of the DeTect; and, (v) any other use of the system may require advance approval under ITARs, agree to advise DeTect prior to any transfer or such use, and will not proceed with such transfer or use without receipt of approval by both DeTect and any required U.S. Government Agencies. The buyer will be granted a single site user license to use the MERLIN™ and HARRIER™ operating software for the intended purpose only. DeTect will deliver a complete set of the operating software executables with the system and periodically will issue updates and patches to the software. Any other such unauthorized use of the software or transfer of or installation of the software to other systems or computers or transfer to other users, companies or individuals is expressly prohibited. Noncompliance with the license requirements will result in revocation of the user license upon notification of which the buyer will immediately and promptly remove, delete, and destroy all copies of said software, providing written certification of compliance of such removal, deletion, and destruction.

m. Acceptance of the order by DeTect is contingent on execution of a contract or order in a form acceptable to DeTect. All specifications and delivery schedules are subject to change based on current models offered at the time of the order.

6. MERLIN ARS Software Suite

The MERLIN ARS applications software delivered with the ARS consists of the following modules:

6.1 MERLIN Administrator - basic system configuration software module used to define all basic settings of the MERLIN software and hardware for proper operation, including radar sensor type and power, radar scanning mode (vertical or horizontal), geographic location (latitudinal and longitudinal position), target tracking parameters and all related parameters. The MERLIN Administrator operates as an on-screen Wizard with tabs for quick navigation and set up or adjustment of the system. Specific parameters set and controlled by MERLIN Administrator include:

- **a. Radar Operating Mode** – Surveillance, for Horizontal Scanning Radar (HSR) mode or Vertical, for Vertical Scanning Radar (VSR) Mode.
- **b. Static Target Filters** – defines clutter filter settings.
- **c. Variable Sensitivity Threshold (VST)** - Standard Deviation of a given pixel value and multiplier as primary and secondary (includes a ~~-B~~uild Clutter Data" option for manual masking of an area of the image).
- **d. Radar Location & Datum** – latitude and longitude as set by the MERLIN GPS/Compass WAAS unit that provide continually time and location hacking during operation to maintain system accuracy.
- **e. Radar Sensor Model and Power** – 2010 standard is 200 watt S-band.
- **f. Time Zone at the Location** - all MERLIN database records are time stamped according to the user selected time (MERLIN also automatically time stamps all records in Zulu time to provide a consistent reference to time that is not affected by daylight savings time).
- **g. Clock Time** - as set by the MERLIN GPS/Compass WAAS unit that provides continually time and location hacking during operation to maintain system accuracy.
- **h. Data Paths and Names** – define location for each type of data produced by the system via a path navigation dialog box for selection of file and directory location including the Display Image Paths, Remote Status Log Paths, Remote User Data Paths, Database File Names, Database Change Times, Auto File Zip option, Remote Status Log (enable or disable), and Maximum Database File Size.
- **i. Risk Threshold Values** – sets MERLIN ATC Low and High risk thresholds and designates the number of targets seen in a given altitude band in a defined time frame minutes that will trigger the altitude risk bar graph color to change from green to yellow or yellow to red.
- **j. Network Configuration Settings -** configures the role (interface or processor) and designation (name) of the MERLIN computer or MERLIN network.
- **k. Radar Operational Settings –** includes settings for the Pulse Filter, Pulse Length (to optimize the radar for biological target detection), CFAR On/Off

(Constant False Alarm Rate for scan-by-scan filter for suppressing radar energy reflected by clutter), CFAR Window Length (represents the number of range bins in a radial that are analyzed to determine the CFAR threshold), CFAR Offset (defines the optimal target detection for a given radar environment), and CFAR Rank.

l. **Range Setting –** set based on the smallest target detection required at operating range and set by the he Image Size Calculator Program, which can be found on the MERLIN computer desktop.

m. **Sampling Rate –** sets the sampling rate used to measure the reflected radar energy (voltage); optimized so that the peak signals will be sampled (measured) by the signal-processing card.

n. **Azimuth Samples –** determines the number of azimuth samples taken for each revolution of the antenna.

o. **Maximum Gated Image Size –** sets maximum image size needed to achieve a desired radar range based on the sampling rate and azimuth samples taken.

p. **Radar Display Origin & Center –** set dependant on the Radar Mode selected (HSR or VSR).

q. **Advanced Processing Parameters –** defines settings for Scan, Frequency Time Constant (FTC) Index, Interference Rejection (Wx and radar), and Use Recorded Data (for processing of recorded raw radar data).

r. **Target Size Filters –** sets Max Size and Min Size (maximum/minimum size based on pixel area for all targets tracked by the MERLIN software to filter real-time data to only targets of interest such as larger targets that pose significant strike risk to aircraft); and, Max LF/Min LF (Linear Filter applied to the Max and Min Size value and to compensate for the increase in target size with distance)

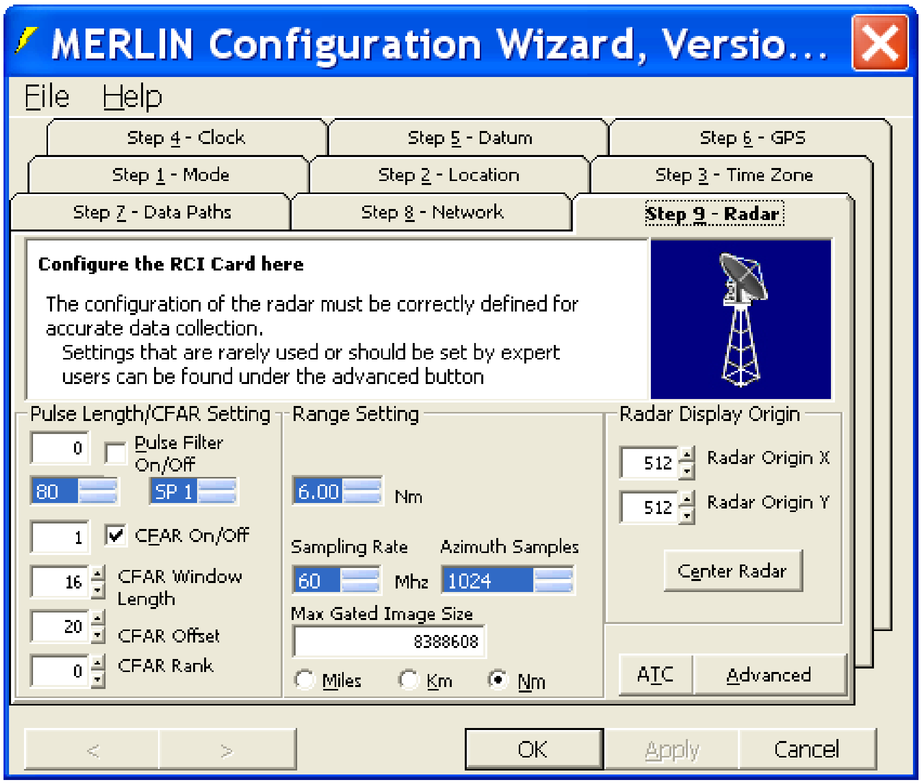


Figure 4: MERLIN Administrator on-screen GUI

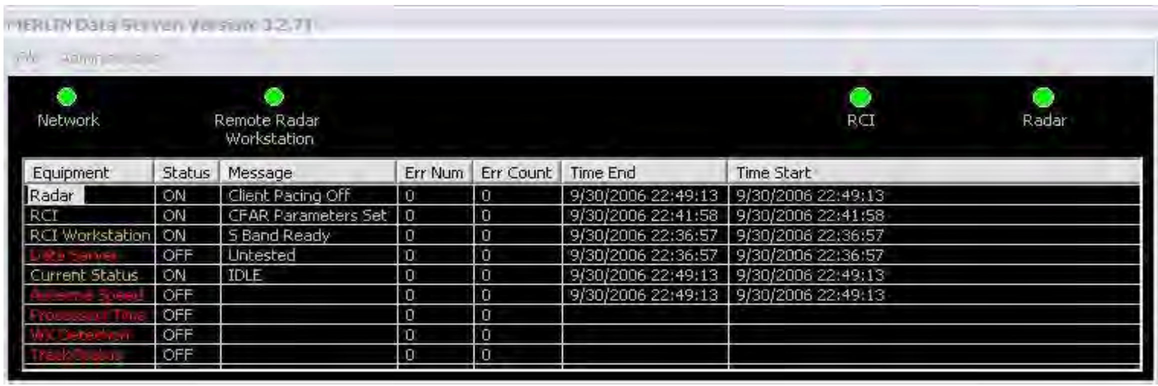
s. **Clear Air Threshold (CAT) level -** eliminates the lowest reflectivity values from MERLIN processing and prevents MERLIN from scanning unnecessary pixels associated with background noise of the radar equipment.

t. **Min Intensity –** defines the increase above the average clutter value for a given location on the display before a target is plotted by the MERLIN software for false target control.

u. **Clutter Statistic Images** - generates a raw radar image that is stored in the database for calibration, diagnostic and reference purposes.

6.2 **MERLIN Data Server** - used to communicate with the Radar Interface Computer (RIC) and relay settings configured in MERLIN Administrator. The data server also monitors the radar and collects and outputs data to MERLIN Display. Data is output to the paths set in the MERLIN Administrator software and controls described below:

Figure 5: MERLIN Data Server Status Window



a. **Build Ref Data -** for weather (Wx) and Chaff detection Build Ref Data samples 255 zones on the screen to find areas of increased reflectivity from Wx or chaff. The background values for this are held in a file functions to provide users information where weather or chaff interference is affecting bird detection making data in that unreliable for risk management. Build Ref Data runs at each system start-up at a system location and slowly works through the ranges available for the pulse length currently set on the radar**.**

b. **Build Clutter Data -** for VST algorithms to map site clutter improving bird detection in high clutter environments and close to ground/water levels.

c. **Output Stat Data -** produces a selection of statistical images and a dynamic range graph that allows users to determine the severity of the clutter environment at the study site. These images can be useful in selecting the most appropriate clutter suppression algorithm.

d. **Dynamic Range Graph -** produces a graph showing all the pixel values contained in the raw radar image and used for determining the optimum Clear Air Threshold settings.

e. **Output CAT Stats -** outputs an image showing every pixel in the raw radar data that is exceeding the Clear Air Threshold value set in MERLIN Administrator and used to determine if too high a number has been used by visually checking whether clutter in the image with higher values are being eroded or if there appears to be no background noise in the image.

f. **Data Collection -** starts data collection (recording of MERLIN track data).

6.3 MERLIN Display – Displays MERLIN processed bird tracks onto the user screen. The display will start at settings based on the last settings used by the system in the previous session. The MERLIN Display Administrator software is used to change the display format and to select user specific options. A wide variety of standard and custom user display formats are available in MERLIN:

Figure 6: Screencapture of MERLIN Horizontal surveillance radar (HSR) display of offshore wind farm site with custom underlay showing radar platform and positions of proposed wind turbines (from Talisman Beatrice MERLIN ARS offshore of Aberdeen, Scotland).

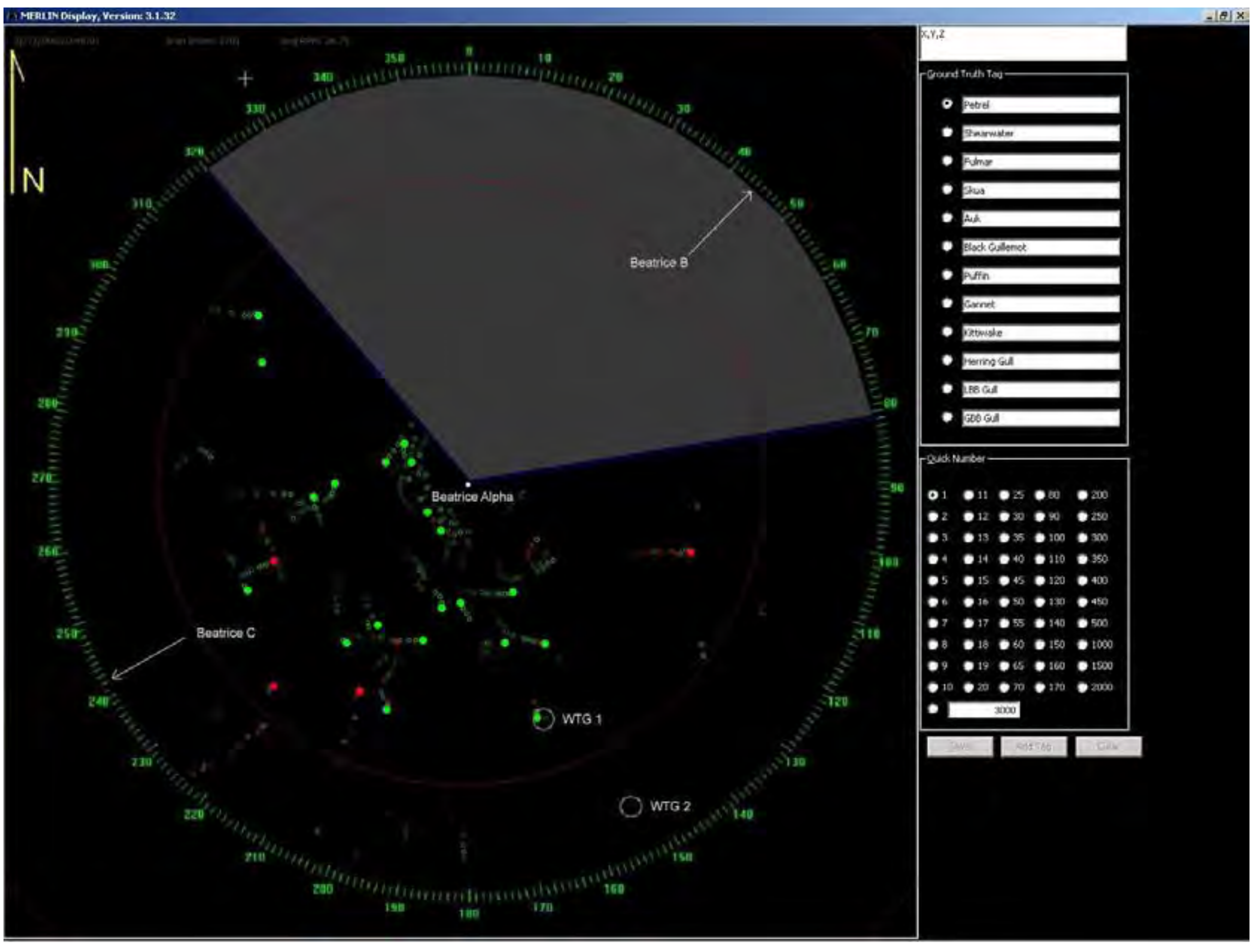
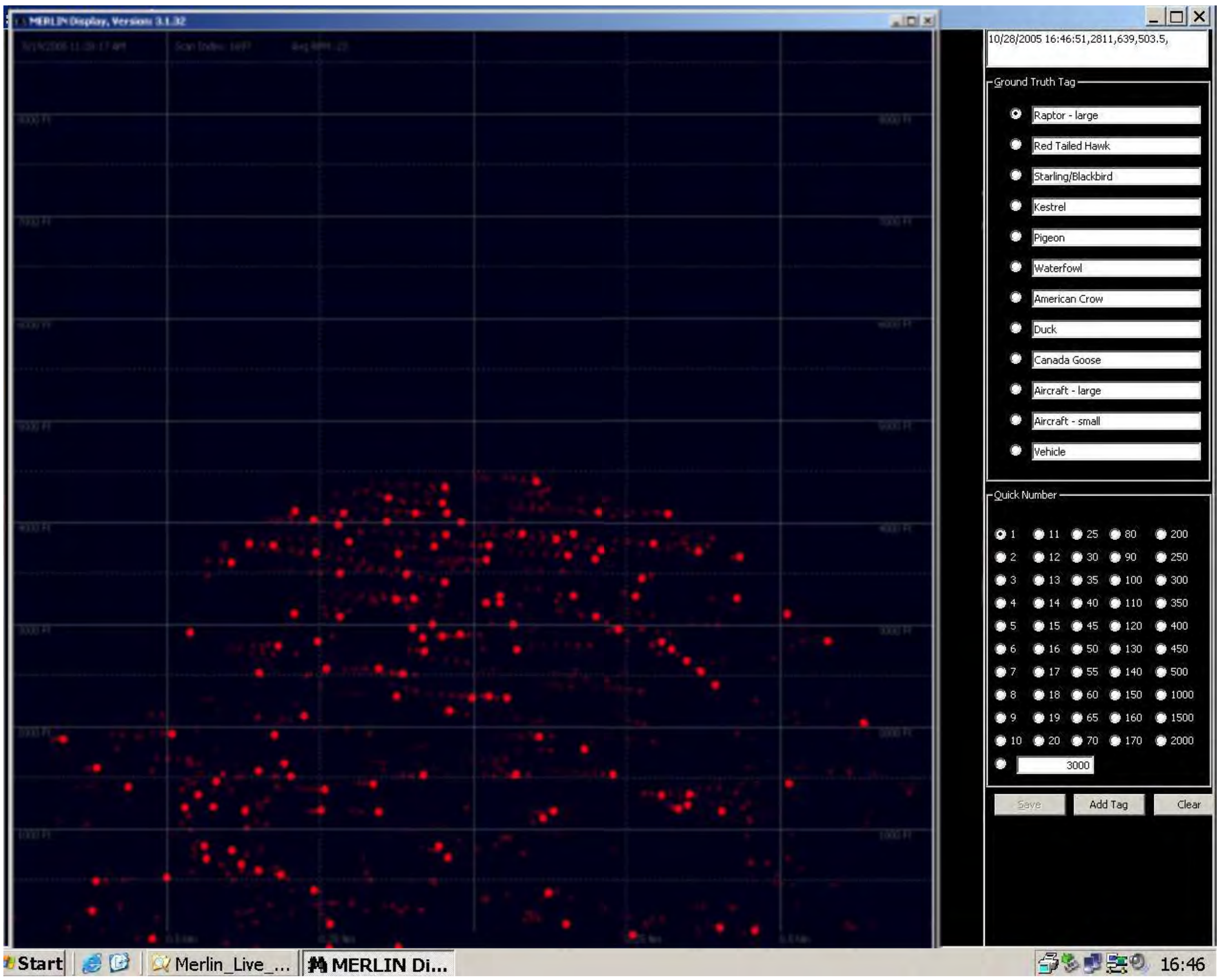


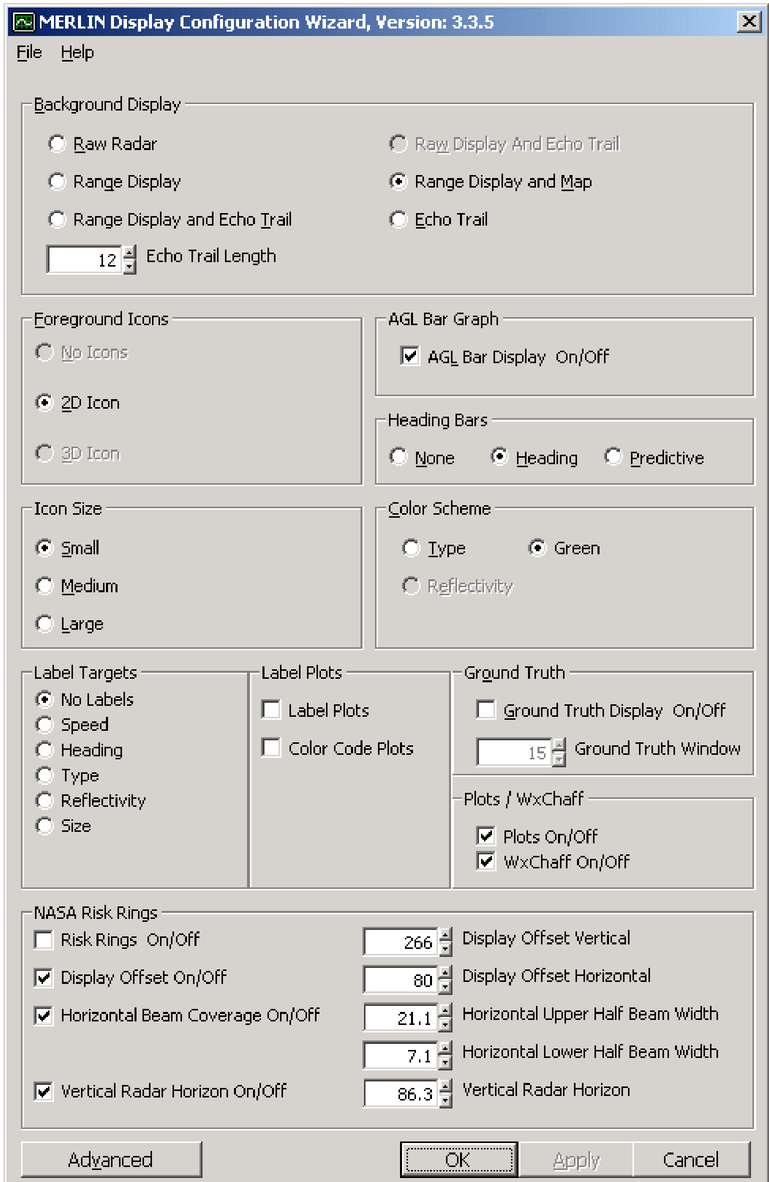
Figure 7 : MERLIN vertical scanning radar (VSR) display with Groundtruth Bar and target tags (size) and Heading Bars enabled during heavy migration (from Cornell Lab of



Ornithology proposed wind farm site survey).

6.4 MERLIN Display Administrator – Activates GUI to configure different MERLIN display options (vertical or horizontal) and set parameters and features required by each user including display type, underlay, tags (speed, size, quality, heading, reflectivity), heading bar (actual or predictive), and the sidebar type (vertical activity or groundtruthing).

Figure 8: MERLIN Display GUI Window



6.5 The real-time data from MERLIN‘s radars (HSR or VSR) can be combined to display on a single computer monitor, or each can be displayed on two separate monitors, depending on the user‘s application.

6.6 The Raw Radar option displays the grayscale ―raw” (unprocessed) radar image as viewed in the source radar signal behind the MERLIN target tracks (green or red ―dots”) and is typically only used by more experienced operators during radar set-up and groundtruthing (tracking and target verification).

6.7 The ―Groundtruth Sidebar" option allows operators to record visually confirmed target information (species, number of birds, flight characteristics, etc.) to the MERLIN database for that target.

6.8 Display configuration and options include:

a. **Range Display** - display with range rings (for the HSR) or altitude bands (for the VSR) with a black background based on the radar operational setting. This display is the standard display for the vertical radar in a two monitor configuration and shows the full horizon-to-horizon ―sweep" of the vertical radar beam. In this display, the radar position is at the bottom center of the screen with distance from the radar and above the radar indicated on the x- and y- axes respectively.

i. In the Range Display, the Groundtruth Bar can be activated on the right side of the screen or, optionally, the Vertical Risk Bar (AGL Bar Graph), can be displayed.

ii. The Vertical Risk Bar indicates the level of target activity above ground level (AGL) in 50 foot (ft) increments and shows the relative risk based on a cumulative running count of the targets counted in each band by the radar over the previous 299 radar scans.

iii. As the count increases within the bands, the count scale at the bottom of the risk bar will change to reflect the current maximum and the colors of the bars will change reflecting pre-set activity levels.

b. **Range Display & Echo Trail** - This display provides the same background as Range Display but also displays the raw radar echoes that are exceeding the clutter threshold set in the MERLIN Administrator software, and typically is only used by technicians for system calibration and performance diagnostics.

c. **Range Display and Map -** This display is the most common format used for display of horizontal radar data and allows a background ‗underlay' map (produced by the end user or by DeTect) to be displayed under the radar tracks shown generated by the MERLIN software. The background map standard is 1024 X 1024 pixels in size. The display software allows an underlay image in Vertical mode that allows reference points on the ground to be indicated on the display.

d. **Echo Trail -** Displays only the radar echoes that have exceeded the background threshold levels (the echo trail length can be set from 1 to 20).

e. **Icon Size -** Changes the size of the display icons (symbols).

f. **Label Targets -** Allows one parameter of each target tracked on the screen to be displayed alongside the icon.

g. **AGL Bar Graph -** Allows a dynamic bar graph (Vertical Risk Bar) of the past 299 radar scans of the vertical scan data to be displayed along the right side of the display window. (This can be shown on both the vertical and horizontal displays). The Vertical Risk Bar indicates the level of target activity above ground level (AGL) in 50 foot (ft) increments and shows the relative risk based on a cumulative running count of the targets counted in each band by the radar over the previous 299 radar scans.

h. **Heading Bars -** Turns heading bars ON or OFF. Heading means that the heading is shown as calculated from the previous scan. Predictive uses information from the previous 4 scans to predict how the target is maneuvering to provide a predicted path. The length of the bar is indicative of the relative speed of the target.

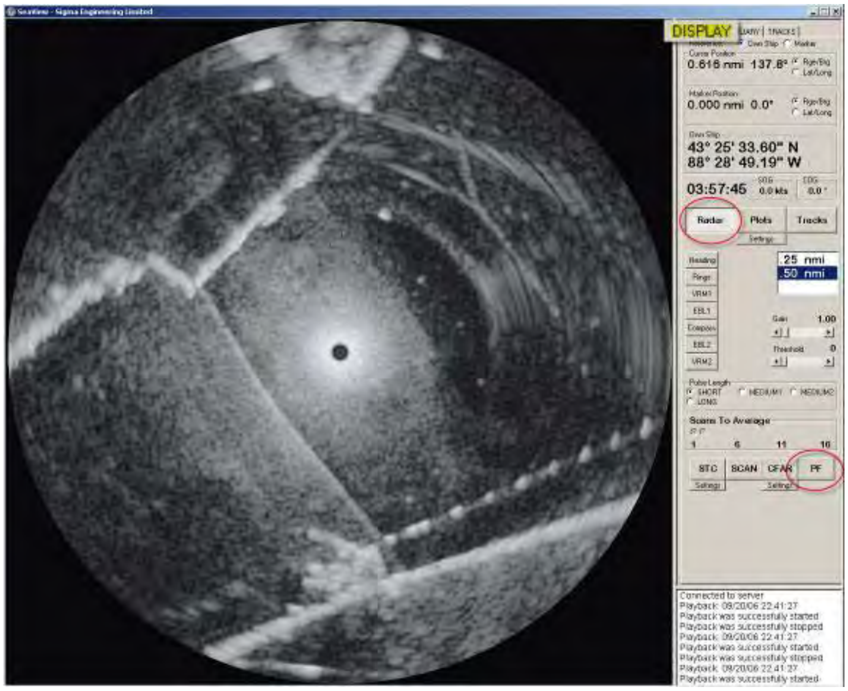
i. **Ground Truth Display -** Using the ON/OFF checkbox allows a ground truth window to be shown on the right side of the display screen. Clicking on the display screen near a target icon will allow the operator to enter information about that target into a text file that is linked to the data for that track in the MERLIN database. The Ground Truth Window size determines how close to a target the mouse must be clicked for the software to determine the target being designated for ground truth information recording.

j. **Plots/WX Chaff -** Allows other icons to be shown on the MERLIN display. If ―Plots On' is checked, then yellow squares will be visible on the screen in locations where a target is being seen by the radar but has not yet been tracked for sufficient scans for the MERLIN software to record it as a target. If WX/Chaff is checked hatched blue blocks will be shown on the display if weather or chaff is being detected by the radar.

k. **Label Plots** - This allows target plots to be labeled with Reflectivity, Size and Distance in pixels from the radar. These labels are useful when setting up target size filters, linear filters and other target parameters in MERLIN Administrator.

6.9 **MERLINRecorder -** The MERLINRecorder software allows for raw (unprocessed) radar recording and playback to support detailed data analysis and recordkeeping. Retention of radar signal data requires large amounts of disk space for storage (100+ gigabytes of storage per 24 hour period depending on the level of resolution of the retained data) and hard drive storage capacity of one terabyte (TB) in included.

Figure 9: MERLINRecorder Record and Playback Control Window



6.10 MERLIN GPS/Compass - Each MERLIN radar sensor unit is equipped with its own WAAS enabled MERLIN GPS/Compass unit to maintain high spatial and temporal data quality:

a. Positional accuracy and correlation of the total MERLIN system.

b. Time synchronization and computer drift correction between all system Computer clocks.

c. Parameters controlled by MERLIN GPS/Compass include the radar North Up (Fixed Reference Point), Magnetic North (Variable) and Heading Offset (True North).

6.11 MERLINRemote - remote system control interface and allows users to remotely control and monitor all critical system components from enabled remote user display workstations.

a. Key MERLIN system features and functions are activated via the remote control panel installed at each radar sensor package.

b. The MERLINRemote suite allows users to control, monitor and display the software over a Local Area Network, Wide Area Network, via the Internet or a SCADA system.

Figure 10: MERLINRemote dashboard GUI (configured for each installation)

c. **The MERLINRemote interface is the MERLIN dashboard –** a software application that allows for control and monitoring of a MERLIN system from a single GUI.

   i. The GUI provides tabs for each of the elements of the hardware, software, controls and sensors to provide an overview of remote operations.

   ii. Standard control and Health & Status Monitoring (HSM) functions included are power (commercial, UPS and backup), radars (transmit, start/stop, test, operational settings), computers (start/stop, status), and environmental primary and secondary (AC, internal, external temperature, humidity).

6.12 MERLINReporter - MERLIN Reporter is the suite of data analysis and reporting applications for the MERLIN system. The suite of analytical and reporting tools in MERLINReporter includes:

a. MERLIN Trackplot - subroutine that works with Horizontal & Vertical Radar Databases (separately) with a primary function is to visualize bird track data that was written to the MERLIN database archives.

b. Trackplot product outputs are images in the form of JPEGs (.jpegs) consistent to the MERLIN Display formats (horizontal and vertical). Trackplot is operated via a simple on screen user window that allows the user to select the data file for analysis, the time period, the data parameters (e.g. size classes) and other parameters.

Figure 11: MERLIN Trackplot GUI window

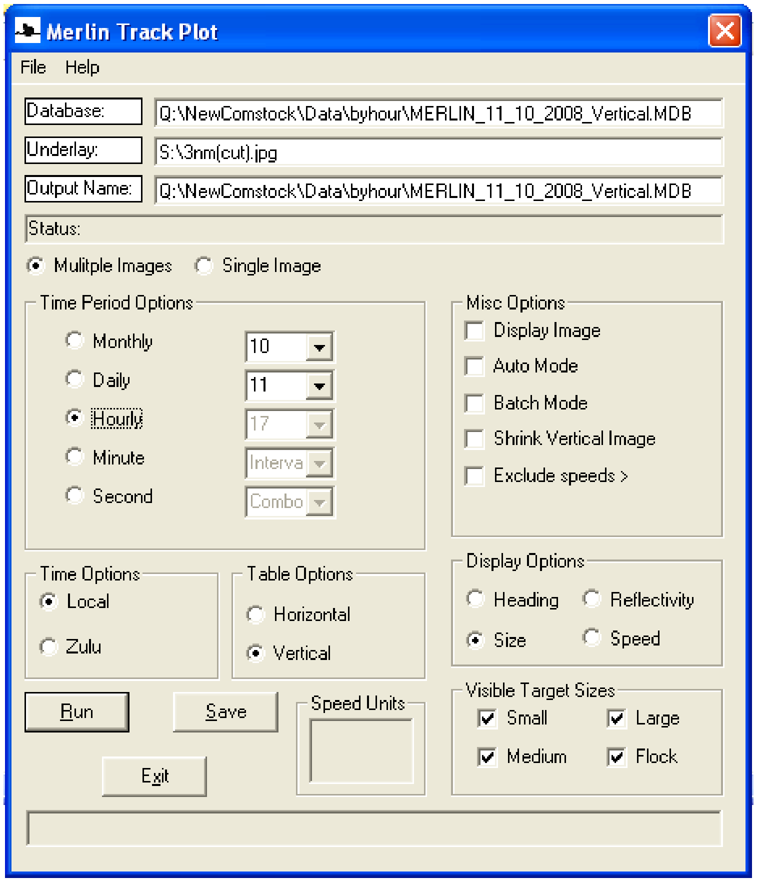
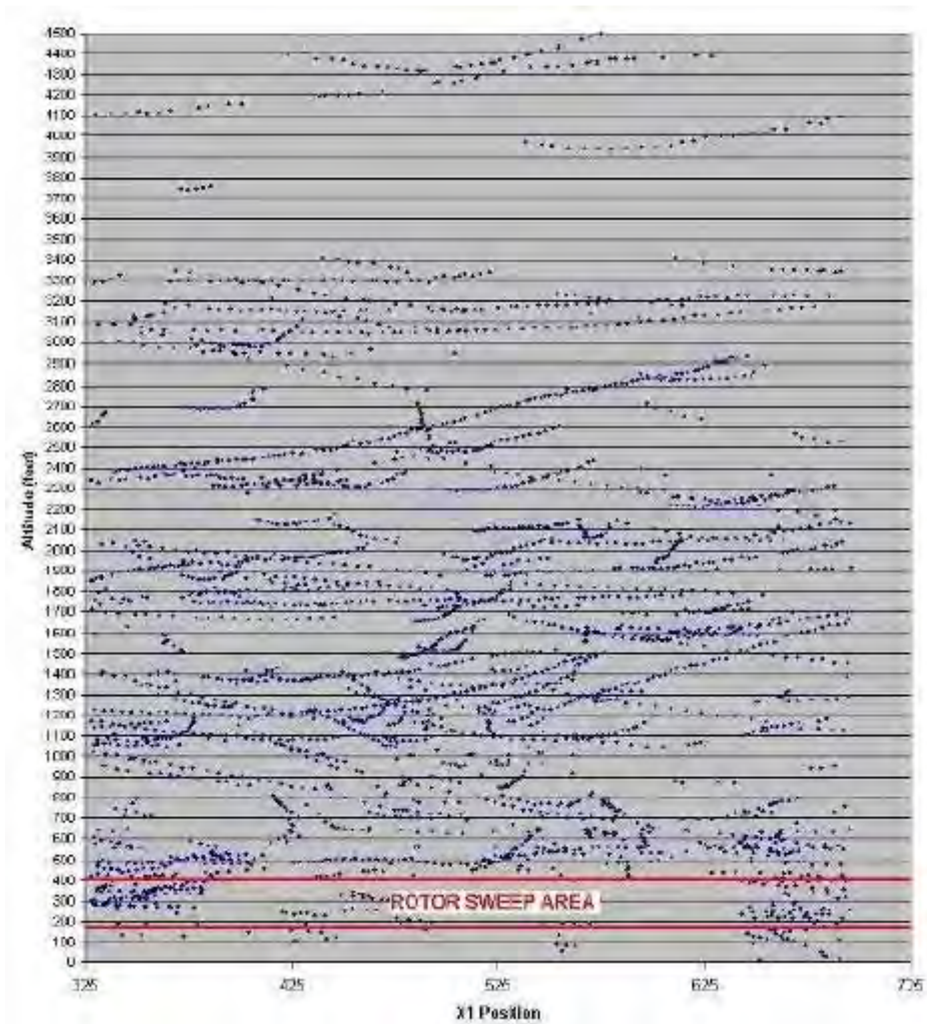

Merlin Track Plot
File
Help
Database:
Q:\NewComstock\Data\byhour\MERLIN_11_10_2008_Vertical.MDB
Underlay:
S:\3nm(cut).jpg
Output Name:
Q:\NewComstock\Data\byhour\MERLIN_11_10_2008_Vertical.MDB
Status:
Mulitple Images
Single Image
Time Period Options
Monthly
10
Daily
11
Hourly
17
Minute
Interva
Second
Combo
Misc Options
Display Image
Auto Mode
Batch Mode
Shrink Vertical Image
Exclude speeds >
Time Options
Local
Zulu
Table Options
Horizontal
Vertical
Display Options
Heading
Reflectivity
Size
Speed
Run
Save
Speed Units
Exit
Visible Target Sizes
Small
Large
Medium
Flock

Figure 12: MERLIN Trackplot vertical data



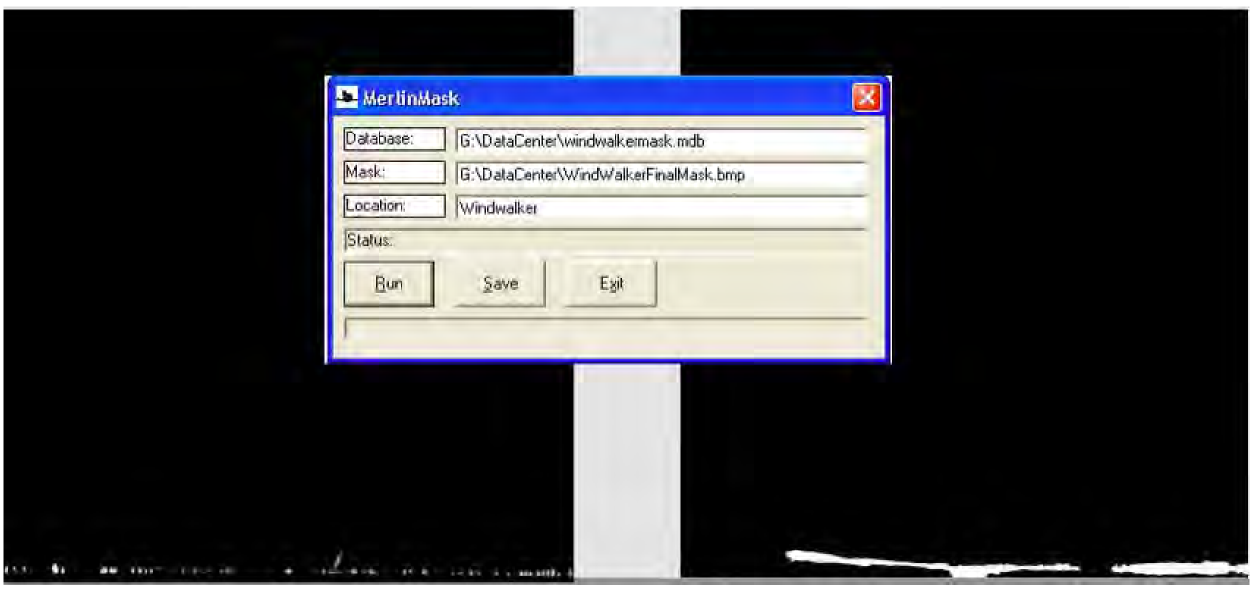
6.13 MERLINMask- allows exclusion of areas where persistent ground clutter tracking exists (i.e. from trees, brush, wind turbines, ships, etc.).

a. MERLINMask - automatically converts a .bmp into a table of a 1024 x 1024 matrix to account for every pixel combination (1,048,576 rows of data with pixel values of 1 for black, 0 for white) and permits quantification of how much a target is clear of clutter (in a sense a ―filter").

b. The current MERLIN build utilizes both static and dynamic clutter maps that allow radar technicians to manually edit static clutter maps while still reaping the benefits of a dynamic clutter map.

c. The MERLINMask is operated via an on-screen GUI and automatically creates the static mask.

Figure 13: MERLINMask GUI with before and after mask.



6.14 MerlinChart - works with both horizontal and vertical MERLIN databases (separately) and its primary function is to produce a quick analysis and visualization of archived historical vertical and horizontal data (generated as text files, images and charts).

a. The output is used typically for flight and bird control planning and to identify peak activity and altitudes of bird activity.

b. MERLINChart is run through a simple on-screen GUI. The application can be run in batch mode on multiple databases in a folder.

Table 14: MERLINChart GUI

All system data is recorded to internal MS Access and SQL compatible databases with all target parameters recorded.

9. Proposed Project Support Staff

For this project DeTect/TRG will provide a project support team of top avian radar experts with direct, relevant experience in development, supply, installation and support of the equipment and services required for this tender. This includes DeTect staff members who have installed and supported MERLIN Avian Radar Systems for terrestrial and offshore wind energy projects in Europe with requirements very similar to those required by this tender. Resumes of the DeTect staff members who will support project can found in the following pages.

NAME: **T. Adam Kelly**

TITLE: Chief Scientist/Principal Biologist, DeTect, Inc.

EDUCATION: Master of Science, Conservation Biology, University of Kent, England (1993); Advanced University Diploma in Raptor Biology with Merit (1992)

YEAR EXPERIENCE: 26 **CURRENT POSITION:** Principal Biologist

Introduction:

Mr. Kelly is a highly experienced Wildlife Biologist specializing in avian biology, bird and bat mortality risk assessment, bird control and radar ornithology. He is a member of the World Working Group on Birds of Prey and Owls, the Wilson Ornithological Society and the Bird Strike Committee USA/Canada. He has conducted captive raptor propagation projects, airfield and industrial bird control programs, telemetry studies, avian radar surveys, mortality risk assessments and mitigation programs on projects in value up to $5 million (USD) in the USA, the United Kingdom, Canada, Europe, New Zealand and Mauritius. Supervisory experience includes training and managing teams of over 30 biologists and bird control specialists in survey, bird control and bird-strike investigation.

Mr. Kelly is a leading world expert in development of sophisticated signal processing techniques for radar remote sensing systems for bird, bat and aircraft detection, tracking and mortality risk assessment and mitigation. Mr. Kelly is currently the Chief Technology Officer/Chief Scientist with DeTect, Inc. (www.detect-inc.com) and heads the company‘s programs for on-going development and field application of advanced methods and systems for bird and bat remote sensing, radar tracking, mortality risk modeling, risk assessment and risk mitigation for aviation safety (bird-aircraft strike avoidance) and for projects with avian mortality issues such as wind farms, communication towers, mine tailing ponds, industrial waste impoundments, oil and gas tanks and commercial landfills.

At DeTect, Mr. Kelly has been the Principal-in-Charge of development and field application of the MERLIN™ Aircraft Birdstrike Avoidance Radar system, the MERLIN Avian Radar System, the MERLIN *detect & deter* Bird Control Radar system, and the VESPER Fixed-beam Vertical Profile Radar. MERLIN is currently the most widely used bird and bat radar with over 60 units operating worldwide. He has been responsible for virtually every major ‗first‘ in bird radar technology including the first …

- Custom bird radar waveform & antenna (MERLIN *SharpEye*, 2009)
- All weather solid-state bird radar system (MERLIN *SharpEye*, 2009)
- Automated Wind Farm radar monitoring and risk mitigation system (MERLIN *SCADA*, 2008)
- Automated birdstrike risk alerting bird radar in a commercial airport control tower (2008, Durban Airport, South Africa)
- Automated birdstrike risk alerting bird radar (2006, USAF, Dover AFB)
- Bird radar system installation at commercial airport (2003, Augusta Regional Airport, Georgia)

- On-airfield bird detection radar in control tower (2003, Royal Air Force Base, Kinloss Scotland)
- Biological target detection algorithm for radar (2001)
- Automatic vertical scanning radar for bird detection (2000)
- Large-scale fully automated bird strike risk management radar network (1999, AHAS, www.usahas.com, USAF)
- Airbase bird avoidance model (1997, USAF)
- Computer-based mission planning model for use by pilots to reduce bird strike risk (1996, USAF)
- Year-round remote sensing studies of bird activity (1995, USAF)

<u>Relevant Experience</u>:

He currently heads DeTect's avian radar system research and deployment group supporting client projects in the US, Canada, Europe and Africa. On-going projects include development of advanced algorithms and radar systems for automatic detection and tracking of birds and bats on NEXRAD and small mobile radars for the US Air Force (USAF), US Air National Guard, National Aeronautical and Space Administration (NASA), US Fish and Wildlife Service (USFWS), US Environmental Protection Agency (USEPA), the Governments of Canada and the United Kingdom and various commercial aviation, mining, industrial and wind energy clients. Mr. Kelly is a world recognized expert in BASH and radar ornithology, has published numerous research papers, frequently presents at subject related conferences, and routinely provides expert testimony at regulatory hearings. Specific areas of expertise include

- Radar ornithology
- Bird and bat radar, acoustic and thermal survey
- Risk assessment and mitigation planning
- Migratory research and studies
- Radio and satellite telemetry
- Bird trapping and banding
- Airfield bird and wildlife control
- Bird-aircraft strike hazard (BASH) management
- Aircraft mishap investigation
- Protected species surveys and habitat assessment
- Avian radar computer algorithm and system design and development

Mr. Kelly is the lead scientist and developer for two Bird Avoidance Models (BAM) for the USAF; the USAF Avian Hazard Advisory System (AHAS, see www.usahas.com), a NEXRAD radar-based system that tracks bird activity in real-time for the continental US, Alaska, Hawaii, Guam and Korea; and, the first automated bird and bat detection and tracking radar systems (MARS and MERLIN). In 2006, the AHAS system was expanded to provide near real-time (every six minutes) biological density imagery in 3-D and he is directing expansion of the system to process Level II NEXRAD data which will increase system resolution by an order of magnitude. The AHAS system archived data includes over 10 years of 24-7 biological density data for the continental U.S. and Mr. Kelly has developed techniques to use this data to support preliminary risk assessments for proposed wind farm sites.

Since June 2006, Mr. Kelly has also been the Program Manager for DeTect supporting the U.S. space agency, NASA, in birdstrike launch prevention for the US space shuttle from Kennedy Space Center (KSC), Florida USA using a custom designed DeTect MERLIN Avian Radar System. Mr. Kelly has been the lead advisor to NASA for bird strike risk mitigation for space shuttle launches from July 4, 2006 to the present and has personally been on-site at the KSC providing expert radar ornithology and birdstrike risk management and advisory support to NASA for fourteen launches of space shuttle.

Representative Project Experience:

Principal Biologist/Radar Ornithologist, Gulf Wind I Windfarm, Texas USA (Pattern Energy) 2006-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System for avian mortality risk monitoring at the wind farm located on the Texas Gulf Coast. The system was installed in the fall of 2006 and collected two years of 24-7 data on avian activity that was used to project potential risk to migratory and resident birds in the proposed wind farm areas and in 2008 oversaw installation of the system as a permanent monitoring system for the operating wind farm. Currently the system uses the MERLIN *SCADA* avian mortality risk mitigation software developed by Mr. Kelly which allows the bird radar to function as an early-warning risk mitigation system for birds at the wind farm providing advance detection of elevated bird activity and automatically idling the wind turbines when birds are detected under high mortality risk conditions. The MERLIN SCADA installation at the Gulf Wind I Windfarm is the first use of automated avian radar technology for risk mitigation at a wind farm in the world.

Principal Biologist/Radar Ornithologist, Penãscal Wind Farm, Texas USA (Iberdrola Renewable) 2008-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System as a permanent monitoring system for this operating wind farm that is located adjacent to the Gulf Wind I wind farm. The system uses the MERLIN *SCADA* avian mortality risk mitigation software developed by Mr. Kelly which allows the bird radar to function as an early-warning risk mitigation system for birds at the wind farm providing advance detection of elevated bird activity and automatically idling the wind turbines when birds are detected under high mortality risk conditions. Along with Gulf Wind I, the MERLIN SCADA installation at the windfarm is the first use of automated avian radar technology for risk mitigation at a wind farm in the world. The systems are currently being integrated into a wider network of bird radars with though a VPN to expand the early warning capability of each individual radar.

Principal Biologist/Radar Ornithologist, Nordwindzee Offshore Windfarm, The Netherlands (Shell/NUON) 2003-present. MERLIN XS2530e Avian Radar System installed in 2003 on an offshore research platform, collected two years of pre-construction survey data. The system is currently installed on the met-mast tower and provides 24-7 monitoring of the operating wind farm with remote administration from the shore via fiber optic network. The system is operated by the project environmental consultant, Bureau Waardenburg bv and in 2009 a secondary ship traffic radar was upgraded with a MERLIN bird radar processor to provide expanded detection of bird activity at the windfarm site.

Principal Biologist/Radar Ornithologist, Beatrice Offshore Wind Park, Aberdeen, Scotland (Talisman Energy/University of Aberdeen) 2005-present. Multi-year avian radar survey of offshore wind turbines off the coast of Scotland in the North Sea. The MERLIN system is installed on an oil platform near the test turbines and is operated by biologists with the University of Aberdeen. Mr. Kelly provided senior biologist oversight and radar data QA/QC for the project.

Principal Biologist/Radar Ornithologist, Plum Island Offshore Wind Park, New York, USA (Deepwater Wind LLC) 2007-present. MERLIN XS2530e Avian Radar System conducting two year pre-construction survey of the first US offshore wind farm. For year One, the radar was installed on-shore and surveyed three near shore turbines sites. For year Two, the radar system will be reinstalled onto the met mast tower 6 miles offshore to collect preconstruction data for the offshore windfarm.

Principal Biologist/Radar Ornithologist, Westfield-Ripley Windfarm, New York, USA (Babcock & Brown) 2007-present. MERLIN XS2530e Avian Radar System conducting pre-construction survey of proposed wind farm site in northern New York state. The radar was installed in the fall of 2007 and is collecting data 24-7 for one year pre-construction. The project site is located in the US Great Lakes flyway and is considered a key resource area.

Principal Biologist/Radar Ornithologist, Smola Windpark, Norway (Norwegian Institute for Nature Research) 2008-present. MERLIN XS2530e Avian Radar System supporting Sea eagle mortality study at operating wind farm. The system is collecting data 24-7 to determine usage patterns for the Sea eagles at the site to develop mortality risk mitigation implementation of the MERLIN *SCADA* mortality risk system.

Principal Biologist/Radar Ornithologist, Lake Ostrowo Wind Farm, Poland (Dong Energy/KAPPA) 2007-present – MERLIN XS2530e Avian Radar System conducting 2 year post-construction survey at Poland‘s largest wind farm located on the Baltic coast. The system is operated by the University of Szczecin with data analysis, processing, QA/QC and general consultation provided by DeTect under Mr. Kelly‘s direction.

Principal Biologist/Radar Ornithologist, Various Windfarms, New Zealand (Meridian Energy Ltd.) 2008-present – MERLIN XS2530e Avian Radar System operated by New Zealand‘s largest wind farm developer to assess migratory bird risk for coastal wind farm sites. The system is operated by the developer‘s consultants with data analysis, processing and risk assessment support provided by DeTect under Mr. Kelly‘s oversight.

Senior Biologist/Radar Ornithologist, proposed Easthaven Wind Farm Avian Radar Survey, Easthaven, Vermont, USA (Vermont Fish and Wildlife Department) 2004. Conducted a limited avian radar survey of the proposed Easthaven Wind Farm in November 2004 under contract to the Vermont Fish and Wildlife Department. Under the contract, Mr. Kelly directed a four week survey of the proposed wind farm site with a DeTect-owned MERLIN X10 bird detection radar system. The work included system operation, data groundtruthing, data analysis and expert testimony for assessment of mortality risk to bird activity from the proposed wind turbine site.

Senior Biologist/Radar Ornithologist, PdV Wind Farm Avian Radar Survey, Kern County, California, USA. 2005-7 In support of the developer‘s consultant, Sapphos Environmental, Inc., provided two-phase avian risk assessment of proposed wind farm site in the Mojave area of California. Phase I provided pre-assessment of the site using processed US NEXRAD data. Historical processed NEXRAD data for the site (24-7 data updated every six minutes) was extracted covering a three-year period for the project site and surrounding area and analyzed for levels of bird activity, with specific focus on nighttime migration period in low visibility. Data was also compared to a known bird habitat resource area and conclusions developed as to the relative level of bird activity and mortality risk expected for the project site. For the fall of 2006, DeTect provided a company-owned MERLIN XS1030e avian radar system to Sapphos biologists for collection of data 24-7 during the fall migratory season. Sapphos biologists were trained on system operation and DeTect provided full remote technical support and data QA/QC. Mr. Kelly also managed data processing and analysis for the risk assessment report developed by Sapphos.

Senior Biologist/Radar Ornithologist, Buffalo Mountain Wind Farm Bat Radar Survey, Oak Ridge, Tennessee, USA. 2005-6. Conducted Phase I bat survey with a MERLIN XS1030e radar system with thermal imaging cameras at the Buffalo Mountain Wind Farm in Oak Ridge, Tennessee in August 2005 under contract to the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI). Project tasks included supply and operation of a DeTect-owned MERLIN Avian Radar System, thermal imaging equipment, operators, field biologists, data analysis and expertise to investigate bat mortality at the site and provide recommendations for the Phase II study and a post-construction monitoring program to address the bat kills at the site. The data developed from this study was used to identify specialized radar requirements for bat mortality risk mitigation and led to the current research effort for DeTect‘s VESPER Fixed-beam Vertical Profile radar system.

Senior Biologist/Radar Ornithologist, Neda Mine/Butler Ridge Wind Farm Bat Survey, Fond du Lac, Wisconsin, USA. 2005-6. Conducted a radar bat survey at the proposed Butler Ridge wind farm near the Neda Mine in Wisconsin under contract to the Wisconsin Natural Resources Foundation with funding from the US Fish and Wildlife Service (USFWS) and the US Environmental Protection Agency (EPA). DeTect provided a MERLIN XS1030e Avian Radar System, thermal imaging equipment, operators, data analysis and expertise to investigate the potential for bat morality at the site relative to the proposed wind farm site. Tasks included detailed analysis and correlation of the radar data with acoustic data from Anabat detectors deployed during the radar survey by staff of the Wisconsin Department of Natural Resources (DNR) and programming of custom algorithms to analyze potential to automatically differentiate bird and bat targets within the radar system in real-time.

Senior Biologist/Radar Ornithologist, Avian Survey and Assessment of proposed Wind Turbine Project, Cape Cod Community College, Hyannis, Massachusetts. April 2005 to 2006. Supported data collection and assessment of bird activity at the proposed wind turbine site. Operated a MERLIN XS1030e Avian Radar System during the fall of 2005 and spring 2006 migratory seasons. Supported data post-processing and analysis in DeTect‘s data center in Panama City, Florida and developed avian impact report based on the data collection.

Senior Biologist/Radar Ornithologist, Avian Survey and Assessment of proposed Wind Turbine Project, Town of Orleans, Massachusetts. April 2005 to 2006. Supported data collection and assessment of bird activity at the proposed wind turbine site. Operated a MERLIN XS1030e Avian Radar System during the fall of 2005 and spring 2006 migratory seasons. Supported data post-processing and analysis in DeTect‘s data center in Panama City, Florida and developed avian impact report based on the data collection.

Senior Biologist/Radar Ornithologist, Avian Radar Survey, Cape Wind Offshore Windfarm, Nantucket Sound, Massachusetts. 2002-3. Designed the avian radar software and hardware for the Geo-Marine Mobile Avian Radar System (MARS) and supported data collection (May – June 2002 from an offshore test platform, and August – September 2002 on Martha's Vineyard) and analysis for the proposed Capewind windfarm site in the Nantucket Sound off the Massachusetts coast. The Capewind site is the first US proposed offshore wind energy development. Work included software development, field radar data collection, data analysis and production of the report on the data collection in 2003.

Principal Biologist/Radar Ornithologist, Central Science Lab (now the Food and Environment Research Agency) Avian Radar System, United Kingdom. January 2003 through 2009. Mr. Kelly managed development, programming and delivery of a Geo-Marine Mobile Avian Radar System (MARS) to the United Kingdom (UK) government Central Science Lab (CSL) Birdstrike Avoidance Team (BAT) in 2003. The CSL BAT is a world leader in research and management of bird hazards to aircraft and in assessment of projects with avian impact issues such as windfarms. The system is used by the CSL to collect bird activity data for a variety of bird detection projects, specifically related to bird hazards to aircraft and bird collisions with wind power structures. In 2006, Mr. Kelly managed delivery and support of a custom DeTect XS2530ex MERLIN Avian Radar System to the CSL and upgrade of the old MARS unit to the MERLIN avian radar system software. In 2008, he supported the CSL in assessment and development of offshore

Prior Experience:

Mr. Kelly started his career as a biologist as a licensed falconer. His prior experience includes telemetry tracking of raptors working as a technical advisor on an Institute for Terrestrial Ecology radio telemetry study on the Common Buzzard. He has successfully applied the telemetry backpack harness technology developed from this study to projects on Turkey and Black Vultures, Canada Geese, Tundra Swans, Red-bellied Woodpeckers, and Sandhill Cranes. Mr. Kelly worked in Mauritius on the endangered Mauritius Kestrel restoration project and applied his experience in captive propagation of raptors and use of hacking techniques for successful release of these birds into the wild. Mr. Kelly also worked with the endangered pink pigeon and echo parakeet and assisted a film crew in locating wild Mauritius Kestrels for a documentary on the species.

Mr. Kelly managed a team of bird control specialists to successfully keep a factory in the UK free of one-half million pied wagtails while a new roof was installed. The team contributed ideas to the roof design process and monitored construction to ensure the new roof sealed birds out of the building and denied any opportunity for roosting. Mr. Kelly also devised an innovative feral pigeon control program control program at Ise Brook Hospital, Wellingbrough, Northants, UK that was successfully concluded with no noise disturbance to patients at the hospital and no lethal means or trapping.

He worked for twelve years with Longwings, Ltd. as the Bird Control Program Manager at a variety of military and industrial situations. As Manager of the USAF-Europe Bird Control Program, he directed bird control operations at eight RAF bases in the United Kingdom (UK) advising on passive control of birds through habitat management at each installation. This included direct supervision of the bird control operations at RAF Mildenhall which included research into the effects of trained falcons on bird species hazardous to aircraft operations, an analysis of 20 years of bird control operations at the airfield, and the first use of a hybrid Peregrine-Merlin falcon for starling control. The USAF Bird-Aircraft Strike Hazard (BASH) Team consistently rated this program as one of the finest bird control programs worldwide. Additional work with the USAF included research on the effects of thermal conditions on the occurrence of

USAF bird strikes with Red-tailed Hawks and Turkey Vultures and investigation of Bird Avoidance Modeling (BAM) methodology.

From 1994 through 2003, Mr. Kelly worked as the lead Radar Ornithologist for Geo-Marine, Inc. supporting BASH and avian survey projects for the USAF and other clients in the aviation, communications and wind energy industries. While with Geo-Marine, he designed and programmed the avian radar data processing system for the Geo-Marine MARS (mobile avian radar system)

NAME: **Andreas Smith**

TITLE: Senior Radar Ornithologist/Project Biologist

EDUCATION: B.S., Fisheries & Wildlife Science, North Carolina State University, 1994

YEARS EXPERIENCE: 12

PROJECT POSITION: Radar Ornithologist/Field Technician Europe

INTRODUCTION

Mr. Smith is a Radar Ornithologist/ Biologist with DeTect based in Europe and supporting MERLIN Avian Radar Systems throughout Europe and the United Kingdom. For the past 12 years, Mr. Smith has specialized in radar ornithology, avian radar systems and avian risk management for airports and other projects with avian mortality issues. Prior to his moving to Europe, he supported development and application of advanced avian remote sensing technologies including work on development of the US Air Force (USAF) Avian Hazard Advisory System (AHAS), computer-based Bird Avoidance Models (BAM), and mobile radar systems for bird and bat survey, detection and risk management. Mr. Smith has also work on avian survey and BASH management plan development projects for the USAF, the US Air National Guard (US), commercial airports, landfills and wind farms at sites throughout the US and Europe.

Recent Experience:

Mr. Smith currently manages and supports field projects for DeTect for bird and bat survey and risk assessment related to aviation safety and environmental management. His areas of expertise include:

- Radar remote sensing and ornithology
- Thermal imaging and acoustic monitoring of birds and bats
- Avian radar research, installation, operation and user training
- Bird-aircraft strike hazard (BASH) management and Bird Avoidance Model development
- Avian Radar System operation and maintenance
- Airfield and landfill bird control
- Field ornithology
- Radio and satellite telemetry
- Protected species surveys
- Bird nest surveys and trapping and banding
- Bird and bat population surveys and habitat assessment

Over the past six years, Mr. Smith has been a key team member on design, construction, testing and operation of mobile avian radar systems and on short- and long-term bird and bat survey and assessment projects for airports, wind farms, landfills and mines. This includes installation, operating and scientific support for two major off-shore wind energy avian survey projects in the North Sea (Scotland and The Netherlands) and USAF birdstrike avoidance radar installations in the US. He is a Certified Radar Technician and has a broad range of knowledge and experience in system design, testing and field deployment having personally operated and maintained systems on multi-year surveys both on-shore and off-shore.

SELECTED RELEVANT EXPERIENCE:

Nordwindzee Offshore Windfarm Avian Radar Survey, The Netherlands. Mr. Smith installed, operated and continues to support a MERLIN XS2530e Avian Radar System that was initially installed in 2003 on an offshore research platform and collected two years of pre-construction survey data. He also provided data processing and analysis support in DeTect's data lab that included query development for the risk model and assessment report. In 2006, he reinstalled the system on the met-mast tower at the operating wind farm that 24-7 monitoring of the operating wind farm with remote administration from the shore via fiber optic network. The system is operated by the project environmental consultant, Bureau Waardenburg bv for the owner Shell/NUON with operational and data analysis support from DeTect.

Beatrice Offshore Wind Park Avian Radar System, Aberdeen, Scotland. Mr Smith installed and currently supports the MERLIN avian radar system for a multi-year avian radar survey of offshore wind turbines off the shore of Scotland. The MERLIN system is installed on an oil platform near the turbines and is operated by biologists with the University of Aberdeen for the project owner Talisman Energy. He also provided data processing and analysis support in DeTect's data lab that included query development for the risk model and assessment report.

Smola Windpark MERLIN Avian Radar System Survey, Smola Norway. Mr. Smith installed, started up and supports a MERLIN XS2530e Avian Radar System at the wind farm to that is being used to develop data on Sea eagle activity around the wind resource area as part of a bird mortality study at the operating wind farm. The system is operated on a day-to-day basis by the Norwegian Institute for Nature Research (NINA) and is collecting data 24-7 to determine usage patterns, flight altitudes and periodic and seasonal population for the Sea eagles at the site to develop a mortality risk mitigation implementation plan to possibly include DeTect's MERLIN SCADA system that automatically idles the turbines when high risk conditions are detected. Mr. Smith provides on-going support to NINA and make regular site visits, provides data QA/QC and technical consulting.

Lake Ostrowo Wind Farm MERLIN Avian Radar System Survey, Poland. Mr. Smith installed, started up and supports a MERLIN XS2530e Avian Radar System that is conducting 2 year preconstruction survey for the developers Dong Energy/KAPPA at Poland's largest wind farm located on the Baltic coast. The system collects data 24-7 and is operated by the University of Szczecin with data analysis, processing, QA/QC and general consultation provided by DeTect. Mr. Smith provides on-going support to NINA and make regular site visits, provides data QA/QC and technical consulting.

Radar Ornithologist. Multi-year MERLIN Avian Radar System Survey, Risk Assessment & Bird Control Program, Louisville International Airport/Waste Management Outer Loop RDF, Louisville, Kentucky USA. Supported a three year, 24-7 MERLIN avian radar survey, monitoring and risk assessment program required by the US FAA for expansion of the Louisville IAP runways. A landfill facility operated by Waste Management, Inc. is located directly south of the main runway at the airport and, under the permit approval agreement to expand the runway between the FAA, the Louisville IAP and Waste Management, a comprehensive BASH plan and bird control program was required to include installation and operation of an avian radar system to monitor and manage bird-aircraft strike risk. The Louisville, as the North American hub for United Parcel Service (UPS) air operations, is the fourth busiest airfreight airport in the world. In addition to commercial, civilian and UPS flight operations, the Louisville IAP also is a co-location for the Kentucky Air National Guard C-17 fleet. Mr. Merritt directed the BASH Plan implementation that included installation and operation of MERLIN Avian Radar System that provides 24-7 bird detection, monitoring and risk alerting to the airport and landfill operators, The avian radar data is additionally used to monitor bird activity with a running comparative analysis with the background bird activity levels for areas the airport. Mr. Smith provided Avian Radar System set up, calibration, groundtruthing and operation and maintenance support for the project.

Radar Ornithologist, Wildlife Hazard Assessment, Avian Radar Survey & Management Plan, Proposed New Conway Municipal Airport, Arkansas USA. Mr. Smith supported a year-long wildlife and MERLIN Avian Radar Survey of the area proposed for the new municipal airport and surrounding airport district in Conway, Arkansas that included field operation of the MERLIN Avian Radar System used for the data collection. The scope included 24-7 supply, delivery, operation and support of a MERLIN Avian Radar System to collect data on bird activity, movement and density at the site for one year. DeTect's services for this project were under contract with the airport design engineering firm, Huitt-Zollars, and work was coordinated with a third party consultant BASH, Inc. with the MERLIN radar operated on a day-to-day basis by a local consultant with the University of Arkansas. Mr. Smith also provide data analysis support, analyzing the data from DeTect data lab in Panama City, Florida that included query development, data processing, data modeling and data quality control/quality assurance.

Field Biologist/Radar Ornithologist. US Avian Hazard Advisory System (AHAS), USAF BASH Team, Kirtland AFB, New Mexico USA. Mr. Smith support DeTect's contract for AHAS providing field biology/radar groundtruthing and system data quality control/quality assurance and validation using mobile MERLIN Avian Radar Systems. AHAS provided daily forecasts of hazardous conditions along specified low-level routes and ranges as well as hourly updates based upon near real-time radar observations (updates every six minutes) processing data from over 150 radar sensors across the continental US, Alaska, Hawaii and Guam 24-7. The AHAS system is a neural computer network located in DeTect's Panama city, Florida office and processes the radar data 24-7 in real-time using custom software developed by DeTect and delivering risk advisories through the Internet (www.usahas.com) in tabular and Google Earth visual formats. The system also archives all data (currently with 8 years of data for the US) and can be queried for historical activity and risk levels to support future mission planning. The AHAS concept is now under consideration for development in other regions of the world including Europe and the Middle East, and DeTect recently completed the radar network assessment and developed the concept plan for a similar system for the United Kingdom.

Radar Ornithologist/Field Technician. NASA Avian Awareness Device MERLIN Radar System Development & Space Shuttle Launch Support. Supported development, testing and delivery of the Avian Awareness Device (AAD) MERLIN Radar System (MRS) supporting the US space agency, NASA, in birdstrike launch prevention for the US space shuttle from Kennedy Space Center (KSC), Florida using a custom designed DeTect Merlin Avian Radar System. The space shuttle struck a Turkey vulture in the summer of 2005 and NASA concluded that represented the second highest safety risk for shuttle launches due to possibility of damage to heat shielding tiles from birdstrikes. In 2006, NASA evaluated available technologies and selected the DeTect MERLIN Avian Radar System for future launch support, taking delivery of a system that first used on the Return-to-Flight launch on July 4, 2006. NASA subsequently ordered a second system in 2008 and the MERLIN units have been used to support bird-strike launch flight safety on nine space shuttle missions to date (STS-121, STS-115, STS-116, STS-117, STS-118, STS120, STS-122, STS-123 and STS-124). Mr. Smith participated in the initial deployment of the prototype NASA MERLIN system in 2006 and assisted in system installation, start-up, testing and operation for the July 2006 shuttle launch.

Central Science Lab Avian Radar System, United Kingdom. Mr. Smith supports two MERLIN Avian Radar Systems purchased by the to the United Kingdom (UK) government Central Science Lab (CSL) Birdstrike Avoidance Team (BAT). The CSL BAT provides research and management consulting for bird hazards to aircraft. The system is used by the CSL to collect bird activity data for a variety of bird detection projects, specifically related to bird hazards to aircraft and bird collisions with wind power structures in the UK.

PRIOR EXPERIENCE:

Mr. Smith prior experience as a Natural Resource Assistant with the U.S. Fish and Wildlife Service (USFWS) performing duties on various wildlife surveys and management projects. He was responsible for supervising a group of resource assistants on several projects for the Mattamuskeet/Swan Quarter/Cedar Island National Wildlife Refuges. These projects ranged from waterfowl capture and banding programs to nest surveys of several bird species. Mr. Smith is a member of The Wildlife Society, the Nature Conservancy, the Natural Resources Defense Council and Wild Rivers.

NAME: **Edward J. Zakrajsek**
TITLE: Senior Biologist – QA/QC, DeTect, Inc.

EDUCATION: M.S., Wildlife Biology, Utah State University, 2001; B.S., Wildlife Management, West Virginia University, 1990

YEAR EXPERIENCE: 16 **CURRENT POSITION:** Operations Manager

Introduction:

Mr. Zakrajsek has over 16 years of experience in wildlife biology, threatened and endangered species management, radar ornithology, bird and bat survey and risk assessment, and Bird Aircraft Strike Hazard (BASH) management. This experience includes project management and scientific support on a variety of projects using advanced radar technologies to detect, track, monitor and assess bird activity that could be hazardous to aircraft or present mortality risk from strikes with wind turbines or communication towers. He has worked extensively on development and application of advanced bird and bat remote sensing radar technologies that has included the USAF Avian Hazard Advisory System (AHAS), computer-based Bird Avoidance Models (BAM), and mobile bird and bat radar detection systems. Mr. Zakrajsek has conducted numerous bird and bat radar surveys and risk assessments in the US and Europe. He also has developed BASH management plans for the USAF, Air National Guard and commercial airports at sites throughout the US.

Relevant Experience:

Mr. Zakrajsek currently manages projects for DeTect for bird and bat survey and risk assessment related to wind energy projects, airports, industrial sites and landfills. His areas of expertise include:

- Radar remote sensing and ornithology
- Thermal imaging and acoustic monitoring of birds and bats
- Avian radar research, installation, operation and user training
- Bird-aircraft strike hazard (BASH) management and Bird Avoidance Model development
- Aviation Mishap Investigations
- Airfield, landfill and industrial bird control
- Field ornithology
- Radio and satellite telemetry
- Protected species surveys
- Bird and bat population surveys and habitat assessment

Over the past ten years, Mr. Zakrajsek has been a key team member on design, construction, testing and operation of mobile avian radar systems and on short- and long-term bird and bat survey and assessment projects for airports, wind farms, landfills and mines as well as for automated bird control at industrial waste ponds and landfills. He has a broad range of knowledge and experience in system design, testing, field deployment and data analysis having personally operated systems and managed projects on multi-year surveys both on-shore and off-shore.

Representative Project Experience:

Project Biologist. Bat Survey and Mortality Risk Assessment, Neda Mine Wisconsin. June 2005 – January 2006. Conducted endangered bat surveys in the area around the Neda Mine in Wisconsin. The Neda Mine contains one of the largest bat hibernacula in Wisconsin with a population estimated at over 50,000 bats. Survey was conducted using a MERLIN avian radar system, acoustic detectors and thermal imaging cameras to assess bat activity and mortality risk in the vicinity of a proposed wind energy farm development.

Radar Ornithologist. Easthaven Wind Farm Avian Radar Survey, Easthaven, Vermont. October through February 2004. Conducted an avian radar survey of the proposed Easthaven Wind Farm in November 2004 under contract to the Vermont Fish and Wildlife Department. Operated a MERLIN X10 Environmental Surveyor bird detection radar system for data collection and supported data analysis for assessment of bird activity at the proposed wind turbine site.

Radar Ornithologist. Avian Survey and Assessment of proposed Wind Turbine Project, Cape Cod Community College, Hyannis, Massachusetts. April 2005 to present. Supported data collection and assessment of bird activity at the proposed wind turbine site. Operated a MERLIN Environmental Surveyor bird detection radar system during the spring and fall 2005 migratory seasons. Supported data post-processing and analysis in DeTect's data center in Panama City, Florida and developed avian impact report based on the data collection.

Radar Ornithologist. Avian Survey and Assessment of proposed Wind Turbine Project, Town of Orleans, Massachusetts. April 2005 to present. Supported data collection and assessment of bird activity at the proposed wind turbine site. Operated a MERLIN Environmental Surveyor bird detection radar system during the spring and fall 2005 migratory seasons. Supported data post-processing and analysis in DeTect's data center in Panama City, Florida and developed avian impact report based on the data collection.

Project Manager. Cape Wind Associates Avian Radar Survey, Nantucket Sound, Massachusetts. May 2002 - May 2003. Managed avian survey project for the Capewind offshore wind project to support the first U.S. off-shore wind park in the U.S. Included management of data collection during the two field seasons, data analysis, and project reporting.

Project Manager. Bureau Waardenburg Avian Radar System, The Netherlands. September 2003 through 2005. Managed delivery, installation, start-up, operation and data analysis for a DeTect MERLIN XS2530 bird detection radar system to operated by the environmental consultant, Bureau Waardenburg bv, for a conduct a multi-year study of a proposed wind turbine farm to be located eight miles off of the Dutch coastline in the North Sea. Mr. Zakrajsek directed the preconstruction site assessment and installation and start up of the system on an offshore research platform located eight km off the Dutch coast near Meetpost Nordwijk. The system has operated since late 2003 collecting data on bird movements in the area. In 2005, Mr. Zakrajsek supported post processing and analysis of the data collected since inception for development of the study report.

Project Ornithologist, Aircraft Birdstrike Avoidance Radar Installation and Operation, Tyndall, Air Force Base, Florida, USA, 2004 to present. Mr. Zakrajsek supported the project team for the design, construction, delivery, installation and start-up for a MERLIN Aircraft Birdstrike Avoidance Radar at the airbase to support the U.S. Air Force's next generator stealth fighter, the F-22 Raptor. The system is installed on the base main runway and provides real time detection and tracking of bird activity within 6 nm of the runway. Information is provided to the base bird control units and operations office to manage aircraft operations and reduce birdstrike damage. The system delivered is a MERLIN XS2530 I series.

Project Scientist. USAF Avian Hazard Advisory System (AHAS) Operation, Development and Refinement. September 1998 to present. AHAS is a nationwide, radar-based system that continuously (24-7) detects and monitors avian activity across the U.S., including Alaska, Hawaii and Guam in near-real time and provides bird hazard advisories through the Internet to all USAF and other military flying units. AHAS processed weather data from the U.S. national network of 168 next generation radars (NEXRAD) to isolate biological targets in near-real time (updated every six minutes) and the National Weather Service data to forecasting bird activity on or near airfields and in military training air space. Mr. Zakrajsek supports the AHAS project team in directing field verification and calibration of AHAS using mobile MERLIN radar systems.

Assistant Project Manager. Outlying Landing Field Avian Radar Survey, U.S. Navy, North Carolina. March - April 2003. Mr. Zakrajsek assisted the management of an avian radar survey of a proposed outlying landing field (OLF) to support the F/A-18 Super Hornet in North Carolina. The site of the proposed OLF was near the wintering grounds of a great number of Snow Geese, Tundra Swans, and other waterfowl, which pose a severe hazard to aircraft. The avian radar system provided bird activity data to support the decision process to select or eliminate the site for development.

Project Technician. Central Science Lab MARS, United Kingdom. January 2003 - June 2003. Mr. Zakrajsek managed the production and delivery of a mobile avian radar system to the UK government‘s Central Science Lab (CSL). The Birdstrike Avoidance Team, an office of the CSL, is a world leader in research and management of birdstrikes to aircraft. They will use the radar system to collect bird activity data for a variety of bird detection projects, especially for bird hazards to aircraft and collisions with wind power structures.

Radar Ornithologist. RAF Kinloss Bird Detection System, Kinloss Scotland. August 2002 - June 2003. Mr. Zakrajsek supported this project to provide to the Royal Air Force the first real-time airport bird-detection radar system in the world. RAF Kinloss has a severe birdstrike hazard caused by large flocks of wintering graylag geese that transverse the airfield during operations. The bird-detection system tracks birds and aircraft in the airport vicinity to allow air traffic controllers to direct aircraft safely or cease operations when the situation becomes overly hazardous. He oversaw the acquisition of system components and the delivery of the system to the UK. He also oversaw the systems US operations including the installation of a mirror test facility, technical support services, and parts inventory.

Assistant Project Manager. Bird Detection System Development, Transport Canada, Canada. January 2002 - June 2003. Mr. Zakrajsek assisted the management of this multi-year, multi-phase project to develop a full-time airport bird detection system for use at Canadian airports. This system uses a 3-dimensional, phased array, Doppler weather radar. The system will have more functionality than the one delivered to RAF Kinloss (above). Transport Canada recognized the need to fund the development of this system to assist in the management of birdstrike hazards in Canada. He managed all lab and field operations in both the US and Canada.

Project Manager. Cape Wind Associates Avian Radar Survey, Nantucket Sound, Massachusetts. May 2002 - May 2003. Mr. Zakrajsek managed an avian radar survey for the wind energy development industry. His bird-radar experience to date had been in the field of bird hazards to aircraft. For over 20 years bird fatalities due to collisions with wind-power structures have been of much interest to the industry, citizens groups, and government regulatory agencies. The bird-radar surveys were to support Cape Wind Associate's Environmental Assessment for their proposed development of the first off-shore wind park in the U.S. He managed the data collection during the two field seasons, data analysis, and project reporting.

Prior Experience:

Project Biologist. U.S. Fish & Wildlife Service, Alligator River National Wildlife Refuge, Manteo, North Carolina. May 1991 - May 1994. Project biologist at the Alligator River National Wildlife Refuge managing and assisting in a number of field surveys including: American alligator spotlight counts, black bear track & scat counts, waterfowl ground & aerial counts, beach nourishment impact sampling, sea turtle nest surveys and relocations, moist-soil vegetation sampling, Atlantic white cedar vegetation sampling, red-cockaded woodpecker surveys, and white-tailed deer track counts. He captured and banded wood ducks, brown pelicans, and common, Caspian and least terns. He assisted trapping and collecting data on black bears and reintroduced, endangered red wolves. He assisted with control efforts during a Fowl Cholera outbreak in the Chesapeake Bay. During fire season he was in charge of the wild land fire-crew and oversaw both prescribed burns and wildfire suppression efforts both on and off the refuge.

Field investigator. Red-Cockaded Woodpecker Survey and Long Term Management Plan, Marine Corps Base Camp Lejeune, North Carolina. 2001-2 Conducted protected species survey for the endangered Red-Cockaded Woodpecker (RCW). He collected forest ecology data for the RCW Habitat Evaluation Procedures and conducted a search for undocumented RCW clusters and cavity trees on the base.

10. DeTect ARS Project References

10.1 ARS Project Overview - Over 50 MERLIN systems are currently in use worldwide. Representative wind energy projects that use MERLIN include:

- Royal Belgian Institute of Natural Sciences (RBINS) - Management Unit of the North Sea Mathematical Model (MUMM)
- El Pino Wind Farm - TORSA Renovables, SL - Los Barrios, Cadiz, SPAIN
- Gulf Wind I Windfarm, Texas & Westfield-Ripley Windfarm, New York, USA (Babcock & Brown Renewables; Gulf Wind I includes MERLIN SCADA)
- Nordwindzee Offshore Windpark, The Netherlands (Shell/NUON)
- Butler Ridge Wind Farm Bat Survey, Wisconsin, USA (US Fish & Wildlife Service/US Environmental Protection Agency/Wisconsin Department of Natural Resources)
- Buffalo Mountain Wind Farm Bat Mortality Study, Tennessee, USA (Electric Power Research Institute/Tennessee Valley Authority)
- Beatrice Offshore Wind Demonstrator, Aberdeen, Scotland (Talisman Energy/University of Aberdeen)
- West Wind Windfarm, Wellington, New Zealand (Meridian Energy Ltd)
- Penãscal Wind Farm, Texas, USA (Iberdrola Renewables; includes MERLIN SCADA)
- Plum Island Offshore Wind Park, New York, USA (Deepwater Wind)
- Smola Windpark, Norway (Norwegian Institute for Nature Research)
- Lake Ostrowo Wind Farm, Poland (Dong Energy/KAPPA)
- Plum Island Offshore Wind Park, New York, USA (Deepwater Wind)

Other MERLIN users include the U.S. Air Force (seven systems purchased to date); the US space agency, NASA (two systems purchased for use on space shuttle launches), the U.S. Geological Survey (USGS, purchased for migratory bird research), the United Kingdom Central Science Lab (two systems used for wind farm and airport studies and monitoring), and the Texas A&M University Cesar Kleberg Wildlife Research Institute (purchased two systems for migratory research).

10.2 Detailed Windfarm Project Summaries

Summaries of two key representative windfarm MERLIN ARS projects follow:

10.2.1 The Near Shore Windpark avian radar survey, risk assessment & post-construction monitoring

DETECT SCOPE: Delivery, installation, system start-up & support for MERLIN™ Avian Radar System for offshore wind energy project avian survey, risk assessment, and post-construction monitoring and mitigation

CLIENT: Bureau Waardenburg b.v., The Netherlands

OWNER: Royal Dutch Shell/NUON Energy

The Near Shore Windpark (NSW) is a joint project of the Dutch government and Royal Dutch Shell to construct 36 wind turbines 10-15 kilometers (km) off the coast of Egmond, the Netherlands. Bureau Waardenburg (BuWa) is the project natural resources consultant to the owner and was tasked to conduct a base line study to assess the effects of offshore wind turbines on birds, specifically focused on the risk of bird mortality, influence on flight patterns and other ecological impacts, and to develop and implement a risk mitigation plan for the project. The long-term assessment research followed a ‗BACI' approach, where data are collected before and after the construction of the wind farm in order to more directly assess impact. The pre-construction assessment started in September of 2003 with the installation of a MERLIN XS2530e Avian Radar System (MERLIN, the radar or the system) on the research platform 'Meetpost' located 10 km off the coast of Noordwijk, The Netherlands. The MERLIN system operated 24-7 for 16 months collecting data on bird activity, flight patterns and behavior. The radar data was processed by DeTect and used to develop the risk assessment for the wind farm. Post-construction monitoring started in December of 2006 with re-installation of the MERLIN avian radar system on a monopole near the wind turbines.

DeTect was contracted by BuWa on behalf of the project owner to design, construct, deliver, install, start-up and support a custom engineered and constructed MERLIN™ Avian Radar System for the project. The scope of DeTect's contract was to provide all required hardware, software, peripherals, technical, data processing and radar ornithology consultation support for a fully functional, avian radar system for continuous monitoring, tracking, recording and analysis of bird data for the pre-construction survey and post-construction risk mitigation phases of the project.

MERLIN system HSR (foreground) and VSR (rear) installation on Meetpost research platform (2003)

The MERLIN configuration included dual radars: a 25 kilowatt (kW) vertically-operated X-band scanning radar (VSR) and a 30 kW horizontally-operated S-band scanning radar; custom radar towers and base plates for mounting to the research platform; custom computer-radar interfaces and workstations; data processing workstations; software licenses; voltage and power regulators; installation and training; and, telephone and Internet technical support. Initial delivery of the system to the project site was made under an accelerated schedule of 30 days after contract award in order to have the system installed and operating in time for the fall 2003 migratory season.

The project had several unique requirements necessitating customization of the system hardware and software to meet specific project needs:

- The MERLIN system was to be installed on an unmanned offshore research platform and was equipped with the ability for remote administration from the mainland via a telephone link.
- The VSR used for height measurement and enumeration of bird targets passing over the study area was equipped with a custom engineered enclosed tower designed to accommodate a servo-motor to allow the radar to be remotely rotated to change the direction of the radar beam.
- The DeTect MERLIN bird detection software included custom modules to provide remote, unattended operation and recordation of bird data to a database for offsite analysis and archiving that included a custom computer communication workstation with removable hard drives and internal modems for use with landlines.
- The system design included hardened components for reliable operation in the adverse environment of the North Sea.
- The system was re-engineering in 2006 for re-installation on a monopole at the operating wind turbines with new functionality including upgrade of the MERLIN avian radar software; addition of advanced remote control features for expanded system control and monitoring from the shore via fiber-optic connection.

DeTect successfully delivered the system in less than 30 days and was able to have the system installed and on-line in time to begin data collection for the fall 2003 migratory season. The MERLIN system operated near continuously 24-7 through 2003 and 2004 collecting data on bird movements in vicinity of the platform. In 2005, DeTect assisted BuWa in data compiling and analysis to develop detailed statistical data on bird distribution, size categories, altitudes, and movements.

The MERLIN system was re-installed on a Monopole in 2006 as an avian monitoring system for the windfarm

Data processing by DeTect in its data center in Panama City, Florida, USA included development and application of specialized track quality control algorithms and supplemental clutter suppression to address specific sea state clutter issues related to this site in the North Sea. The processed data and resultant queries were provided to BuWa for incorporation in their 2005 project report. The MERLIN system continued to operate collecting additional baseline data through project construction, and in the last quarter of 2006 the system was installed on a monopole to provide post-construction monitoring for the operating wind farm. In September 2007, MERLIN processors were added to a ship collision avoidance radar at the wind farm to provide a second avian radar system for expanded bird detection range.

DeTect provided engineering, programming and on-site re-installation support for the monitoring system that included design review of radar custom radar mounts for the monopole; re-installation QA/QC; specification of custom magnetrons to eliminate in-band interference from other marine radars in the project area; delivery of a new, expanded capability remote control interface; delivery and installation of MERLIN avian radar software upgrades; development of automated data processing software for the monitoring phase of the project; updated user training to BuWa; radar installation and calibration; and, data processing and quality assurance.

10.2.2 Beatrice Wind Farm, Offshore Avian Radar Survey, Scotland

DETECT SCOPE: Delivery, installation, system start-up & support for MERLIN™ Avian Radar System for offshore wind energy project avian survey, risk assessment, and post-construction monitoring and mitigation

CLIENT: **Talisman Energy, Ltd.**

OWNER: **Talisman Energy/Scottish and Southern Energy**

The Beatrice Wind Farm is the flagship project for offshore wind energy development in Scotland, the UK and Europe. The €41 million project aims to install two demonstrator wind turbines adjacent to the Beatrice oil field, 25 km off the east coast of Scotland. The project is owned by Talisman Energy and Scottish and Southern Energy, who contracted the University of Aberdeen to conduct an avian survey of the proposed installation area.

Furuno marine radar on the Talisman-Beatrice platform (top unit - blue); the MERLIN processor was installed in the equipment console to the left.

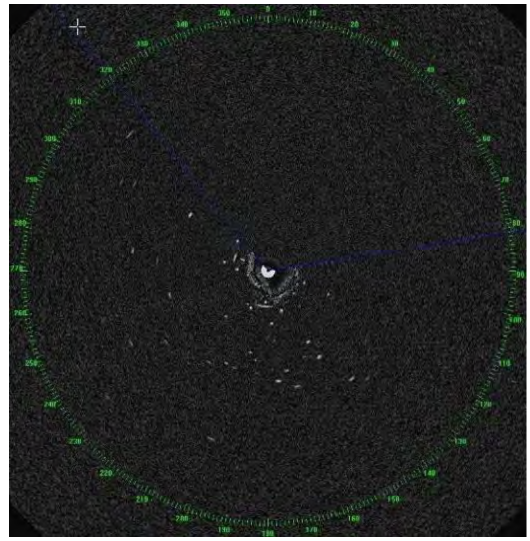
In 2005, Talisman purchased a Furuno 25 kW S-band marine radar for the University to use to conduct an avian survey and mortality risk assessment for the proposed wind farm. The radar was installed by the Talisman and the University on the Talisman Beatrice oil platform off the Scottish coast and operated in a horizontal scanning mode. After the radar was installed, the University determined that manual interpretation of standard marine radar display and data did not provide sufficiently reliable data to support the survey and risk assessment.

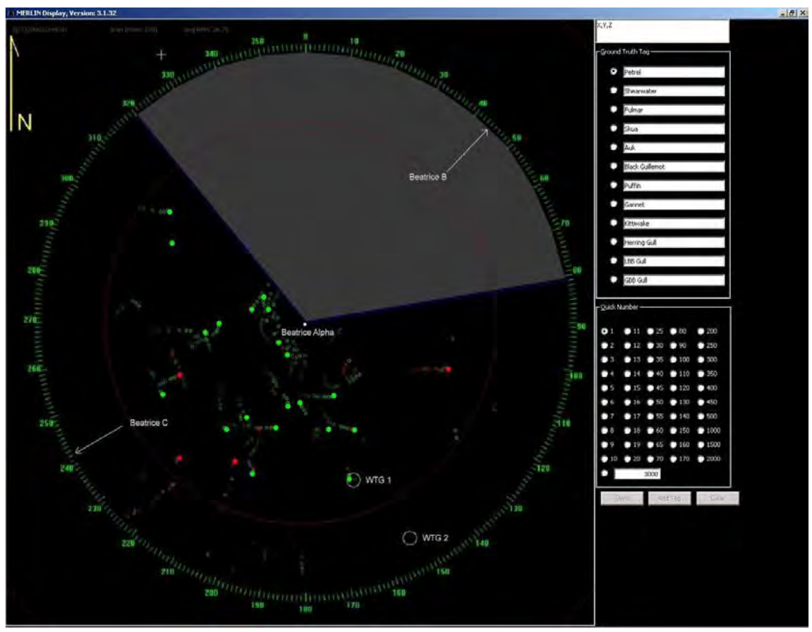
The University contacted DeTect and requested a feasibility proposal for DeTect to upgrade the Furuno radar to DeTect's MERLIN™ avian radar processor. DeTect was contracted by Talisman Energy in early 2006 to provide a project assessment and deliver, install and start-up hardware and software, to automate the radar data collection and processing. DeTect added the MERLIN computer equipment and software, including the MERLIN avian radar processing software, to the Furuno radar in March 2006 and the system was operable and automatically collecting data 24-7 in time for the spring 2006 migratory season. DeTect provides on-going data analysis, processing, interpretation, QA/QC and radar ornithology consultation to the University and Talisman for the project.

After inspecting the project site and reviewing the assessment plan developed by the University, DeTect recommended additional of a vertical scanning X-band radar (to collect altitude data on the survey area), installation of internet connectivity (to the radar to provide remote data access and system control), and addition of a radar shield to the horizontally scanning S-band radar (to reduce sea clutter interference). In November, 2006, DeTect's contract was expanded to include addition of the recommended upgrades and to provide long-term advisory and avian biology support services to the University and Talisman for the project.

The MERLIN processor addition in 2006 provided the University biologists with real-time processed bird track data in a presentation format that is usable to the study researchers. The MERLIN system additionally automatically records all radar system and bird track data directly into the MERLIN database for offsite analysis and use in risk determination. The photo to the right is a screen photo of the pre-MERLIN upgrade standard (unprocessed) Furuno S-band radar display as installed by the University in 2005. The small white “spots” in the image from south-southeast to the west are bird targets being tracked by the radar. The white semicircle at the center of the display is reflectivity clutter from the metal oil platform structure. The lighter white “smearing” near the center is sea state (wave top) clutter interference. With this display, the biologist must continually monitor the screen, decide which targets are birds, determine the sizes of the birds and attempt to count and record the targets. Additionally the presence of clutter obscures some bird targets reducing the reliability of the data.

Right photo– the Furuno raw radar image before MERLIN processing. Bottom photo – the same data displayed by the MERLIN radar processing software





The bottom photo is the same date after being processed by the MERLIN software. The MERLIN system removes the interference clutter with its custom clutter suppression algorithms; identifies, tracks and converts the bird targets in to readily discernible symbols with “trails” indicating the historical path of the bird; and adds a custom “map” reference underlay showing the radar position (screen center), bearing, relative distance (red 1 nm range ring), and the bird targets in relation to other features (WTG 1 & 2 – the proposed turbine locations).

All information on each target (track ID#, target size, speed, bearing, etc.) is also continuously recorded by the MERLIN software to the system's internal database – this data can be queried with the software's standard programs to develop density and passage rate values for mortality risk calculation. The MERLIN display also shows the MERLIN Groundtruth Bar (the right panel of the screen) that allows biologist observers on the platform to visually confirm bird targets tracked by the radar and append observational data such a species, quantity, flight behavior, etc. to the specific target track in the database.

10.3 Radar Survey Project References

A list of additional representative wind farm survey project that have used the MERLIN Avian Radar System follows:

Block Island Offshore Wind Park, Rhode Island, USA (Deepwater Wind LLC) 2008-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System for a yearlong pre-construction survey the proposed offshore wind farm. For the first year, the radar was installed on-shore and surveyed near shore turbines sites. DeTect's work also included supply and installation of four Anabat bat detections to develop data to identify bat activity in the MERLIN radar data. For year Two, the radar system will be reinstalled onto a met mast tower 4 miles offshore to collect preconstruction data for the offshore windfarm installation. In the fall of 2009, the survey was supplemented by installation of a DeTect VESPER Fixed-beam Vertical Profile Radar to develop data on bat activity at the site. The VESPER deployment is funded by a grant from the U.S. Department of Energy. DeTect provides bird radar study technical design, consulting and data processing and analysis support working with the owner's environmental consultants, Tetratech, Inc. and Pandion Associates.

Plum Island Offshore Wind Park, New York, USA (Deepwater Wind LLC) 2007-2008. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System for a yearlong pre-construction survey the proposed offshore wind farm. For the first year, the radar was installed on-shore and surveyed three near shore turbines sites. For year Two, the radar system will be reinstalled onto the met mast tower 6 miles offshore to collect preconstruction data for the offshore windfarm. DeTect provides bird radar study technical design, consulting and data processing and analysis support working with the owner's environmental consultant, ecology & environment, Inc.

Buffalo Mountain Wind Farm Bat Radar Survey, Oak Ridge, Tennessee, USA. (Tennessee Valley Authority and Electric Power Research Institute) 2005-2006. DeTect conducted a Phase I bat survey with a MERLIN XS1030e radar system with thermal imaging cameras at the Buffalo Mountain Wind Farm in Oak Ridge, Tennessee in August 2005 under contract to the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI). Project tasks included supply and operation of a DeTect-owned rental MERLIN Avian Radar System unit, thermal imaging equipment, operators, field biologists, data analysis and expertise to investigate bat mortality at the site and provide recommendations for the Phase II study and a post-construction monitoring program to address the bat kills at the site. The data developed from this study was used to identify specialized radar requirements for bat mortality risk mitigation and led to the development of DeTect's VESPER Fixed-beam Vertical Profile radar system.

Cape Cod Community College Wind Turbine, Hyannis, Massachusetts (Massachusetts Technology Collaborative) 2005-2006. Supported data collection and assessment of bird activity at the proposed single wind turbine site including delivery, operation of a MERLIN XS1030e Avian Radar System during the fall of 2005 and spring 2006 migratory seasons. DeTect also provided data post-processing and analysis in DeTect's data center in Panama City, Florida and developed avian impact and risk report based on the data collection.

Central Science Lab Avian Radar Systems, York, England, United Kingdom (Food and Environment Research Agency, fera) 2003-present. DeTect has supplied and supports two

MERLIN XS2530e Avian Radar Systems used by fera for wind farm and airport avian surveys and support throughout the United Kingdom. Included a MERLIN XS2530ex system with an extended height expandable tower and upgrade of a Geo-Marine MARS bird radar unit to the MERLIN avian radar system software. In 2008, DeTect supported the fera in assessment and development of offshore avian radar survey methodologies to set standards for the European Union.

Comstock Wind Farm, Reno, Nevada (Great Basin Wind/Oak Creek Energy) 2008-2009. DeTect supplied and supported operation of a company-owned MERLIN XS1030e Avian Radar System for survey and assessment of bird activity at the proposed wind turbine site for the fall 2008 and spring 2009 migratory seasons. The owner's consulting biologists, Klein elder, Inc., were trained on system operation and maintained system operation and data collection during the 4 week survey periods for each season. DeTect provided full remote technical support and data analysis, QA/QC, bird mortality risk assessment and reporting.

Easthaven Wind Farm Avian Radar Survey, Easthaven, Vermont, USA (Vermont Fish and Wildlife Department) 2004. Conducted a limited avian radar survey of the proposed Easthaven Wind Farm in November 2004 under contract to the Vermont Fish and Wildlife Department. Under the contract, DeTect conducted a four week survey of the proposed wind farm site with a DeTect-owned rental MERLIN X10 bird detection radar system. The work included system operation, data groundtruthing, data analysis and expert testimony for assessment of mortality risk to bird activity from the proposed wind turbine site.

Gulf Wind I Windfarm, Texas USA (Pattern Energy, formerly Babcock & Brown USA) 2006-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System for avian mortality risk monitoring at the wind farm located on the Texas Gulf Coast. The system was installed in the fall of 2006 and collected two years of 24-7 data on avian activity that was used to model potential risk to migratory and resident birds in the proposed wind farm areas. In 2008 the system was installed as a permanent monitoring system for the operating wind farm with the MERLIN *SCADA* avian mortality risk mitigation software which allows the bird radar to function as an early-warning mortality risk mitigation system for migratory birds providing advance detection of elevated bird activity and automatically idling the wind turbines when birds are detected under high mortality risk conditions. The MERLIN SCADA installation at the Gulf Wind I Windfarm is the first use of automated avian radar technology for risk mitigation at a wind farm in the world. DeTect provides bird radar study and monitoring technical design, consulting and data processing and analysis support working with the owner's environmental consultants, SWCA, Inc. and Texas ESA.

Lake Ostrowo Wind Farm, Poland (Dong Energy/KAPPA) 2007-present – Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System conducting multi-year post-construction survey at Poland's largest wind farm located on the Baltic coast. The system is operated by the University of Szczecin with on-going data analysis, processing, QA/QC and general consultation provided by DeTect.

Neda Mine/Butler Ridge Wind Farm Bat Survey, Fond du Lac, Wisconsin, USA. 2005-2006. Conducted a radar bat survey at the proposed Butler Ridge wind farm near the Neda Mine in Wisconsin under contract to the Wisconsin Natural Resources Foundation with funding from the US Fish and Wildlife Service (USFWS) and the US Environmental Protection Agency (EPA). DeTect provided a MERLIN XS1030e Avian Radar System, thermal imaging equipment, operators, data analysis and expertise to investigate the potential for bat morality at the site relative to the proposed wind farm site. Tasks included detailed analysis and correlation of the radar data with acoustic data from Anabat detectors deployed during the radar survey by staff of the Wisconsin Department of Natural Resources (DNR) and programming of custom algorithms to analyze potential to automatically differentiate bird and bat targets within the radar system in real-time.

Penãscal Wind Farm, Texas USA (Iberdrola Renewables) 2008-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System as a permanent monitoring system for this operating wind farm that is located adjacent to the Gulf Wind I wind farm south of Corpus Christi, Texas in Kenedy County. The system uses the MERLIN *SCADA* avian mortality risk mitigation software which allows the bird radar to function as an early-warning risk mitigation system for migrating birds at the wind farm providing advance detection of elevated bird activity and automatically idling the wind turbines when birds are detected under high mortality risk conditions. Along with Gulf Wind I, the MERLIN SCADA installation at the windfarm is the first use of radar technology for migratory bird mortality risk mitigation at a wind farm in the world. The systems are also integrated into a wider network of bird radars with though a VPN to expand the early warning capability of each individual radar between each wind farm. DeTect provides bird radar study technical design, consulting and data processing and analysis support working with the owner‘s environmental consultants, SWCA, Inc., Texas ESA and WEST, Inc.

PdV Wind Farm Avian Radar Survey, Kern County, California, USA. 2005-7 In support of the developer‘s consultant, Sapphos Environmental, Inc., DeTect provided a two-phase avian risk assessment of proposed wind farm site in the Mojave area of California. Phase I provided pre-assessment of the site using processed US NEXRAD data with DeTect‘s BirdMap technology. Historical processed NEXRAD data for the site (24-7 data updated every six minutes) was extracted covering a three-year period for the project site and surrounding area and analyzed for levels of bird activity, with specific focus on nighttime migration period in low visibility. Data was also compared to a known bird habitat resource area and conclusions developed as to the relative level of bird activity and mortality risk expected for the project site. For the fall 2006 migratory season, DeTect provided a company-owned rental MERLIN XS1030e avian radar system to Sapphos biologists for collection of data 24-7 during the fall migratory season. Sapphos biologists were trained on system operation and DeTect provided full remote technical support and data analysis, QA/QC, bird mortality risk assessment and reporting.

El Pino Wind Farm, Spain (Torsa Renovables) 2009-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS25200me Avian Radar System equipped with a solid-state MERLIN*SharpEye* horizontal scanning radar supporting a vulture mortality risk mitigation study at operating wind farm. The system is collecting data 24-7 to determine usage patterns for the vultures at the site to develop mortality risk mitigation implementation of the MERLIN *SCADA* mortality risk system. DeTect is providing the study design, field installation oversight, system startup, field biology support, consulting and data processing and analysis support working with the owner‘s biologists.

Ross Island Windfarm, New Zealand (Meridian Energy Ltd.) 2008-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System operated by New Zealand‘s largest energy company and wind farm developer to assess migratory bird risk for the Antarctic coastal wind farm site. The system is operated by the developer‘s consultants, Boffam Miskell, with data analysis, processing and risk assessment support provided by DeTect.

Town of Orleans Wind Turbine, Massachusetts (Massachusetts Technology Collaborative) 2005 to 2006. Supported data collection and assessment of bird activity at the proposed single wind turbine site including delivery, operation of a MERLIN XS1030e Avian Radar System during the fall of 2005 and spring 2006 migratory seasons. DeTect also provided data post-processing and analysis in DeTect‘s data center in Panama City, Florida and developed avian impact and risk report based on the data collection.

Smola Windpark, Norway (Norwegian Institute for Nature Research) 2008-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System supporting Sea eagle mortality risk mitigation study at operating wind farm. The system is collecting data 24-7 to determine usage patterns for the Sea eagles at the site to develop mortality risk mitigation implementation of the MERLIN *SCADA* mortality risk system. DeTect provides bird radar study technical design, consulting and data processing and analysis support working with the owner‘s consultants, NINA and SINTEF.

Tetratech, Inc. MERLIN Avian Radar Systems, Portland, Maine USA (Tetratech, Inc.) 2003-2009. DeTect has supplied and supports two MERLIN XS2530e Avian Radar Systems used by a leading international environmental and engineering consulting firm, Tetratech, for wind farm and airport avian survey projects. The MERLIN system delivered in 2008 includes the extended scissor-lift option that elevates the radar sensors to 38 feet above ground level.

Westfield-Ripley Windfarm, New York, USA (Babcock & Brown) 2007-present. Design, delivery, installation, start-up and operational support of a mobile MERLIN XS2530e Avian Radar System conducting pre-construction survey of proposed wind farm site in northern New York State. The radar was installed in the fall of 2007 and is collecting data 24-7. The project site is located in the US Great Lakes flyway and is considered a key resource area. DeTect provides study technical design and data processing and analysis working with the owner‘s environmental consultant, ecology & environment, Inc.

10.4 Commendations

DeTect's MERLIN Avian Radars are used at facilities and project sites worldwide with a proven record of exceptional performance, reliability and operability, with over 500,000 hours of operating experience. The company has a strong record of repeat business: the USAF has purchased seven DeTect systems to date based on a documented record of improved aircraft safety, and NASA after conducting intensive market research and competitive testing of available technologies, in 2006 selected DeTect technology to support launch safety for the $2 billion space shuttle during the July space shuttle Return-to-Flight (NASA subsequently ordered a second DeTect system in 2008 for the Kennedy Space Center).

DeTect routinely receives commendations from its clients for its high level of customer service and technology …

Mike Leinbach, NASA Space Shuttle Launch Director …
Your system worked like a champ and allowed us to launch the Space Shuttle Discovery safely July 4, 2006 on her STS 121 Mission to the International Space Station. Thank you very much.

Anthony Griffith, NASA JSC Sub-Orbital Debris Radar Program Manager …
You guys should be justifiably proud that while radar was a late comer to the bird abatement party, it is one of the few remaining systems fielded for flight support among dozens of alternatives that were investigated after STS-114. Quite an accomplishment.

Bruce MacKinnon, Transport Canada, Manager Security and Safety …
I know that the staff of Vancouver International Airport share my high regard for the DeTect team. We believe that the DeTect team is the only group capable of delivering the results that we seek.

Stephen J. Payne, NASA Shuttle Test Director, Launch and Landing Division …
Thanks for your excellent support of the STS-118 launch. You have become a regular feature at our launches and it is always a pleasure to work with you.

Rick Greiner, Babcock & Brown Renewable Holdings, Permitting Manager …
[B&B] has, since 2005, contracted with Detect for equipment and services on projects in Texas and New York. We are convinced that the MERLIN Avian Radar Survey methodology is the best on the market today. The level of service provided by Detect and the reliability of their equipment is very high. We continue to rely on Detect for radar equipment and services for many of our most critical projects. It has been our experience that the staff at Detect Inc. has always been very responsive to our project needs.

Michael Kujawa, Winergy Power, Director Research & Analysis …
The DeTect MERLIN system has surpassed our expectations as to the depth of detail, digital processing, and data mining capabilities that we needed. A similar response has been voiced by all government regulators regard such data as a critical determinant for granting of the permits for the project. We are highly satisfied by DeTect's prompt and sustained support and willingness to quickly develop new solutions to meet unforeseen challenges that we faced by placing the unit in such a remote location. Finally, we greatly appreciate the level of professionalism and depth of knowledge that has been displayed by DeTect support personnel. It would be hard

to image a better combination of state of the art technology and organizational backing.

WINERGY POWER

DeTect Inc.
Mr. Gary Reynolds
3160 Airport Road
Panama City, Florida 32405 USA

May 6, 2008

Dear Mr. Reynolds:

We understand that DeTect avian and bat detection radar is being considered for environmental monitoring for a project in New Zealand.

Winergy Power Holdings LLC ("Winergy) is a leader in the development of an offshore wind energy industry in the coastal waters of the United States. We are in the process of obtaining the final permits for the first offshore wind demonstration project in the USA and, simultaneously, applying for permits for offshore meteorological and environmental monitoring towers and State-requested offshore wind farm projects.

The DeTect Merlin avian and bat monitoring system that we have installed on an island adjacent to our offshore wind energy demonstration project site has surpassed our expectations as to the depth of detail, digital processing, and data mining capabilities that we needed. A similar response has been voiced by all government regulators regard such data as a critical determinant for granting of the permits for the project.

We are highly satisfied by DeTect's prompt and sustained support of the Merlin system, and willingness to quickly develop new solutions to meet unforeseen challenges that we faced by placing the unit in such a remote location.

Finally, we greatly appreciate the level of professionalism and depth of knowledge – both technology and biology – that has been displayed by DeTect support personnel. It would be hard to imaging a better combination of state of the art technology and organizational backing than we have received thus far.

Sincerely,

Michael Kujawa

Director – Research and Analysis
Winergy Power

150 Motor Parkway, Suite 425, Hauppauge, NY 11788 USA
(631) 434-9100 | (631) 239-6686
dennis@winergyllc.com | www.winergyllc.com

BABCOCK & BROWN

Babcock & Brown LP
1600 Smith Street · Suite 4025 · Houston TX 77002 USA
T 713 571 8900 · F 713 571 8004 · www.babcockbrown.com

May 6, 2008

RE: Letter of Recommendation for Detect Inc. MERLIN Avian Radar Survey services and equipment

To whom it may concern,

Babcock & Brown Renewable Holdings Inc. has, since 2005, contracted with Detect Inc. for equipment and services on projects in Texas and New York. We are convinced that the MERLIN Avian Radar Survey methodology is the best on the market today. The level of service provided by Detect and the reliability of their equipment is very high.

We continue to rely on Detect Inc. for radar equipment and services for many of our most critical projects. It has been our experience that the staff at Detect Inc. has always been very responsive to our project needs. We look forward to continuing our working relationship on future projects.

Sincerely,

John F. (Rick) Greiner, CPG
Permitting

4 September 2008

Gary Andrews
Principal in Charge
DeTect Inc.
1902 Wilson Avenue
Panama City
Florida 32405
UNITED STATES OF AMERICA

Dear Gary

Delivery, setup and initial support of Meridian Energy's MERLIN radar system

This letter is to advise you that the delivery, setup, calibration and training of field operators for the MERLIN radar has been completed to Meridian's satisfaction.

Further, we would like to acknowledge the outstanding work of Jon Bortle in achieving this. At times issues relating to achieving this outcome were challenging and required patience, communication and negotiation.

Meridian was very impressed with Jon's professionalism, enthusiasm and dedication in ensuring Meridian's best interests were maintained at all times.

On another note, Meridian is extremely pleased with the MERLIN radar and we can clearly envisage that it will be a crucial tool in evaluating avian ecological issues, for gaining wind farm consents.

We look forward to Jon's return to New Zealand for the next phase of monitoring.

Please pass on our sincere thanks to Jon, his work was truly appreciated.

Kind regards

Graeme Mills
Wind Investigation Manager

Marise Mettrick
Resource Monitoring

Meridian Energy Limited

Level 1, 33 Customhouse Quay
PO Box 10-840
Wellington 6143, New Zealand

Phone +64-4 381 1200
Fax +64-4 381 1272
www.meridianenergy.co.nz

10.5 MERLIN SCADA Papers

A Quantitative Methodology for Determination of Migratory Bird Mortality Risk at Windfarms

Authors: Ronald L. Merritt, Principal Biologist, DeTect, Inc.; T. Adam Kelly, Chief Scientist, DeTect, Inc.; Gary W. Andrews, Scientist, DeTect, Inc.

Presented at the American Wind Energy Association, Windpower 2008 Conference in Houston, Texas, USA June 1-5, 2008

Abstract.

Assessment of migratory bird mortality risk at windfarm sites to date has relied mostly on traditional biological techniques - visual surveys and literature reviews — resulting in at best qualitative estimation of risk. The subjectivity and indeterminacy inherent in this approach subsequently leaves the conclusions open to vigorous debate between the project stakeholders. Radar is increasingly being used to conduct bird surveys at wind farm sites based on its ability to extend the distance the biologist can "see" as well as its capability to detect and track birds at night. Radar techniques to date however have primarily relied on conventional radar ornithological methods where a trained biologist monitors a radar screen visually deciding which "blip" on the radar screen is a bird and manually recording the number of birds and other data. This technique, while more reliable than visual surveys alone, is still highly subjective and results can vary greatly by operator and technique.

Since the 1980's, the U.S. Air Force has led development of specialized avian radar systems to detect and track birds to reduce aircraft-bird collisions (strikes) and has developed complex programs and mathematical models to predict and manage strike risk. A variant of these models has been applied to the communication tower and wind energy industries that uses data from modern avian radar and meteorological systems to collect detailed data activity and more accurately model bird movements in project areas and to quantitatively predict bird mortality risk from collisions with the structures. The objectivity in the data and model provides the wind energy industry with a new tool to more accurately predict and assess potential risk, evaluate project impacts, and address core developer and stakeholder issues.

Additionally, the current generation of advanced avian radar systems now on the market can be integrated with windfarm control systems to continuously monitor bird activity around the windfarm applying the model in real-time to provide active risk mitigation through a variety of response measures that can include selective idling of turbines during periods of high mortality risk conditions. Recent studies have indicated that the economic impact to the wind energy project from this technological approach is minimal as the high risk periods typically occur during times of low wind and/or non-peak demand resulting in a manageable mitigation cost.

Bird Survey Methods.

Assessment of migratory bird mortality risk at windfarm sites to date has relied mostly on traditional biological techniques - visual surveys and literature reviews — resulting in at best a highly subjective, qualitative estimation of risk. Visual survey techniques include point counts, where the biologist periodically "count" birds within a view 360 degrees around a reference point (figure 1) and other methods that similarly rely on the skill and visual acuity of the field biologist to see, count and project the number of birds in a project area.

Figure 1: Traditional point count bird survey

Radar Ornithology.

Radar ornithology is being increasingly being used for bird surveys at wind farm sites based on the ability of radar to extend the distance the biologist can "see". Radar ornithology offers several advantages to the study of bird movements as it can sample large volumes of airspace continuously and consistently and can track birds of all sizes, well beyond the capabilities of an observer with a spotting scope (Eastwood, 1967; Blokpoel, 1976).

Even during conditions of good visibility, small, highflying or distant birds that often are missed by visual observers can be detected by radar (Korschgen et al., 1984). Radar also allows study of nighttime, dusk, and dawn bird movements when visual observations are unreliable or not possible and radar operates well in fog when typical visual techniques are ineffective (Gauthreaux, 1994). Radar provides highly reliable information on the movements within a range of a few kilometers (Williams et al., 1972; McCrary et al., 1981; Cooper et al., 1991) with small marine radars (10 kilowatt [kW] power) able to reliably detect individual small birds (swallows) out to 1.2 km (0.75 mi.) and single larger birds out to 2.4 km (1.5 mi) (Gauthreaux, 1994).

Virtually any radar can detect and track birds with birds appearing as small "blips" in the radar display (figure 2). Radar bird surveys typically have a trained biologist monitor the radar screen visually deciding which blip on the radar screen is a bird and manually recording the number of birds and other data such as estimated bird size, speed, direction and altitude.

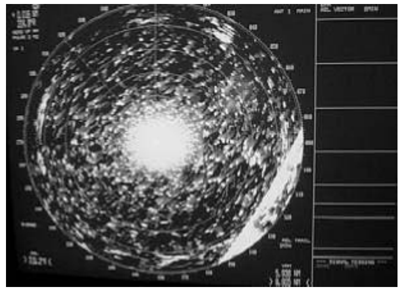


Figure 2: Unprocessed "raw" marine radar display during migration

The most commonly used radar for bird surveys is the "fan beam T-bar marine radar" (figure 3) which ranges from low cost, low power units widely that are typically used on recreational boats to more expensive, industrial grade systems that are used on commercial, oceangoing ships. Some efforts have been directed to improve the manual interpretation process by recording the radar display and post analysis of image or video, but the method is still highly reliant on manual interpretation of the base radar imagery. While more reliable than visual survey, "manual" radar ornithology is highly labor intensive and very costly for long term survey or operational monitoring.

Manual Radar Ornithology Data Error.

Manual radar ornithology is subject to a high level of error in data reliability due to a number of factors that include, but are not limited to operator proficiency, inter-and intra-operator variability, fatigue, count limitations, equipment capabilities, and, methodology. Observer fatigue in air traffic control radar operation is well studied and is directly analogous to radar ornithology *(Fatigue in Air Traffic* Controllers, Transport Canada, TP 13457, July 2000). Likewise, count error introduced by a high number of bird targets is obvious (figure 2) as during peak activity periods there can be simply too many targets for the operator to accurately assess and count. Low activity periods however also can be demanding as watching a radar display during periods of low activity involves intense concentration while waiting for "something to happen".

Measurement accuracy is also a leading error cause that includes count errors (over- or under-counting or mis-identification of a bird target), target detectability, and equipment sensitivity. Marine radar data is normally rendered to a data display as a Plan Position Indicator (PPI) display (see figure 2). The raster image of a PPI display can be visualized as a piece of graph paper: the larger the piece of graph paper and the smaller the grid squares, the finer the detail that can be rendered in scale. The lower cost, recreational marine radars that are used for many bird surveys have small screens and with few colors or shades (of grayscale) with far lower resolution than the higher cost, larger high resolution displays in more expensive industrial marine radars. Recreational marine radar systems are additionally rarely capable of rendering radar target intensities at more than 16 levels and, even when they can, only 2-3 levels of variability can be perceived by the human eye. Video or screen image recording of the display further compresses the detail resulting in more lost data and introduced artifacts.

Figure 3: T-bar type marine radar in horizontal surveillance scanning position

Manual radar ornithology typically uses the "echo trail" function to show the target "track". During migration with a significant number of bird targets moving at one time, the screen can quickly become saturated with bird targets and trails complicating target counting (figure 2). It is not unusual for the ornithologist to simply stop counting targets during high activity conditions resulting in significant undercounts and data gaps.

Many manual radar ornithology surveys also use only a single radar to survey both the vertical (y-z) and horizontal planes (x-y) with samples for each collected for short periods of time (typically 15 minutes) by "flipping" the radar from the horizontal survey mode (figure 4) onto its side into the vertical mode (figure 5) where the radar antenna spins in a windmill manner scanning from horizon-to-horizon (figure 6, Harmata et al. 1999). The resultant data gaps from the horizontal and vertical must be extrapolated introducing data gap bias into the data.

Figure 4: Marine radar in the horizontal scanning position

Figure 5: Marine radar in the vertical scanning position

Many radar bird surveys also use data from the radar in the horizontal scanning position to project bird counts and "passage rates" with altitude estimated based on calculation, not actual measured height of the target above the ground. In the horizontal mode the amount of the radar display lost to ground clutter (terrain, vegetation) is generally high (see figure 2). When the ground clutter level gets too high and saturates the radar receiver, or is so high that the addition of a small target such as a bird does not significantly change the signal, the target is cannot be "seen" by the observer on radar screen and is not counted (is "lost" in the clutter). In contrast, scanning in the vertical mode, mostly looks at clear air and only scans the ground clutter near the horizontal plane and up to the height of the terrain, so that the majority of the bird targets are clear of clutter. Imaging small targets against clear air results in a greater contrast than when imaging targets against a background of clutter, and accordingly, vertical scanning has a significant advantage over horizontal radar for detecting and counting the actual number of targets passing through a survey area.

The physics of insect contamination in radar data is also widely not completely or mis-understood. In manual radar ornithology, targets moving under 4 meters/seconds (m/s) in the data are frequently simply discarded as insects and not included in the bird target count based on misinterpretation of conclusions from studies with military tracking radars (Larkin 1991, *Flight speeds observed with radar, a correction: slow "birds" are insects).* Although pencil (tight) beam marine radar can detect insects, those that use the T-bar antenna start at a performance disadvantage. Under the right conditions, insects are readily detectable and observable when the marine radar is set to the shortest range setting (0.25 nm). But as the range setting is increased, the numbers of small targets visible is reduced significantly with this same "scaling effect" occurring with larger targets such as birds and bats with the result that valid bird targets are often rejected as insects in manual ornithology.

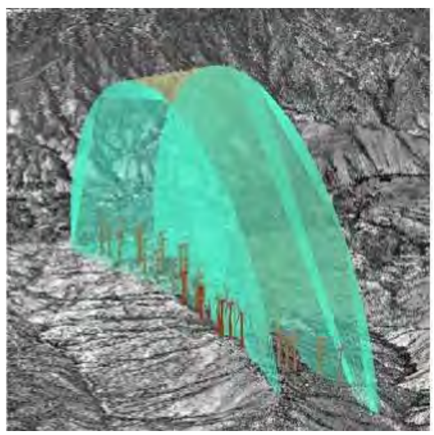


Figure 6: Vertical scanning coverage for wind farm survey

Automated Avian Radar Systems.

Since the 1980's, the U.S. Air Force has led development of specialized, highly automated avian radar systems to detect and track birds to reduce aircraft-bird collisions (strikes) and has developed complex programs and mathematical models to predict and manage strike risk. These advanced avian radar systems (figure 7) have recently become available on the commercial market and are seeing increasing use for environmental survey and scientific research. The systems generally include high-end, high-resolution industrial radars scanning simultaneously in both the vertical and horizontal planes and sophisticated, real-time radar data processing computer algorithms that automate clutter suppression and bird target identification, tracking and counting reducing or eliminating many of the deficiencies inherent in manual radar ornithology. The more advanced systems additionally can operate unattended 24-7, cost-effectively collecting detailed datasets on bird activity at project sites that can be used to assess bird activity and model mortality risk.

The current generation avian radar systems can also be integrated with windfarm control systems to continuously monitor bird activity around the windfarm applying the risk models in real-time to provide active risk mitigation through a variety of response measures that can include selective idling of turbines during periods of high mortality risk conditions. Recent long term studies have indicated that the economic impact to the wind energy project from this technological approach is minimal as the high risk periods typically occur during times of low wind and/or non-peak demand.

Quantitative Bird Mortality Risk Analysis for Wind Farms

A variant of the military birdstrike models has been developed for the communication tower and wind energy industries that uses data from these modern avian radar and meteorological systems to more accurately model bird movements in project areas and quantitatively predict migratory bird mortality risk. The objectivity in this model provides the industry with a new tool to more accurately predict and assess potential risk, evaluate project impacts, and address core developer and stakeholder issues.

Bird avoidance of obstacles such as tall structures, radio towers, communication towers, and wind turbines during day and night periods (including dawn and dusk) is near 100% as evidenced by the

Figure 7: Advanced avian radar system developed by DeTect, Inc. of Panama City, Florida, model MERLIN XS2530e

fact that significant bird kills are generally not observed daily near buildings, forests, towers, wind farms, and other similar structures. Mortality risk appears however to increase during nocturnal movements under conditions of low visibility (generally defined as visibility of less than 1/3 mile) such as heavy fog and haze (Kruse 1996, Kemper 1996, Larkin 2000, WT Docket No. 03-187 2004). Accordingly, migratory bird collision mortality risk analysis for wind farms is typically focused on periods when risk conditions of low visibility (e.g. fog) occur at night. The level of avoidance of birds to obstacles under conditions of low visibility at night is not well understood however and some avoidance is likely to exist even under these conditions.

The commonly applied methodology for normalizes the bird passage rates across a 1 kilometer (km) front at the height affected by the turbine rotor — the Rotor Swept Zone (The RSZ is defined as the turbine blade reach area from the lowest sweep point of the turbine blade to its highest sweep point) - over the period of one hour. Automated radar technology scans the full 1 km surface area at a sample rate of approximately 24 observations per minute with sampling in both the vertical and horizontal simultaneously and continuously. Subsequently, survey data, including passage rates of birds across areas of concern, can be analyzed at higher resolution time frames to provide maximum insight into the dynamics of bird activity at the site as well as mortality risk.

Evaluation of a risk considers:

(1) the specific risk,

(2) probability of occurrence, and

(3) resultant consequences.

Risk assessment is the relationship of exposure to the risk versus the consequence(s) of the risk. The specific risk to birds presented by a proposed windfarrn is collision (strike) of birds with the wind turbine components (tower, hub, blades) resulting in serious injury or mortality. The majority of studies of wind farm bird collisions have recorded relatively low levels of mortality (Drewitt, et al., 2006). As discussed previously, migratory birds generally have good visual powers to "see and avoid collisions" with static or moving objects, however bird visual acuity is compromised during conditions of low visibility conditions at night. Low visibility conditions occur during fog, sea mist and low cloud conditions, or occasionally from other obscurants such as smoke, and are exacerbated at night.

This probability analysis model is based on the model originally developed and used by the USAF for calculating aircraft-bird strike risk (Meyer, George E, 1975; Tucker, V.A. 1996). This model calculates the risk of a bird collision with turbine components based on the frontal zone presented by the target relative to the bird targets passing through the zone and provides a quantitative basis for estimation of risk.
In this model, the radar scanned zone is the total area in which the radar collects data (Figure 8; yellow shaded area). Data for the 1 km front is the area within the radar scanned zone 0.5 km to either side of the radar (Figure 8; green shaded area). The rotor swept zone (RSZ) is the 1 km wide area within the 1 km front area from the bottom most sweep of the turbine blade to the topmost extent of the rotor blade sweep (Figure 8; red shaded area). The Rotor Swept Area (RSA) is the circular area "swept" by the blades of a turbine during operation.

The moving parts of the wind turbine (the blades) present the most strike risk to birds, but birds can collide with any part of the wind turbine structure, including the support tower (figure 9) and the central hub of the nacelle (hub).

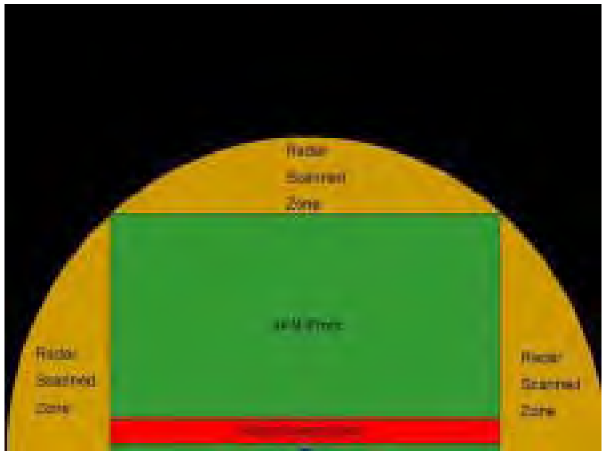


Figure 8: Illustration of the radar scanned zone, the 1 km front, and the rotor swept zone

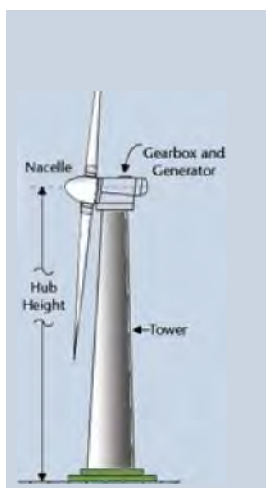


Figure 9: Components of a typical wind turbine

The RSA and RSZ can be calculated for each specific project from the turbine manufacturer data. For a single turbine installation, the Rotor Swept Area occupies only a very small portion of the 1 km front, and the blades only occupy a small percentage of the swept area at any given time. The Frontal Area presented by the turbine includes the frontal area of the tower, the generator, gearbox, blades and nacelle, and are included in the calculated value for the Frontal Area used for risk analysis (expressed as an area in square meters; Figure 10).

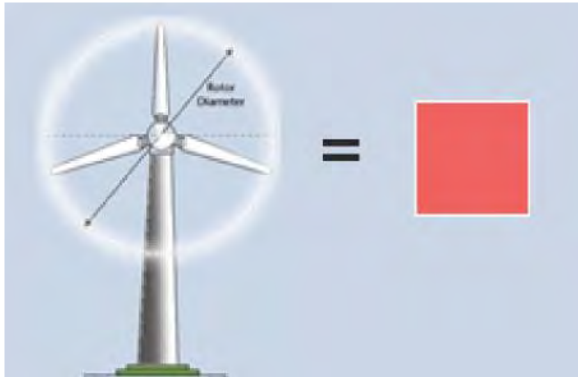


Figure 10: The frontal area of a wind turbine can be expressed as an equivalent frontal area in square meters.

Using the frontal area, the number of discrete pathways within the RSZ can be determined with a Discrete Pathway being equal in area to the frontal area of the wind turbine. The total number of Discrete Pathways (Figure 11) in the RSZ for a single wind turbine is calculated as:

Rotor Swept Zone Frontal Area of the turbine structure

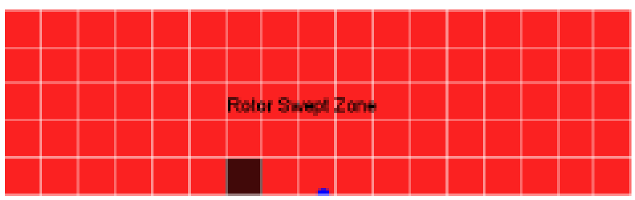


Figure 11: Array of discrete pathways in the rotor swept zone with one of all the Discrete Pathways blocked by a wind turbine

The calculated number of Discrete Pathways for a project results in a 1 in "x" chance (with "x" being the Number of Discrete Pathways) that a target passing through the Rotor Swept Zone will have to change its flight path to avoid a component of the turbine structure. Accordingly, if the Passage Rate of targets (number of bird targets/hour/1 km front) as measured by the radar does not exceed the number of discrete pathways, then statistically no single target crosses the probability "Risk Threshold" of having to see and avoid any turbine component. This model assumes a worst case scenario of zero avoidance of obstacles by birds during low visibility at night conditions, so that the actual risk is most likely lower than the risk projected.

Conclusion

The advantage of this model is that the data is highly quantitative and objective, providing a means to develop standardized data for the wind energy industry to more reliably compare projected results with the actual mortality at the operating wind farm. Data developed by the model can also be used with advanced avian radar system technology as a risk mitigation system where the radar integrated with windfarm control systems to continuously monitor bird activity around the windfarm applying the model in real-time to provide active risk mitigation responses that can include selective idling of turbines during periods of high mortality risk conditions. Recent studies have indicated that the economic impact to the wind energy project from this technological approach is minimal as the high risk periods typically occur during times of low wind and/or non-peak demand resulting in a manageable mitigation cost.

11. System Warranty and Operation & Maintenance Costs

11.1 MERLIN ARS Characteristics

The MERLIN ARS is proven, highly reliable technology with over 50 systems operating worldwide since 2003. The technology was originally developed for the US Air Force and the US space agency, NASA, and has been engineered to deliver superior performance and the highest level of system reliability as a critical flight safety system component. The USAF has to date purchased seven MERLIN systems, including a theater deployed system for Afghanistan, based on a documented history of birdstrike reduction and high system reliability. NASA, purchased two MERLIN systems to date and carefully assessed MERLIN system reliability as part of its acquisition process, certifying MERLIN for operational support of the $2 billion space shuttle based on its validated performance and highest level of reliability (birdstrikes are NASA's second highest safety risk to the shuttle and NASA will not launch the space shuttle without MERLIN system support).

Other government agencies that include the British government and international airports have similarly selected the MERLIN system for flight safety support and MERLIN is the most widely used bird radar technology for wind energy project preconstruction survey and operational wind farm monitoring and risk mitigation. The oldest MERLIN system at an operating wind farm is the system installed at the Near Shore Wind Park (Nordwindzee) wind farm off of the Dutch coast that was installed in September 2003. The system has operated unattended at the remote offshore site nearly continuously since 2003 which includes 2 years of preconstruction survey and continuous monitoring operation when the wind farm went on line in 2006. This system used the older magnetron-based radar systems (not the state-of-the-art solid state radars proposed for this tender) yet has had very low system downtime (less than 2%) and service costs (under 16,400 euro). In 2008, the first round of DeTect recommended system upgrades was implemented which included replacement of the system processing computer units.

11.2 DeTect Warranty Terms

MERLIN is designed and manufactured by DeTect, Inc. of Panama City, Florida USA (a U.S. Corporation) and is supported by DeTect through a network of worldwide representatives. The systems are engineered and constructed to meet US industrial, MILSPEC and other US and international standards for durability, reliability and performance under continuous 24-7 operation and in high demand, adverse operating conditions.

DeTect provides a full parts and labor warranty with system that includes DeTect repair or replacement of any defective parts for the term of the warranty, exclusive of wear parts. *For this offer a one-year parts and labor warranty is included for all system components* - **DeTect will replace any covered parts that fail in the first year at its expense, which includes parts and labor**.

Note: The only components excluded from this warranty are wear parts are parts which degrade under normal use and include, but are not limited to, motor brushes, generators, tires, and other such components, or parts that fail due to deterioration from environmental or chemical exposure conditions. In 2009, DeTect significantly improved system reliability by upgrading the

MERLIN technology to all solid-state radar sensors with 50,000 hour MTBF manufacturer ratings (replacing magnetron based sensors that had 3000 hour MTBF manufacturer ratings).

DeTect Inc.
detection technologies

es&s
www.esands.com

Date:	October 19, 2011	**Quotation:**	QDT-111005D
To:	RPS North Queensland, Australia	**Validity:**	**90 Days**
Via:	**Tim Cookes - ES&S**		
Ex Works	DeTect, Inc.		
Ref:	**Migratory Bird Mortality Risk Mitigation for Ratchaburri's Windfarms in North Queensland - Australia**		

MERLIN ARS System - Avian Survey Configuration

Item	Description	QTY	Unit Price (US$)
1.0	Phase 1 - MERLIN XS25200me Avian Radar System See Item 3. MERLIN XS25200me Avian Radar System (ARS) Deliverables of our Technical Proposal QDT-111005D.	1	$553,900
2.0	Phase 2 - MERLIN SCADA Risk Rule Development and Implementation (if deemed applicable)	1	$138,600
	TOTAL SYSTEM - CIF Australia		$692,500

Radar Coverage Extension (Phase 3)

Item	Description	QTY	Unit Price (US$)
3.0	Additional MERLIN XS25200me Avian Radar System (same configuration as Item 1)	1	$553,900
4.0	Additional 25KW VSR radars (skid mount) as needed for full windfarm coverage (final quantity to be determined at the end of Phases 1 and 2) *Note: Radar locations, number of and type of radar units/sensors and radar range settings are all subject to change based on further analysis and site visit(s) by DeTect Inc.	1	$270,000

All pricing is in U.S. Dollars and the client assumes all foreign exchange risk.
Delivery quoted is CIF nearest major seaport (customer to arrange customs clearance, import duties, and local transport to project and installation sites).

Payment Schedule & Terms:
• 30% of contract with order and executed contract
• 15% payment due 30 days after contract
• 15% payment due 60 days after contract
• 15% payment due 90 days after contract
• 15% payment due prior to shipment
• Balance in equal payments to be invoiced monthly with 5% due at start-up and the ÿnal 5% due within 60 days after startup

Payments are to be made within twenty (20) days of invoice date.
Failure to make payments in accordance with the terms and schedule may result in extension of delivery.

Rev. 10/19/2011

Item	Description	QTY	Unit Price (US$)

MERLIN ARS System - Avian Survey Configuration

Delivery Lead Time:
6-8 months after receipt of order

General Terms & Conditions:

1. Specifications are subject to change without notice. Systems will be delivered in general accordance with specifications and design currently in effect at time of order.
2. The price proposed is exclusive any and all applicable sales taxes, fees, licenses, duties, operating permits and other costs resulting from the sale, delivery, transfer, installation, and operation of the system and the buyer will be responsible for obtaining and costs related to such items. DeTect will provide available information for applications, permits and licenses as required by the buyer.
3. Title to the equipment will be transferred to the buyer upon receipt of all payments due from the buyer to DeTect under this proposal and any subsequent contract.
4. The buyer will be granted a single site user license to use the MERLIN™ operating software for the intended purpose only. DeTect will deliver a complete set of the MERLIN operating software executables with the system and periodically will issue updates and patches to the software. Any other such unauthorized use of the software or transfer of or installation of the software to other systems or computers or transfer to other users, companies or individuals is expressly prohibited. Non-compliance with the license requirements will result in revocation of the user license upon notification of which the buyer will immediately and promptly remove, delete, and destroy all copies of said software, providing written certification of compliance of such removal, deletion, and destruction.
5. Client user to provide required infrastructure for system in advance of delivery to include equipment pads, power connections and connections for remote system control and display via client fiber optic (or similar) network.
6.Purchase and delivery the system may be subject to the United States International Traffic in Arms Regulations (ITARs). Non-US government buyers at purchase will be required to execute an agreement acknowledging that: (i) DeTect's MERLIN system (defined as technology, hardware and software) may be governed by the United States ITARs; (ii) the system will be used solely for the intended commercial purpose and will be used in strict compliance with ITARs; (iii) he will implement procedures for restricting access to said system and agrees not to sell, rent, lease or in any manner transfer the system or any component to any country or individual to which such access or transfer is restricted; (iv) will not to export or transfer the equipment outside of the U.S. except as permitted by ITARs and with the express written approval of the DeTect; and, (v) any other use of the system may require advance approval under ITARs, agree to advise DeTect prior to any transfer or such use, and will not proceed with such transfer or use without receipt of approval by both DeTect and any required U.S. Government Agencies. The buyer will be granted a single site user license to use the MERLIN™ and HARRIER™ operating software for the intended purpose only. DeTect will deliver a complete set of the operating software executables with the system and periodically will issue updates and patches to the software. Any other such unauthorized use of the software or transfer of or installation of the software to other systems or computers or transfer to other users, companies or individuals is expressly prohibited. Noncompliance with the license requirements will result in revocation of the user license upon notification of which the buyer will immediately and promptly remove, delete, and destroy all copies of said software, providing written certification of compliance of such removal, deletion, and destruction.
7. Acceptance of the order by DeTect is contingent on execution of a contract or order in a form acceptable to DeTect. All specifications and delivery schedules are subject to change based on current models offered at the time of the order.

Environmental Systems & Services Pty Ltd
PO Box 939
Hawthorn
VIC 3122
Australia

www.esands.com
esands@esands.com

Standard Terms and Conditions of Trade

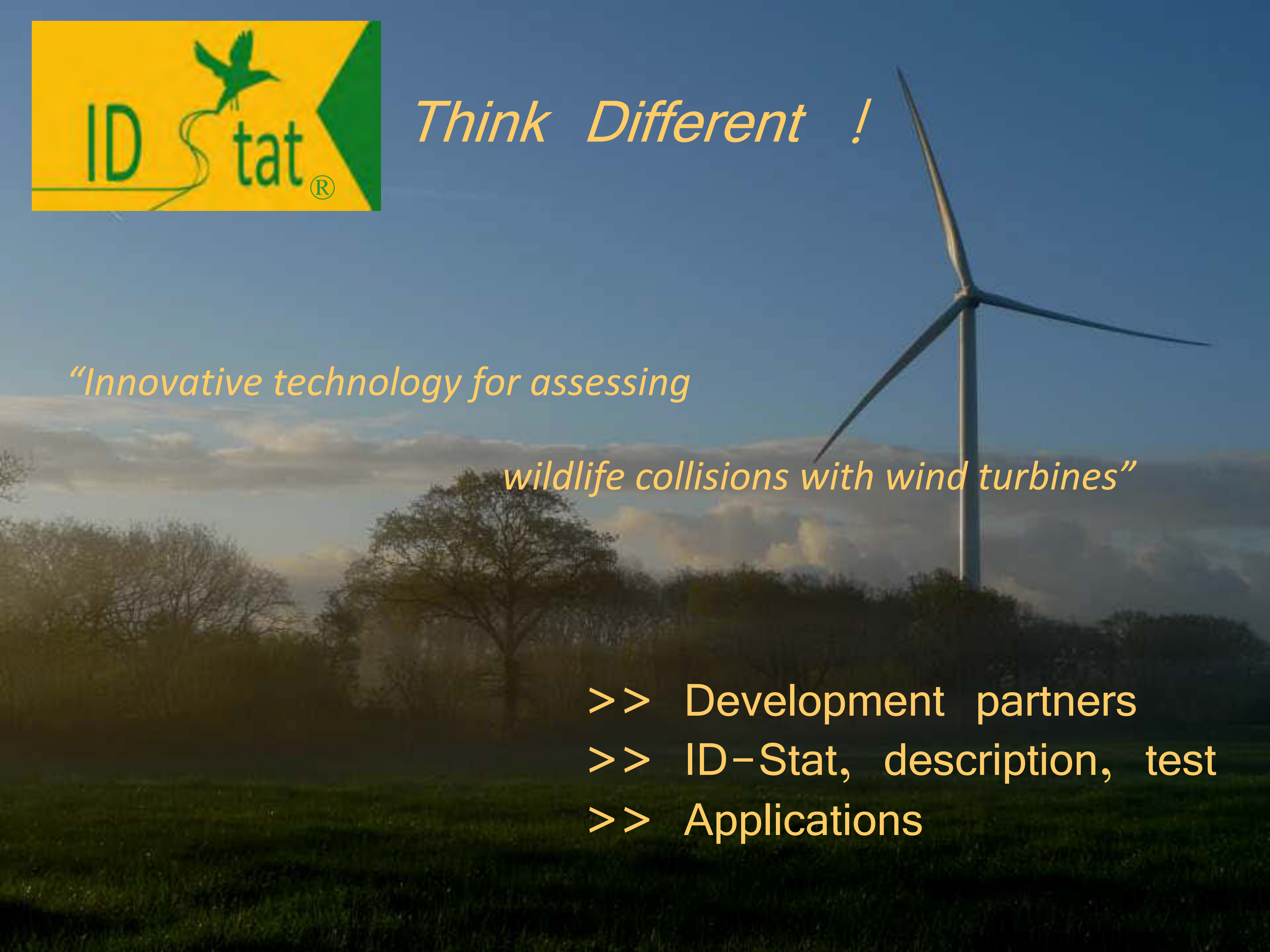
To the fullest extent legally possible, all dealings between Environmental Systems & Services Pty Ltd ACN: 006 349 122 ("ESS") and any Customer ("the Customer") relating to any products or services are subject to the following Terms & Conditions of Trade ("these Terms") unless otherwise agreed in writing.

1. Payments to be within 30 days of invoice date without deduction, unless otherwise agreed.
2. Interest is payable on overdue accounts at ESS' election at the rate prescribed under the Penalty Interest Rates Act 1983 (Vic) plus an additional 3% per month.
3. Property:
   a. Property in products shall not pass until payment in full of all monies owed to ESS on any basis
   b. ESS reserves the right to take possession & dispose of products as it sees fit at any time until full payment & the Customer grants permission to ESS to enter any property where any product is in order to do so with such force as necessary
   c. Immediately upon delivery the Customer accepts liability for the safe custody of products
   d. A certificate signed by an officer of ESS identifying ESS products & certifying that monies are owing to ESS shall be conclusive evidence of ESS' title thereto
   e. Upon sale or disposition of products prior to payment in full the Customer agrees to hold all proceeds Upon Trust for ESS in a separate bank account agrees not to mix proceeds with any other monies & will upon request immediately account to ESS therefore even if ESS may have at any time granted any credit facility &/or time to pay
   f. Until full payment the Customer agrees
      i. to keep all products as fiduciary and Bailee for ESS & store them in a manner which shows ESS as owner
      ii. only to sell products in its usual course of business
      iii. sale on terms, at cost or less than cost shall not be "in the usual course"
   g. Clause 3 is not intended to create a charge & shall be read down to the extent necessary to avoid being a charge
   h. if the Customer uses or incorporates any products in any production, process, manufacture or construction or combines them with anything to create a finished or combined new thing for disposition by the Customer then upon such disposition prior to payment in full of all monies owing, the Customer agrees to hold such part of the proceeds thereof (& until payment is received by the Customer, that part of any applicable book debt of the Customer) as equals the costs of the products used and/or incorporated therein (at the prices invoiced by ESS to the Customer for them) Upon Trust for ESS until payment in full of all monies.
4. Limitation Of Liability:
   a. The Customer will limit any claim upon ESS relating to products, to the cost of replacement of products or the supply of equivalent products and relating to services, to the cost of having services supplied again
   b. ESS will not be liable in any way for any contingent consequential direct indirect special or punitive damage arising whether due to ESS's negligence or otherwise & the Customer acknowledges this limit of liability & agrees to limit any claim accordingly
   c. No other term condition agreement warranty representation or understanding whether express or implied in any way extending to or otherwise relating to or binding upon ESS is made or given
   d. ESS will not be liable for any claim re any alleged fault or defect caused or contributed to by the Customer or any 3rd party nor for any transport installation rectification labour or other cost.
5. Returns:
   a. Any products which are accepted by ESS as defective may be returned and
      i. be replaced free of charge or
      ii. be the subject of a credit for the invoiced value. Replacement free of charge does not include labour transport or material costs.
6. Specific Orders. Customer specific orders may be rejected by ESS at its election, unless accompanied by a non-refundable deposit of at least 50% of the total order price.
7. Placement Of Orders:
   a. if any dispute arises concerning any order (& including any measurement quality quantity identity or authority or any telephone facsimile e-mail or computer generated order) the internal records of ESS will be conclusive evidence of what was ordered
   b. each order placed shall be & be deemed to be a representation made by the Customer at the time that it is solvent & able to pay all of its debts as & when they fall due
   c. failure to pay in accordance with these Terms shall be & be deemed to be conclusive evidence that the Customer had no reasonable grounds for making the representation referred to in 7.b) & that the representations were unconscionable, misleading and deceptive
   d. when any order is placed, the Customer shall inform ESS of any material facts which would or might reasonably affect the commercial decision by ESS to accept the order &/or grant credit in relation thereto. Any failure to do so shall create & be deemed to create an inequality of bargaining position shall constitute & be deemed to constitute the taking of an unfair advantage of ESS & to be unconscionable, misleading and deceptive.
8. Delivery:
   a. ESS accepts no responsibility for delivery but may elect to arrange delivery at its discretion & without any liability & at the Customer's costs & responsibility in all things
   b. ESS reserves the right to charge for any delivery
   c. the Customer shall be deemed to have accepted delivery & liability for the products immediately ESS notifies that they are ready for collection or when they are delivered to a carrier or to the Customer's business premises or site whether attended or not
   d. a certificate purporting to be signed by an officer of ESS confirming delivery shall be conclusive evidence of delivery as shall any signed delivery docket
   e. ESS will not be liable for delay, failure or inability to deliver any products
   f. once the Customer has been notified that products are ready for collection, the Customer agrees to pay all costs of holding or handling products
   g. Frustrated Delivery: If the time spent in attempting to or effecting delivery exceeds 30 minutes or requires more than one attempt, the Customer agrees to pay all costs relating thereto together with a loading of 10% to cover administration costs.
9. Variation or cancellation of any order dealing or arrangement must be agreed in writing
10. Purchase Price:
    a. All sales are made by ESS at its quoted price at the time of order placement
    b. government imposts and any GST ("imposts") will be to the Customer's account
    c. ESS's price lists exclude imposts unless expressly noted thereon.
11. Exclusions:
    a. No dealing with the Customer shall be or be deemed to be a sale by sample or description
    b. If ESS publishes material about its products & prices, any part which is incompatible with these Terms is expressly excluded
    c. the Customer will rely on its own knowledge & expertise in choosing any product for any purpose
    d. Any advice or assistance given for or on behalf of ESS shall be accepted at the Customer's risk & shall not be or be deemed given as expert or adviser nor to have been relied upon.
12. Default or breach by the Customer of these Terms or in any dealings with ESS will entitle ESS to retain all monies paid, call-up all monies owing, cease further deliveries & recover from the Customer all loss of profits without prejudice to any other of its rights.
13. Severability: Any part of these Terms can be severed without affecting any other part.
14. Products:
    a. ESS may update modify make substitution or alter any of its products or any component or raw material incorporated in or used in forming any party of any products as part of its ongoing business. The Customer agrees to accept current products in substitution for any products ordered provided they are not materially different
    b. ESS disclaims any responsibility or liability relating to any products
       i. processed or made to designs drawings specifications or measurements etc or with materials which are provided or approved (whether in part or fully) by or on behalf of the Customer
       ii. utilised stored handled or used incorrectly or inappropriately
    c. The Customer agrees to check products for compliance with all applicable Standards & regulatory bodies before use, on-sale or application & only to use on-sell or apply products in accordance therewith and with any manufacturer's or ESS' recommendations & directions as well as with sound commercial practice.
15. Other Terms & Conditions & Notice: No terms &/or conditions sought to be imposed by the Customer upon ESS shall apply unless agreed in writing by ESS.
16. Recovery Costs: The Customer will pay all costs & expenses of ESS, its legal advisers, mercantile agents & others acting on its behalf in respect of anything instituted or being considered as a result of any breach of these Terms or of any dealings with ESS.
17. Attornment: To give effect to its obligations arising under in these Terms the Customer hereby irrevocably appoints any solicitor for ESS from time to time, as its attorney.
18. Customer Restructure: The Customer will notify ESS of any change in its structure or management including any change in director shareholder management partnership or trusteeship or sale of any material part of its business within 7 days of any such change.
19. Jurisdiction: All contracts made with ESS shall be deemed to be made in Victoria & the parties submit to the jurisdiction of the appropriate Courts in or nearest Melbourne.
20. Credit Limit: ESS can vary or withdraw any credit facility or limit at any time at its discretion & without any liability to the Customer or any other party.
21. Waiver: If ESS elects not to exercise any rights arising as a result of breach of these Terms it shall not constitute a waiver of any rights relating to any subsequent or other breach.
22. Notice: The Customer will be deemed to have notice of any change to these Terms, immediately they are adopted by ESS in its business.
23. Security For Payment: The Customer
    a. agrees on written request to charge in favour of ESS
       i. by way of a fixed charge, all its books of account goodwill documents of title & current & later acquired real & intellectual property &
       ii. by way of a floating charge the whole of the Customer's other undertaking property & assets with payment of all monies owed to ESS
    b. grants a lien to ESS over any of its property in the possession or control of ESS for any monies due and owing to ESS under these Terms or otherwise.
24. Force Majeure: ESS will not be in default or breach of any dealing with the Customer as a result of Force Majeure (ie: anything beyond ESS' reasonable control).
25. Patents etc : If ESS utilises any design patent or intellectual property or follows any instruction provided by or on behalf of the Customer the Customer indemnifies ESS against any claim proceeding damages or liability for any loss cost or expense arising as a result whether for any alleged infringement of any intellectual property or otherwise.
26. Specifications:
    a. Any illustration drawing or specification supplied by ESS ("Specs") are drafts and approximates
    b. Any tangible or intellectual property rights in Specs shall remain the property of ESS and may be recalled at any time
    c. Specs to be treated at all times as confidential and not made use of without the prior written consent of ESS.
27. Materials: All materials supplied by the Customer must be shipped by the Customer to the factory or site nominated by and in accordance with ESS instructions & at the cost and risk of the Customer. Such materials will remain at the Customers risk at all times.
28. Stock Discretion: ESS has a continuing discretion to allocate available stock and gives no warranty as to certainty of supply unless expressly agreed in writing in advance.
29. Partial Delivery/Forward Orders: If the Customer places forward orders or request partial or instalment delivery, the Customer agrees
    a. to pay for so much of any order as is from time to time delivered by ESS
    b. that no delay or failure to fulfil any part of any order shall entitle the Customer to cancel or vary any order or delay or reduce any payment.
30. On-Sale: The Customer agrees that upon on-sale of any products to inform any third party involved of these Terms and in particular the provisions of clause 4 and sub-clause 4.
31. Indemnity: The Customer indemnifies ESS against any claim or loss arising from or related in any way to any contractor dealing between ESS & the Customer or anything arising therefrom or arising as a result of or subsequent to any breach of these Terms Insurance: The Customer agrees to insure ESS from any liability claim or damage arising in any way; whether directly or indirectly under part VA of the Trade Practices Act, these Terms, which insurance will note the insured interest of ESS

Appendix 26

"Innovative technology for assessing wildlife collisions with wind turbines"

Prepared by ID-Stat


ID Stat®
Think Different !
"Innovative technology for assessing
wildlife collisions with wind turbines"
>> Development partners
>> ID-Stat, description, test
>> Applications

ID Stat®

Developed and patented

In collaboration with

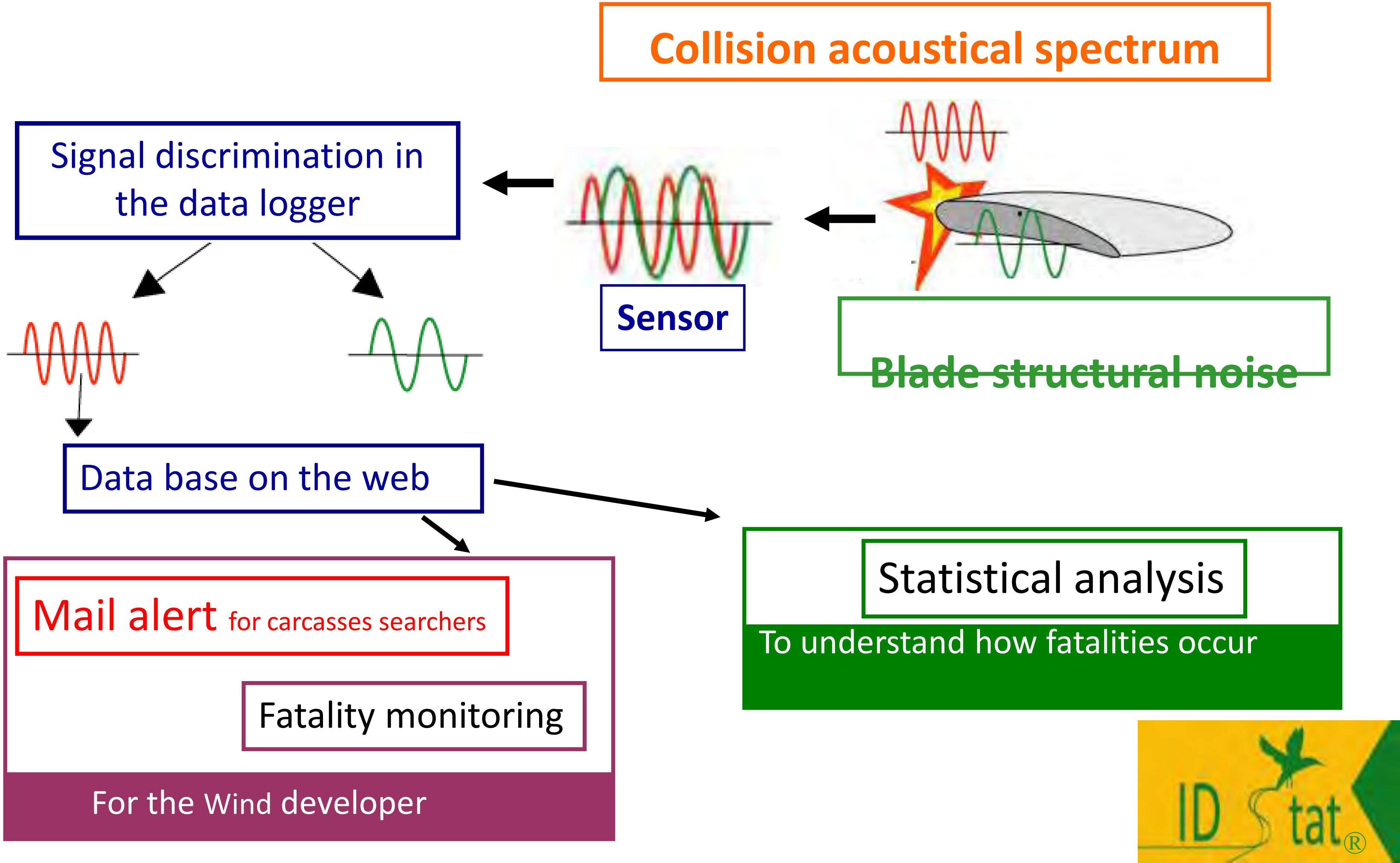
Eneria CAT

M. Bertrand DELPRAT
14 rue Picard
44 620 La Montagne
France

Calidris
Donnez des ailes à vos projets

M.Aymeric MINOT
1 rue de Longpont
91 311 Montlhéry
France

>> ID-Stat, automatic and standard collision detector

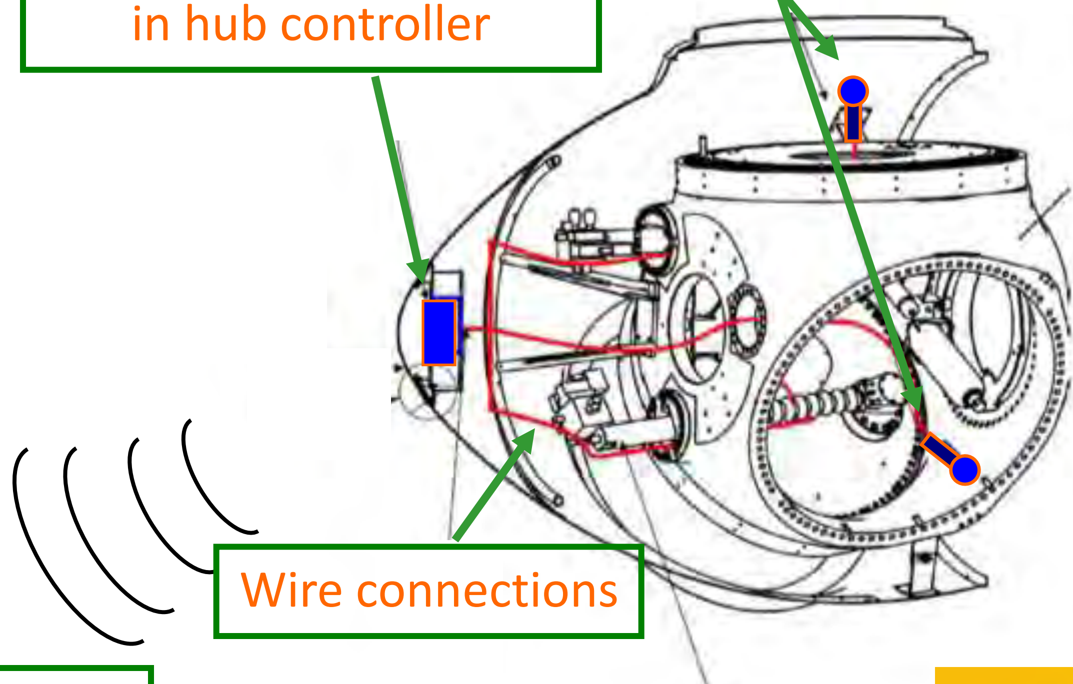


>> ID-Stat, non-invasive vibro-acoustic collision detector

Three microphones

NON-INVASIVE ATTACHMENT

Data logger connected in hub controller



Wire connections

GSM technology

for data collection ...

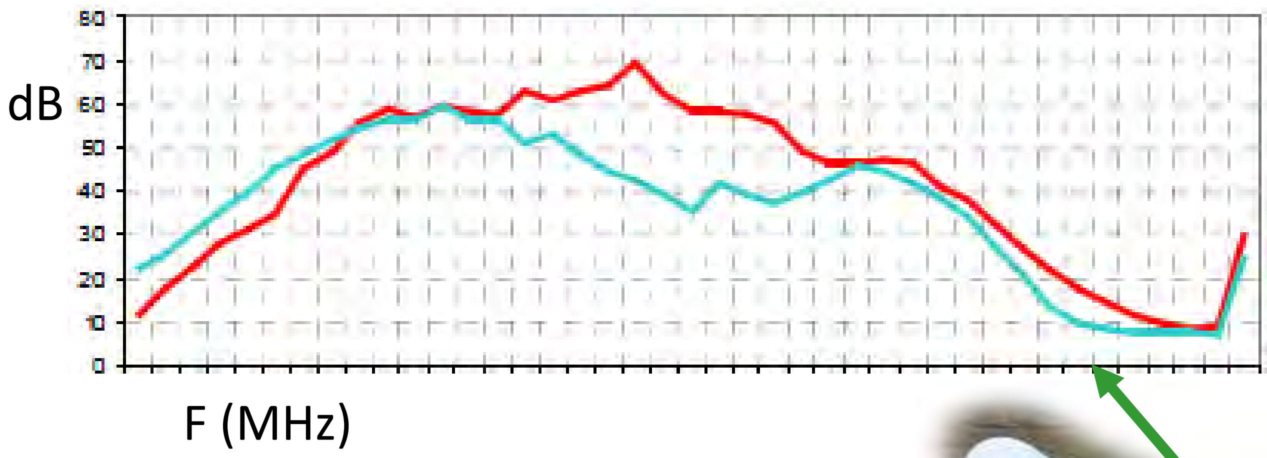
ID Stat ®

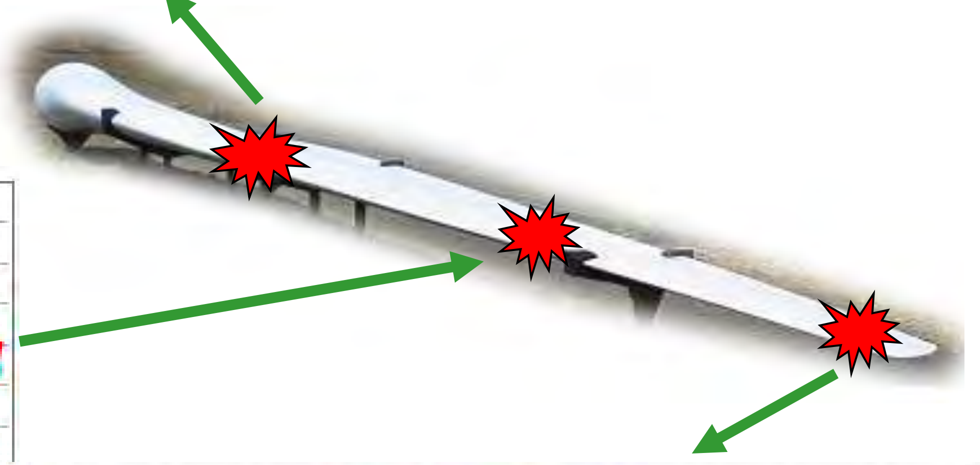
>> Test issues

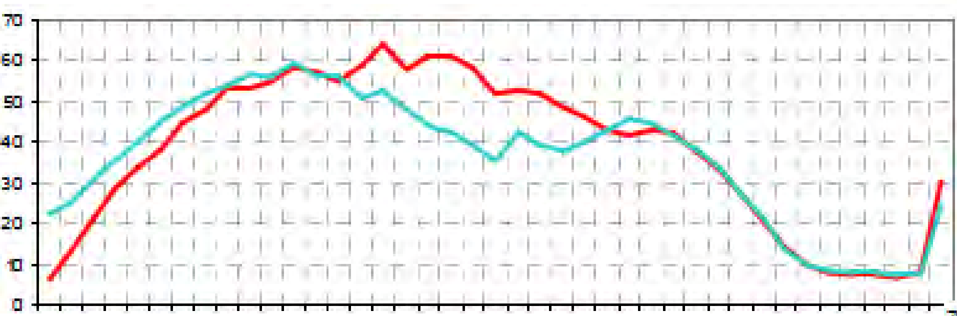
- acoustical detection validation
- acoustical detection level
- ID-Stat validation for industrial applications

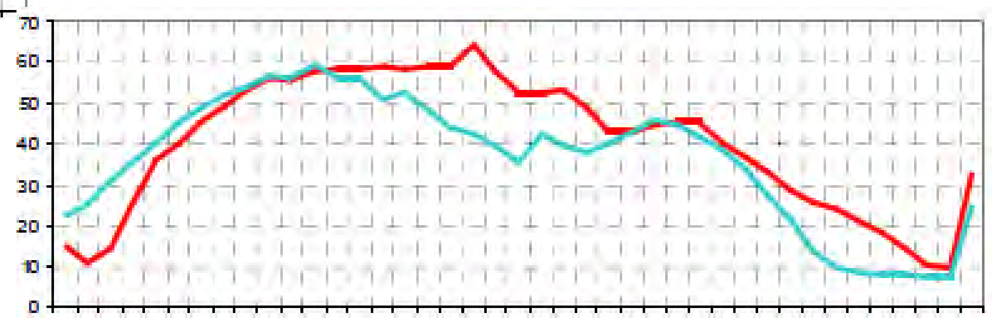
>> Blade acoustical properties …

Acoustical spectrum constant from base to tip









Red *is the collison + laboratory structural noise*
Blue *is the structural noise*

>> First test results

=> Collision detection

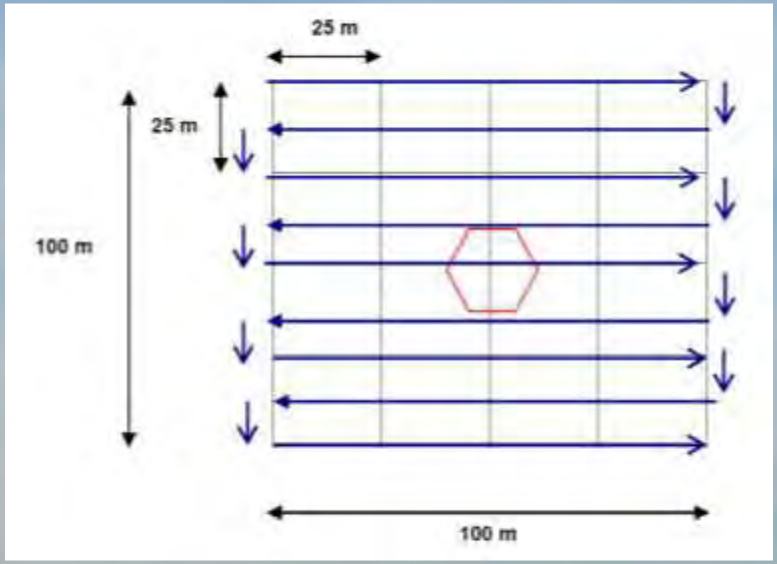
-> with flying chicks 30g

-> with "artificial bird" 2,5g

Customised chicken gun ®

2,5 g artificial bird

>> First long term test



Ground fatality research methodology

=> 1 windturbine (western France)

=> 1 ID-Stat collecting 24/7 since May, 3d 2011

=> daily ground fatality searches

>> ID-Stat applications

- *fatality monitoring offshore & onshore,*
- *mitigation measure validation,*
- *collision model validation,*
- *industrial wind constraints acceptable for **biodiversity** and **still profitable***
- *international collisions data base (due to patent),*
- *train/truck birds and bats fatality monitoring …*


Thank’s, Multumesc, Danke, Grazie,
Obligado, Gracias, Takk …
for your attention ☺
ID tat
aminot@eneria.com
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Cell : 00 33 (0)6 25 57 32 15

Appendix 27

Mount Emerald Wind Farm Aeronautical Assessment

Prepared by REHBEIN Airport Consulting

REHBEIN AIRPORT CONSULTING

DATE 26 SEPTEMBER, 2011

CONTACT MICHAEL WARD

Mount Emerald Wind Farm Aeronautical Assessment

For Transfield Services (Australia) Pty Ltd

TABLE OF CONTENTS

Document Control Page

Revision	Date	Description	Author	Signature	Verifier	Signature	Approver	Signature
0	01/06/11	DRAFT	MMW		KCM		BJH	
1	28/07/11	FINAL	MMW		KCM		BJH	
2	26/09/11	FINAL	MMW		KCM		BJH	

1.0 EXECUTIVE SUMMARY

Transfield Services (Australia) Pty Ltd is proposing to locate up to 79 wind turbine generators at Mount Emerald near Atherton, Queensland. The site is located approximately 50 KM south west of Cairns Airport in the Tablelands Region and covers approximately 2,000 hectares. The turbine blade tips will be 129 m above ground level.

Civil Aviation Safety Regulation (CASR) 139.365 requires the proponent of a proposed structure *"…the top of which will be 110m or more above ground level…"* to notify the Civil Aviation Safety Authority (CASA) of their intention and to provide the proposed height and location of the building or structure. If the proposed obstacle, building or structure is deemed to be hazardous to aircraft operations CASA may direct the proponent to light or mark the hazard in accordance with the *Manual of Standards (*MOS Part 139 — *Aerodromes)*. CASA formerly provided guidance material on lighting of wind farms in Advisory Circular AC 139-18(0) *Obstacle Marking and Lighting of Wind Farms,* now withdrawn.

Following a recent risk review of man made objects located away from regulated aerodromes CASA is contemplating the development of a regulatory framework similar to that of the United States Federal Aviation Administration for marking and lighting of obstacles. The United States regulations define obstacles as buildings, objects and structures of 150m or more in height. In conjunction with rulemaking activity, CASA intends to review Advisory Circular 139-08(0) on reporting of tall structures and will consider reviewing the withdrawn Advisory Circular 139-18(0) on lighting of wind turbines to refer to lighting requirements for structures 150 metres or more above ground level. Updated guidance material is normally released with new regulations, following a process that may require two years to complete. However, guidance contained in AC 139-18(0) on lighting of wind turbines to fulfil duty of care obligations continues to be relevant.

This study considered in detail the likely impact of the location, height and blade rotation of the proposed wind turbines on the nearest aerodromes; air navigation and air traffic management services; transiting air routes; designated airspace such as Danger, Restricted or Prohibited areas; any other aviation activity; and electromagnetic interference (EMI) with airborne radio.

The proposed wind farm will not impact upon aircraft operations to and from Cairns Airport or Mareeba and Atherton Aerodromes. Nor will it interfere with airborne radio or navigation aid performance. Flights operating under the Visual Flight Rules (VFR) should not be affected by the proposed wind farm as these flights are required to be conducted at a minimum height of 500 ft above ground level outside populous areas and will be above the level of the turbines. The structures will be sufficiently conspicuous by day, and at night local en route lowest safe altitudes (LSALTs) will provide clearance required for flights under the Instrument Flight Rules (IFR) and night operations under the Visual Flight Rules (Night VFR).

Investigation undertaken by REHBEIN Airport Consulting suggests the impact, if any, of the proposed wind farm upon radar and radio performance in the region will not be of operational significance. However it would be prudent to confirm whether Airservices Australia has any concerns about the potential impact of the wind farm.

Low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding. However, agricultural spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations.

Apart from aerial agricultural operations over the wind farm the risk to civil aviation activities if any that this wind farm may pose is trivial. However, as with any reported tall structure that may pose a risk, regardless of its triviality, the position of the proposed wind farm should be shown on appropriate air navigation charts to assist pilots operating in the region. Additionally, hazard lighting in accordance with MOS 139, Chapter 9, Section 9.4 should be installed on sufficient turbines in the Mount Emerald Wind Farm to define the extremities of the site. The lighting should be operated in a manner consistent with a general duty of care towards aviation, such as during the period 1 hour before sunset to 1 hour after sunrise, and during conditions of reduced visibility caused by smoke, dust or haze. Implementation of such mitigation measures will ensure all the safeguards put in place by CASA to reduce the risk posed by tall structures, including wind turbines, to the safety of civil aircraft operations are satisfied.

2.0 INTRODUCTION

Transfield Services (Australia) Pty Ltd is proposing to locate wind generator towers at Mount Emerald near Atherton in Queensland and is seeking approval from the Queensland Government for their development. This assessment is intended to provide a sufficient level of detail to accompany a planning permit application.

The Mount Emerald Farm site is located approximately 50 KM south west of Cairns Airport in the Tablelands Region. The site location is shown in Appendix A. The nearest sizable towns are Atherton to the south east and Mareeba to the north with the country towns of Walkamin approximately 3 KM to the northeast and Tolga approximately 8 KM to the southeast.

The proposal is for a wind farm of 79 wind turbine generators (WTGs) with a maximum height of 129 metres above ground level, consisting of a mast 80 metres high and rotor blade length of 49 metres. The maximum height of the turbine blades will be approximately 3,869 ft AMSL.

As the proposed wind turbines will be greater than 110 metres in height, they must be reported to the Civil Aviation Safety Authority (CASA) for assessment of the risk the proposed structure may pose to civil aircraft operations. The Royal Australian Air Force (RAAF) also has an interest in assessing tall structures and it can be expected that CASA in its assessment will consider the impact upon military flying operations and if required, advice from the Australian Defence Force will be sought.

This aeronautical study has been carried out using the advice promulgated in CASA Advisory Circular AC 71-1(0), *Guidelines for Airspace Risk Management and Associated Aeronautical Study Methodology.*

3.0 LEGISLATIVE BACKGROUND

Under the provisions of the *Civil Aviation Act 1998,* the *Civil Aviation Regulations* (CAR) or the *Civil Aviation Safety Regulations* (CASR)*,* CASA is not empowered to approve or oppose the erection of structures on or near an aerodrome. If deemed necessary, CASA has limited power to order the removal of an object which is classified as an obstruction or hazardous to aircraft operations within 3,000m of an aerodrome (CAR 95).

CASR Part 139.E promulgates the requirements to be met in relation to obstacles and hazards. CASR 139.365 requires the proponent of a proposed structure *"…the top of which will be 110m or more above ground level…"* to notify CASA of their intention and to provide the proposed height and location of the building or structure.

In accordance with CASR 139.370 CASA may determine after conducting an aeronautical assessment that an obstacle, building or structure is, or will be hazardous to aircraft operations. If the proposed obstacle, building or structure is deemed to be hazardous to aircraft operations CASA may direct the proponent to light or mark the hazard in accordance with the *Manual of Standards (MOS) - Part 139 Aerodromes*. With respect to the lighting of wind farms CASA formerly provided guidance material in Advisory Circular AC 139-18(0) *Obstacle Marking and Lighting of Wind Farms,* subsequently withdrawn*.* Other means of providing lighting and / or marking can be proposed to CASA such as those detailed in advice from European agencies and the International Civil Aviation Organisation (ICAO).

Following a recent risk review of man made objects located away from regulated aerodromes, CASA is contemplating the development of a regulatory framework similar to that of the United States Federal Aviation Administration for marking and lighting of obstacles. The United States regulations define obstacles as buildings, objects and structures of 150m or more in height. In conjunction with rulemaking activity, CASA intends to review Advisory Circular 139-08(0) on reporting of tall structures and will consider reviewing the withdrawn Advisory Circular 139-18(0) on lighting of wind turbines to refer to lighting requirements for structures 150 metres or more above ground level. Guidance material is normally released with new regulations in a process that may require up to two years to complete. However, guidance contained in withdrawn AC 139-18(0) on lighting of wind turbines to fulfil duty of care obligations continues to be relevant.

CASA may determine that a particular activity is dangerous to aircraft operations and declare the area encompassing the activity a danger zone.

If a wind turbine is found to penetrate prescribed airspace surrounding an airport, it will be defined as an obstacle and shall be dealt with in accordance with the requirements set out in Chapters 7, 8 and 9 of the *Manual of Standards (MOS),* Part 139 – *Aerodromes*. If the aerodrome is used for night operations, lighting of the obstacle must be in accordance with the provisions of Chapter 9 of the MOS.

The legislative instruments protecting civil aircraft safety can be assumed to replicate the interests of the Australian Defence Force (ADF) aircraft operations and as such input from the ADF could be expected if the proposed activity has a potential impact on military flying operations. CASA may liaise with the RAAF Aeronautical Information Service (AIS) as that organisation maintains the tall structure database on behalf of the aviation community.

Likewise Airservices Australia, the provider of Air Traffic Control Services and Air Navigation Services has an interest in assessing proposed tall structures to ensure there is no impact upon the performance of ground based navigation aids and radar facilities.

4.0 METHODOLOGY

In carrying out the assessment REHBEIN Airport Consulting has considered the likely impact of the location, height and blade rotation of the proposed wind turbines on:

- The nearest aerodromes and:
  - the types of flying activities conducted there;
  - their airspace protection requirements established by the Obstacle Limitation Surfaces (OLS);
  - any existing aircraft instrument procedures published in the Aeronautical Information Publication – Departure and Approach Procedures (AIP-DAP); and
  - prescribed airspace;
- Air navigation and air traffic management services including:
  - radar; and
  - ground based navigation aids;
- Transiting air routes, including:
  - routes used by civil pilots operating under instrument flight rules (IFR);
  - routes used by civil pilots operating under visual flight rules (VFR); and
  - routes used by military aircraft;
- Designated Airspace such as Danger, Restricted or Prohibited areas;
- Any other aviation activity; and
- Electromagnetic interference (EMI) with airborne radio.

5.0 IDENTIFIED ISSUES

Each individual stakeholder will have differing concerns regarding a proposed development. Below is a breakdown of the stakeholder issues REHBEIN Airport Consulting has identified which are addressed in this aeronautical assessment.

5.1 CIVIL & MILITARY AIRCRAFT PILOTS

REHBEIN Airport Consulting has considered the effect of the proposed wind farm on aircraft transiting the region, arriving and departing from local aerodromes and on aircraft flying instrument approaches into Mangalore aerodrome. This consideration has addressed visual flight rules (VFR) and instrument flight rules (IFR) operations.

5.2 AIRPORT OPERATORS

REHBEIN Airport Consulting has assessed the aerodromes in close proximity to the proposed wind farm such as Mareeba Aerodrome and the Atherton ALA including the types of flying activities conducted at each.

5.3 AIRSERVICES AUSTRALIA

REHBEIN Airport Consulting has undertaken an assessment of the impact of the proposed wind farm on the performance on both ground based navigation aids and radar facilities.

5.4 OTHER AVIATION ACTIVITY

5.4.1 AERIAL APPLICATION

REHBEIN Airport Consulting has undertaken an assessment of the likely type of agricultural activities conducted in the area of the proposed wind farm and the impact of the turbines on aerial agricultural operations.

5.4.2 RECREATIONAL AVIATION

Given the proximity to Mareeba Aerodrome and Atherton ALA, consideration has been given to the effect of the proposed wind farm on recreational aviation and flying training in the region.

6.0 POTENTIAL RISKS TO AVIATION ACTIVITIES

As with any proposed obstacle, building or structure, wind turbines must be assessed for any potential hazard/risk to aircraft operations.

6.1 AIRSPACE AROUND AERODROMES

There are two key airspace surfaces which may be relevant dependent on the category of operations into the aerodrome.

6.1.1 OBSTACLE LIMITATION SURFACE (OLS)

The OLS is a set of imaginary surfaces associated with an aerodrome. They define the volume of airspace that should ideally be kept free from obstacles in order to minimise the danger to aircraft during an entirely visual approach or during the final visual segment of an instrument approach procedure. These surfaces are of a permanent nature and comprise the reference datum which defines an obstacle. Anything above the vertical limits of the OLS is regarded as an obstacle. Obstacles are reported so that CASA can determine if they are "hazardous" and therefore need to be marked and/or lit to ensure they are prominently identified.

Airspace requirements will depend on the nature and scale of activities at an aerodrome but could extend to a radius of 15 KM. The OLS also need to be considered in relation to both current and future aerodrome developments and activities.

Wind turbines may be acceptable in the areas covered by the OLS but will need to be assessed in relation to critical manoeuvres such as the approach to land and possible low level missed approaches, and a reduced power take-off following an engine failure.

6.1.2 PANS-OPS SURFACES

Airspace associated with aircraft instrument approach and departure procedures is defined by the PANS-OPS surfaces for an aerodrome. These surfaces are ascertained in accordance with the criteria in the International Civil Aviation Organisation (ICAO) *Procedures for Air Navigation Services - Aircraft Operations* (Doc 8168, PANS-OPS).

The PANS-OPS surfaces are intended to safeguard an aircraft from collision with obstacles when the pilot is flying by reference to instruments. The designer of an instrument procedure determines the lateral extent of areas needed for an aircraft to execute a particular manoeuvre. The designer then applies minimum obstacle clearance to structures, terrain and vegetation within that area to determine the lowest altitude at which the manoeuvre can be safely executed. As a result, PANS-OPS surfaces cannot be infringed in any circumstances.

These airspace requirements will depend on the nature and scale of activities at an aerodrome but could determine the acceptable obstacle heights to a radius of 10 - 20 KM from the aerodrome.

6.2 RADAR

Tall structures may interfere with electromagnetic transmissions. Steel towers and rotating turbine blades can cause reflection and/or deflection of radiated waves and cause interference with aviation communication, navigation and surveillance (CNS) systems established for air traffic management. The CNS system includes aerodrome based and enroute navigation aids (navaids) and radar used for air traffic control at an aerodrome and/or enroute surveillance.

Two types of radar are used for air traffic control (ATC) and surveillance – primary radar and secondary surveillance radar (SSR).

Primary radar works by radiating electromagnetic energy and detecting a return signal from reflecting objects. Comparison of the return signal with the original transmission provides information such as the direction and range of the target from the radar site. ATC radars are designed to filter returns from stationary objects to avoid moving targets, primarily aircraft, being obscured by radar clutter. Other than this means of differentiating between stationary and moving targets, primary radar cannot tell the type of object and has no means of determining the height of the object.

SSR emits radio frequency (RF) interrogation messages that trigger automatic responses from a “transponder” onboard an aircraft. The transponder reports aircraft identification and altitude.

The blades of a wind turbine may be detected if within the coverage and line of sight of primary radar. A grouping of blades will return intermittent reflections that create the impression of a moving target. Since the primary radar gives no height information, reflections from wind turbine blades may cause an air traffic controller to divert aircraft which may be in the vicinity of the wind farm within primary radar coverage regardless of their flight level.

The turning blades may also reflect or deflect the primary radar signals and prevent aircraft flying in their “shadow” from being detected. In this case the co-located SSR would also detect the aircraft but even then the reflection of SSR transmissions in some instances could cause the aircraft to be wrongly identified or its position to be inaccurately shown on ATC radar.

Weather radar can similarly be affected, and this too impacts on flight safety which relies on accurate forecasting of major weather events and wind shear at higher altitudes.

6.3 RADIO NAVIGATION AIDS

Ground based radio navigation aids could suffer from similar reflection and deflection effects as with radar. The effect of this may be that an aircraft is not tracking accurately towards the aid on the designated air route. This false tracking can cause the aircraft to deviate too far from the intended flight track and expose it to obstacles which infringe on the clearances defined in the design of the particular flight procedure in instrument conditions. Similarly, visually navigated aircraft may track erroneously due to a conflict of navigation data available from maps and navigation aids.

Line of sight principles again apply but this type of facility will normally be protected by preventing new structures if they will extend above an elevation angle of 1º as seen from the site of the radio navigation aid.

This means that on level ground a 129 m high wind turbine could be safely located at around 7.5 KM from the site of the aid.

6.4 INSTRUMENT & VISUAL FLIGHT RULES

6.4.1 INSTRUMENT FLIGHT RULES (IFR)

Aircraft operating under IFR are navigated by reference to cockpit instruments which process data from aircraft systems, ground-based navaids or satellites. All regular public transport (RPT) jet aircraft operating into or between major Australian cities operate only in controlled airspace and under IFR.

In contrast, turboprop or piston engined regional RPT aircraft travelling to or from a regional city may operate route sectors outside controlled airspace (OCTA) and even under VFR.

Charter and business aircraft may operate in controlled airspace under IFR or VFR, or OCTA under VFR. General aviation training aircraft are most likely to operate under VFR. Military aircraft may operate anywhere and may be flying at very low levels.

Aircraft operating under IFR may do so either OCTA or within controlled airspace. If flying below 10,000 ft pilots must select, or will be assigned, cruising altitudes which are multiples of 1,000 ft – odd thousands if their track is 0 ºM - 179ºM and even thousands if their track is 180 ºM - 359ºM. IFR traffic must select or be assigned to a designated air route depicted on air navigation charts.

Since IFR pilots may be relying solely on cockpit instruments and have no outside visual reference, a lowest safe altitude (LSALT) is published for each air route. It is determined by adding 1,000 ft minimum vertical clearance to the highest terrain or known structure enroute.

It is conceivable that a new wind farm, if located on prominent terrain, may require an increase in LSALT for a particular air route.

6.5 VISUAL FLIGHT RULES (VFR)

Aircraft operating under VFR may do so only in visual meteorological conditions (VMC) defined as an average range of visibility of 5,000 m forward of the cockpit, horizontal cloud clearance of 1,500 m and vertical cloud clearance of 1,000 ft.

VFR traffic is most likely to operate OCTA but may fly in Class E controlled airspace without reference to ATC. VFR pilots may fly a designated air route in which case they must select altitudes which are multiples of 500 ft - odd thousands plus 500 ft if their track is 0 - 179ºM and even thousands plus 500 ft if their track is 180 - 359ºM. This rule ensures there should be a minimum 500 ft separation between IFR and VFR traffic using the same air route.

The minimum statutory height for VFR flight is 500ft above ground level or clear of obstacles in non-populous areas. Night VFR pilots must fly at or above the LSALT for the route. Night VFR pilots must use either a published LSALT for the area or if on a dead reckoning (DR) track then a calculated LSALT taking into account obstacles and terrain within 10 NM of the nominated track.

VFR traffic in daylight hours is not confined to air routes and these aircraft may operate anywhere provided they do so in VMC and observe the same rules for selecting their cruising altitude.

In these conditions wind farms should be easily visible and have no impact on VFR flying activity.

6.6 MILITARY LOW FLYING

Military pilots must conduct low level flying training so that the skill becomes second nature. Low level flying exercises are carried out by military aircraft from a number of Defence aerodromes. Routes at or below 5,000 ft AGL used by military jet aircraft for low level, high speed navigation or terrain following exercises are designated as Military Low Jet Routes (MLJR).

Routes are planned to avoid controlled airspace, civil restricted areas and danger areas, civil aerodromes by at least 5 NM laterally and 4000 ft vertically, and CTAF airspace unless aircraft are equipped with the appropriate radio frequency.

Routes and duration of MLJR operations are advised by the Notice to Airmen (NOTAM) system. This policy means that MLJRs are more flexible and new installations such as wind farms would be considered by the Australian Defence Force (ADF) when planning low level flights.

6.7 DESIGNATED AIRSPACE

Special use airspace, extending to varying heights, is defined on air navigation charts and identified as P (Prohibited), R (Restricted) or D (Danger). For safety reasons flight into this airspace may be prohibited or restricted or the airspace may be designated as a danger area to warn pilots to take additional care.

Wind turbines will not be permitted within prohibited or restricted areas as these are usually set aside for military training, weapons firing or security sensitive structures.

Danger areas will usually relate to mining or quarrying sites, chimneys or stacks with high velocity or high temperature discharges, special aviation activities such as aerobatic training and the like. While pilots may elect to avoid these areas there is no restriction on entry.

Wind turbines may not be compatible with some activities conducted within a designated Danger Area but, more importantly, CASA may elect to designate a Danger Area around a wind farm in order to alert pilots to avoid low altitude flying.

6.8 OTHER AVIATION ACTIVITIES

Special use areas for hang-gliding, parachuting or radio controlled model aircraft flying are marked by symbols on air navigation charts. Although these do not usually justify the designation of a Danger Area the symbol serves to alert pilots to over-fly these sites at a safe height. Since a wind farm shares low level airspace it could seriously curtail these types of recreational activities. Wind farms are now being indicated on charts by a symbol in the same manner.

6.9 ELECTROMAGNETIC INTERFERENCE WITH AIRBORNE RADIO

Large scale power generation activities may cause electromagnetic interference (EMI) with on-board radio communication equipment in aircraft overflying and/or flying in the vicinity of the wind farm.

The available literature indicates that this effect may be considered negligible because of the standards which apply to wind turbine construction. Wind turbines have been installed world wide with very few instances of EMI being recorded.

7.0 AERONAUTICAL RISK ASSESSMENT

Having considered the potential risks to aviation activities as outlined in **Section** 6.0 as part of an overall analysis of the proposed wind farm, the following risk assessments are detailed.

7.1 AERODROMES

The proposed Mount Emerald Wind Farm is located approximately 7 NM (13 KM) northwest of the Atherton ALA, and 5 NM (10 KM) southwest of Mareeba Aerodrome.

Each aerodrome is serviced by a Common Traffic Advisory Frequency (CTAF). Pilots are encouraged to communicate with each other on the relevant CTAF when operating within 10 NM of the Atherton ALA or Mareeba Aerodrome.

Lower level controlled airspace in the area of the proposed wind farm is well above the planned heights for the wind turbines. Airspace in the Mount Emerald region is Class G and is not controlled (i.e. not subject to Air Traffic Control clearances / separation) below 6,500 ft between 22 and 36 NM by DME from Cairns. ATC may provide a Flight Information Service (FIS) in Class G airspace if resources allow. VFR aircraft operating in Class G airspace are not required to maintain radio contact below 5,000 ft or to operate with a serviceable transponder below 10,000ft.

7.1.1 ATHERTON ALA

Atherton ALA is located approximately 2 KM east of Atherton. The ALA is owned and operated by Tablelands Regional Council and consists of a single natural surface runway. Runway 15/33 is 1,160 m long and 30 m wide. The ALA caters for light general aviation activity only.

Since the greatest extent of the OLS for any ALA is 900m, the proposed height and location of the turbine structures will not infringe the OLS for Atherton ALA.

There are no published aircraft instrument procedures for Atherton ALA.

7.1.2 MAREEBA AERODROME

Mareeba Aerodrome is a certified aerodrome owned and operated by Tablelands Regional Council. The aerodrome is located approximately 7 KM south of Mareeba and has one sealed runway. Runway 10/28 is 1,505 m long and 30 m wide.

Mareeba currently caters to general aviation and helicopter aircraft activity with many serving the mining and agricultural industries and supplying remote communities. In addition, ultra light and manned balloon operations are conducted at the aerodrome. A draft Mareeba Airport Development Plan has been produced and a $13 million upgrade is planned to improve facilities and encourage increased usage as well as promote the aerodrome to pilot training schools.

The aerodrome is currently not equipped with any radio navigation aids however the Biboohra VHF omni-directional range (VOR) is located approximately 9 NM to the north of the aerodrome.

Mareeba Aerodrome is served by non-precision VOR–A and RNAV (GNSS) aircraft instrument procedures. The minimum descent altitude for the RNAV approach to Runway 10 is 2,390 ft and the missed approach procedure requires a climbing left turn onto (340°M), away from the wind farm site. The wind farm will not affect this procedure.

The minimum descent altitude for the VOR-A approach procedure is 3,160 ft and the missed approach procedure requires a climb on 170°M to 5,800 ft. The highest terrain to the south west of Walkamin in the vicinity of the proposed site is shown as 3,681 ft above mean sea level (AMSL) approximately 9 NM south of the missed approach point for the VOR-A procedure Assuming the standard missed approach gradient of 2.5% the worst case missed approach climb would put aircraft at approximately 4,380 ft AMSL over the wind farm site. As the blade zenith of the highest WTG will be 3,869 ft AMSL the VOR-A approach procedure will be unaffected by the proposed wind farm.

The runway at Mareeba Aerodrome is currently a Code 3 non-precision runway. The critical OLS in relation to the proposed wind farm are the approach and departure surfaces which extend out from the runway strip ends and diverge away from the runway centreline. For Mareeba Aerodrome these surfaces extend out 15 KM, which is the greatest extent for any aerodrome. As a result of the runway orientation there are no proposed wind turbines under the approach and departure surface and the proposed height and location of the turbine structures will not infringe the OLS.

7.2 PRESCRIBED AIRSPACE

Cairns Airport is approximately 25 NM (47 KM) north east of the proposed wind farm site. Cairns Airport is a Commonwealth leased airport and protected by prescribed airspace. Prescribed airspace consists of OLS and Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) surfaces for the airport.

Since the greatest extent of the OLS for any aerodrome is 15 KM the proposed height and location of the turbine structures will not infringe the OLS for Cairns Airport.

The PANS-OPS surfaces for Cairns Airport lie within a 25 NM radius of the airport. The outer edge of the protection surface for the 25 NM Minimum Safe Altitude (MSA) of 6,500 ft AMSL is close to the wind farm site but the required minimum obstacle clearance will not be infringed. Other protection surfaces are distant from the wind farm site. Therefore the wind farm need not be considered in relation to prescribed airspace for Cairns Airport.

7.3 RADAR, COMMUNICATIONS, AND RADIO NAVIGATION AIDS

7.3.1 RADAR AND COMMUNICATIONS

The nearest radar is the Cairns SSR approximately 15 NM north of the proposed wind farm site on the Hann Tableland. The proposed wind farm is below the 0.5° protection surface for the radar outlined in the MOS Part 139 and should not affect its operation.

Primary radar and SSR facilities located adjacent to Cairns Airport are approximately 30 NM southeast of the proposed wind farm and therefore the wind farm will not affect the performance of radar, navigation, and communications facilities at the airport.

Additionally, the wind farm will not affect the Bellenden Kerr Communications Facilities.

It would nevertheless be prudent to confirm if Airservices Australia are concerned about possible impact on services in Class G airspace which may need to be evaluated by detailed investigation and/or modelling.

7.3.2 NAVAIDS

The Biboohra VHF omni-directional range (VOR) is located approximately 13 NM to the north of the proposed site and on that basis its intended operation will not be affected by the wind farm.

7.4 TRANSITING AIR ROUTES

7.4.1 IFR AIR ROUTES

The Atherton Tablelands Region area has spot heights of 3087, 3681 and 3156, and 3760 ft on the VNC. The maximum height of the turbine blades will be approximately 3869 ft AMSL. The only IFR air route passing over the site has a LSALT of 5700 ft and will not be physically affected by the proposed wind farm.

In regard to likely future marking and lighting requirements, the maximum recommended turbine blade zenith is 129 metres above ground level. This height is beneath the envisaged mandatory height of 150 metres AGL foreshadowed by CASA for future marking and lighting of tall structures away from aerodromes.

7.4.2 VFR AIR ROUTES

There are no published VFR routes in the vicinity of the proposed wind farm site. Aircraft approaching Cairns from the west will elect to track via the Mareeba Aerodrome and Atherton ALA approach points and avoid flying directly overhead the wind farm.

CASA has indicated in its Advisory Circular AC 139-18(0) Obstacle Marking and Lighting of Wind Turbines (see Section 5) that wind turbines are sufficiently conspicuous by day not to require painting in obstacle marking colours and/or patterns to alert VFR pilots.

As noted earlier, when flying a designated IFR route, night VFR traffic is required to fly at an appropriate cruising level above the published LSALT which, in this case, is at least 5700 ft. This height is beneath the envisaged mandatory height of 150 metres AGL foreshadowed by CASA for future marking and lighting of tall structures away from aerodromes.

The proposed wind turbines will have no impact on VFR flying activity.

7.4.3 MILITARY LOW FLYING OPERATIONS

The Department of Defence (DoD) should be informed of the wind farm proposal and any wind monitoring towers and other associated infrastructure of height. Early consultation is recommended before the planning permit application process. This will allow the Department time to undertake a formal assessment of the likely impact of the wind farm on military flying operations and on military aviation infrastructure including communications. To assess the proposal the following information will need to be provided to the DoD:

- Location map showing the wind farm land boundary, locations of WTGs and other infrastructure (i.e. wind monitoring masts, concrete batching plants, overhead wires etc.) and their orientation in relation to populated areas in the vicinity;
- WTG tower and blade dimensions; and
- WTG and associated infrastructure elevations.

The information can be forwarded to:

Brenin Presswell
Executive Officer, Land Use Planning
Estate Planning Branch - Infrastructure Division
Department of Defence
P: 02 6266 8138
F: 02 6266 8294
lpsi.directorate@defence.gov.au

RAAF Aeronautical Information Services (RAAF AIS) is informed of any structure taller than 30 m AGL prior to construction and again once construction is complete. This will enable monitoring masts, turbines, etc to be appropriately charted and help maintain safe flying. The RAAF AIS website at http://www.raafais.gov.au/ includes a form for submission of this data.

7.4.4 RESTRICTED AREAS

The proposed site is not near any restricted areas.

7.5 OTHER AVIATION ACTIVITY

7.5.1 AERIAL AGRICULTURAL OPERATIONS

It is assumed there is low or no requirement for aerial application of chemicals in the vicinity of the proposed wind farm as the proposed site is located on elevated undeveloped land. Nevertheless, it should be noted that low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding.

Studies suggest that a wake length equivalent to 6 times the rotor diameter is considered a minimum in wind conditions of 10-15 knots (18-28 km/h)[1]. When the wind turbines are operating in winds of 15 knots (28 km/h) or greater the wake from a single turbine is still prevalent at 10 blade diameters and can persist for up to 16 blade diameters downwind of the turbine. The majority of modern wind turbines reach their maximum output, and in theory, generate the strongest wake turbulence in wind speeds of approximately 47km/h. At this speed, and in combination with the wake produced by other turbines, the wake may exist up to 5km downstream from a large turbine cluster of several rows.

Agricultural aerial spreading and spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations during the periods of wind speeds at which these aircraft operate.

7.5.2 SPORT AVIATION

Symbols on navigation charts show that parachuting may occur around Mareeba.

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[1] L.J Vermeer, J.N. Sorenson, A Cresp, *Wind Turbine Wake Aerodynamics,* Progress in Airspace Sciences 39 (2003).

Hand M, Simms D, Finger L, Jager D, Coteril J, Schreck S, Larwood S *Unsteady aerodynamics experiments phase VI: Wind tunnel test configuration and available data campaigns.* Technical Report BREL/TP-500-29955, NREL (December 2001).

Wind Turbine Wakes – Control and Vortex Shedding by Davide Medici. Technical Reports from KTH Mechanics Royal Institute (2004)

These activities should not be adversely affected by the proposal as they are remote from the proposed wind farm site.

7.6 ELECTROMAGNETIC INTERFERENCE WITH AIRBORNE RADIO

Available literature indicates that this effect may be considered negligible because of the standards which apply to wind turbine construction. Wind turbines have been installed world wide with very few instances recorded of EMI affecting aircraft radio systems.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The proposed wind farm will not impact upon aircraft operations to and from Mareeba Aerodrome and the Atherton ALA. Nor will it interfere with airborne radio or navigation aid performance.

Analysis undertaken by REHBEIN Airport Consulting indicates that there will be no impact upon IFR traffic transiting the area. Traffic operating under the VFR should not be affected by the proposed wind farm as the structures will be sufficiently conspicuous by day, and en route LSALTs will provide adequate clearance from the turbines for Night VFR operations.

It would be prudent to confirm whether Airservices Australia has any concerns about the impact of the proposed wind farm upon radar and radio performance in the region although investigation undertaken by REHBEIN Airport Consulting suggests the impact, if any, will not be of operational significance. Early consultation is recommended in order to provide an opportunity for any objections to be addressed before the planning permit application process and to avoid delays during final planning. Apart from site plans and location of the proposed wind farm, Airservices Australia requires the following information to complete technical and operational assessments:

- Exact dimensions of proposed structures (turbine or wind monitoring mast).
- Maximum blade tip heights in AHD (Australian Height Datum) and above ground height for each turbine.
- The exact location including coordinates and datum for each turbine/wind monitoring mast extracted by survey:
  - Accurate Coordinates in latitude/longitude (Degrees, Minutes, Seconds)
  - Datum – WGS84 (or MGA94 can be received)
- A description of each structure to be built, including details of proposed external cladding materials, and proposed use (in this case, wind monitoring mast or wind turbine).
- Where possible, MicroStation .dgn files or AutoCAD .dwg files.

It is also advisable to provide an opportunity for the Department of Defence to comment formally during the planning permit application process as outlined in Section 7.4.3. Early consultation is recommended to provide an opportunity for any objections to be addressed before the planning permit application process begins.

A discussion with the Tablelands Regional Council is recommended to gain an understanding of their plans for development and expansion at Mareeba Aerodrome.

Low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding. However, agricultural spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations during the periods of wind speeds at which these aircraft operate.

Aviation legislation does not require Transfield to consult with land owners in the vicinity of the proposed wind farm in regard to its likely impact on the conduct of aerial agricultural operations. However, Transfield may wish to initiate this consultation during early planning to determine the extent of reliance on agricultural aviation for seeding, spreading or weed control in the area and if any impact could be expected.

CASA currently allows fixed structures up to 110 m AGL without marking, lighting or advice to the aviation industry. These structures could be located anywhere and be any shape, size, colour or number. In this instance Transfield Services Pty Ltd proposes structures that are substantially higher at 129 metres above ground level, concentrated in a defined area, conspicuous because of their shape and colour and unlikely, on the basis of this preliminary investigation, to pose a hazard to aviation. In this case, apart from aerial agricultural operations over the wind farm the risk to civil aviation activities if any that this wind farm may pose is trivial.

However, as with any reported tall structure that may pose a risk, regardless of its triviality, the position of the proposed wind farm should be shown on appropriate air navigation charts to assist pilots operating in the region. Additionally, medium intensity hazard lighting in accordance with MOS 139, Chapter 9, Section 9.4 should be installed on sufficient turbines in the Mount Emerald Wind Farm to define the extremities of the site. Where clusters are widely separated this may entail lighting the turbine at the end of each cluster and one at or near the centre so clusters are well defined from the air. A detailed lighting plan should be submitted to CASA for comment. The lighting should be operated in a manner consistent with a general duty of care towards aviation, such as during the period 1 hour before sunset to 1 hour after sunrise, and during conditions of reduced visibility caused by smoke, dust or haze.

The foregoing recommendation concerning lighting is made pending rulemaking action by CASA concerning man-made objects located away from aerodromes. In regard to objects that are deemed to be obstacles outside the obstacle limitation surfaces of an aerodrome, CASA has foreshadowed an increase in the height of such objects from 110 metres to 150 metres above ground level. Objects 150 metres or more above ground level will require obstacle lighting unless an aeronautical study can show that an object will not be an obstacle. Objects not exceeding 150 metres in height may require some lighting to discharge duty of care obligations to aviation operators

Revisions to associated guidance material are likely to include reissue of CASA Advisory Circular AC139-18(0), *Obstacle Marking and Lighting of Wind Farms* updated to incorporate advice on providing obstacle lighting for structures 150 metres or more above ground level.

9.0 SOURCES OF INFORMATION

Aircraft Owners and Pilots Association, Airfields 2008/09

Airservices Australia, Aeronautical Information Publication – Departure and Approach Procedures, Amendment 127, 02 June 2011

Airservices Australia, Aeronautical Information Publication – Enroute Supplement Australia, 02 June 2011

Airservices Australia, Designated Airspace Handbook, 02 June 2011

Airservices Australia, Visual Terminal Chart – Cairns 02 June 2011

Airservices Australia, En Route Chart (ERC) Low – L4 Brisbane/Townsville, 02 June 2011

Airservices Australia, En Route Chart (ERC) High – L4 Brisbane/Townsville, 02 June 2011

Airservices Australia, World Aeronautical Chart (WAC) – Townsville (3219), 02 June 2011

Airservices Australia, Terminal Area Chart (TAC) – TAC-1 Cairns/Brisbane/Townsville, 02 June 2011

CASA Advisory Circular AC139-18(0) (Draft), 21 June 2004

CASA Manual of Standards, Part 139 – Aerodromes, Version 1.5 May 2010

CASA Visual Flight Rules Guide, 24 September 2010

Civil Aviation Safety Regulation 139

Defence (Areas Control) Regulations

Wind Energy, Defence and Civil Aviation Interests Working Group, (UK) Wind Energy and Aviation Interests - Interim Guidelines, 2002

10.0 ABBREVIATIONS

AC	Advisory Circular
AGL	Above Ground Level
AIP-DAP	Aeronautical Information Publication – Departure and Approach Procedures
AIP-ERSA	Aeronautical Information Publication – En route Supplement Australia
AIS	Aeronautical Information Service
AMSL	Above Mean Sea Level
R-AOS	Rehbein AOS Airport Consulting
ATC	Air Traffic Control
CAR	Civil Aviation Regulations
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
CTAF	Common Traffic Advisory Frequency
CTR	Control Zone
DoD	Department of Defence
EMI	Electromagnetic Interference
IFR	Instrument Flight Rules
LSALT	Lowest Safe Altitude
M	Magnetic
MLJR	Military Low Jet Routes
MOS	Manual of Standards
Navaids	Navigation aids
NDB	Non Directional Beacon
NM	Nautical Miles
NOTAM	Notice to Airmen
OCTA	Outside Controlled Airspace
OLS	Obstacle Limitation Surfaces
PANS-OPS	Procedures for Air Navigation Services – Aircraft Operations
RF	Radio Frequency
RIS	Radar / ADS-B Information Service
RPT	Regular Public Transport
RSR	Route Surveillance Radar

SSR	Secondary Surveillance Radar
TAR	Terminal Area Radar
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VNC	Visual Navigation Chart
VOR	VHF Omni Directional Radio Range

11.0 GLOSSARY OF TERMS

Advisory Circular (AC): Advisory documents issued by CASA suggesting preferred methods for complying with the CASR. The advice contained in the AC is meant to be read in conjunction with the CASR and Manual of Standards.

Aeronautical Information Publication (AIP): A publication issued by or with the authority of a State and containing aeronautical information of a lasting nature essential to air navigation. The AIP for Australia and its Territories is published under Section 8 of the *Air Services Act 1995.*

Aeronautical Information Service (AIS): A service provided by AA to collect, collate, edit and publish aeronautical information.

Air route: The navigable airspace between two points and the terrain beneath such airspace identified, to the extent necessary, for application of flight rules.

Air traffic control (ATC): A service established by Airservices Australia pursuant to section 8 of the *Air Services Act 1995*. ATC functions are chiefly to prevent collisions between aircraft (and on the manoeuvring area, between aircraft and obstructions), and to expedite and maintain an orderly flow of air traffic.

Civil Aviation Advisory Publication (CAAP): Advisory documents issued by CASA suggesting preferred methods for complying with the CAR and CASR. The advice contained in the CAAP is meant to be read in conjunction with the CAR, CASR and Manual of Standards.

Civil Aviation Regulations (CAR): Regulations made by the Governor-General under the *Civil Aviation Act 1988*.

Civil Aviation Safety Regulations (CASR): Regulations made by the Governor-General under the *Civil Aviation Act 1988*.

Common traffic advisory frequency (CTAF): A frequency for pilots to exchange traffic information while operating to or from an airport without an operating control tower, or within a designated area.

Controlled airspace: Airspace of defined dimensions within which ATC service is provided to controlled flights. A control area or control zone.

Danger area: An airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times.

Departure and approach procedures (DAP): An aeronautical information publication (AIP-DAP) which contains aerodrome/landing charts, instrument approach and landing procedures, standard instrument departures, DME or GPS arrivals and noise abatement procedures.

En route Supplement Australia (ERSA): This AIP supplement (AIP-ERSA) is a joint military/civil publication containing the aerodrome and facility directory for military aerodromes and civil public aerodromes. ERSA contains aerodrome diagrams (ADDGM) and other information such as physical characteristics, visual ground aids, aeronautical lights, MBZ and CTAF boundaries.

General aviation (GA): All civil aviation operations other than RPT operations.

IFR operation: An operation conducted in accordance with the Instrument Flight Rules prescribed in Part XII of the Civil Aviation Regulations. These operations (landings and take-offs at an airport) are made in periods of inclement weather and poor visibility and under these conditions, positive control on approach and climb-out is maintained by the use of electronic navigational aids.

Instrument approach procedure: A series of pre-determined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route, to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route clearance criteria apply. The approved procedure to be followed by aircraft in letting down from cruising level and landing at an aerodrome.

Instrument flight rules (IFR): A set of rules, as outlined in Part XII of the CAR, governing the conduct of flight under instrument meteorological conditions (IMC). See also "IFR operation".

Instrument meteorological conditions (IMC): Meteorological conditions expressed in terms of visibility, distance from cloud and ceiling less than minima specified for visual meteorological conditions (VMC).

Lowest safe altitude (LSALT): The lowest altitude that will provide safe terrain clearance at a given place.

Nautical mile (NM): A length of 1 852 metres.

Navigation aid: A ground based or airborne facility or equipment relying primarily on the transmission/reception of radio or radar signals to provide information used to determine the location of an aircraft. Navaids are designed to be used either for en-route navigation or to assist in approach and landing in reduced visibility conditions.

Non-directional beacon (NDB): A ground radio station emitting continuous signals and providing an omni-directional radiating pattern which is used in conjunction with airborne ADF equipment to provide directional guidance to aircraft.

Notice To Airmen (NOTAM): A notice containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to persons concerned with flight operations. NOTAM are published under Section 8 of the *Air Services Act 1995*.

Obstacles: All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft, or which extend above a defined surface intended to protect aircraft in flight. See also "obstacle limitation surfaces (OLS)".

Obstacle lights: Lights mounted on or adjacent to obstacles or potential hazards to aircraft moving on the ground or in the navigable airspace, for the purpose of indicating the obstructions or hazards by night.

Obstacle limitation surfaces (OLS): A series of planes associated with each runway of an airport, or the airport itself, which define the desirable limits to which objects may project into the airspace around the airport. Objects penetrating an OLS are defined as obstacles and may need to be marked and/or lit in accordance with CASA requirements.

PANS-OPS criteria: Specifications in ICAO *Procedures for Air Navigation Services —Aircraft Operations* (Doc 8168, PANS-OPS) for obstacle assessment or identification and allowances for minimum obstacle clearance used in the design of each stage of an instrument departure or approach procedure.

Primary radar: A radar system which uses reflected radio signals.

Prohibited area: An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is prohibited.

Radar: A radio detection device which provides information on range, azimuth and/or elevation of objects.

Regular public transport (RPT): The transport of persons generally, or cargo for persons generally, for hire or reward in accordance with fixed schedules and to and from fixed terminals over specific routes.

Restricted area: airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions.

Route: A way to be taken in flying from a departure to a destination airport, specified in terms of track and distance for each route segment.

Route surveillance radar (RSR): long range radar which is used for en route surveillance by ATC personnel.

Secondary surveillance radar (SSR): A system of secondary radar using ground transmitters/receivers (interrogators) and airborne transponders.

Terminal area radar (TAR): High definition radar used for air traffic control purposes in the terminal area.

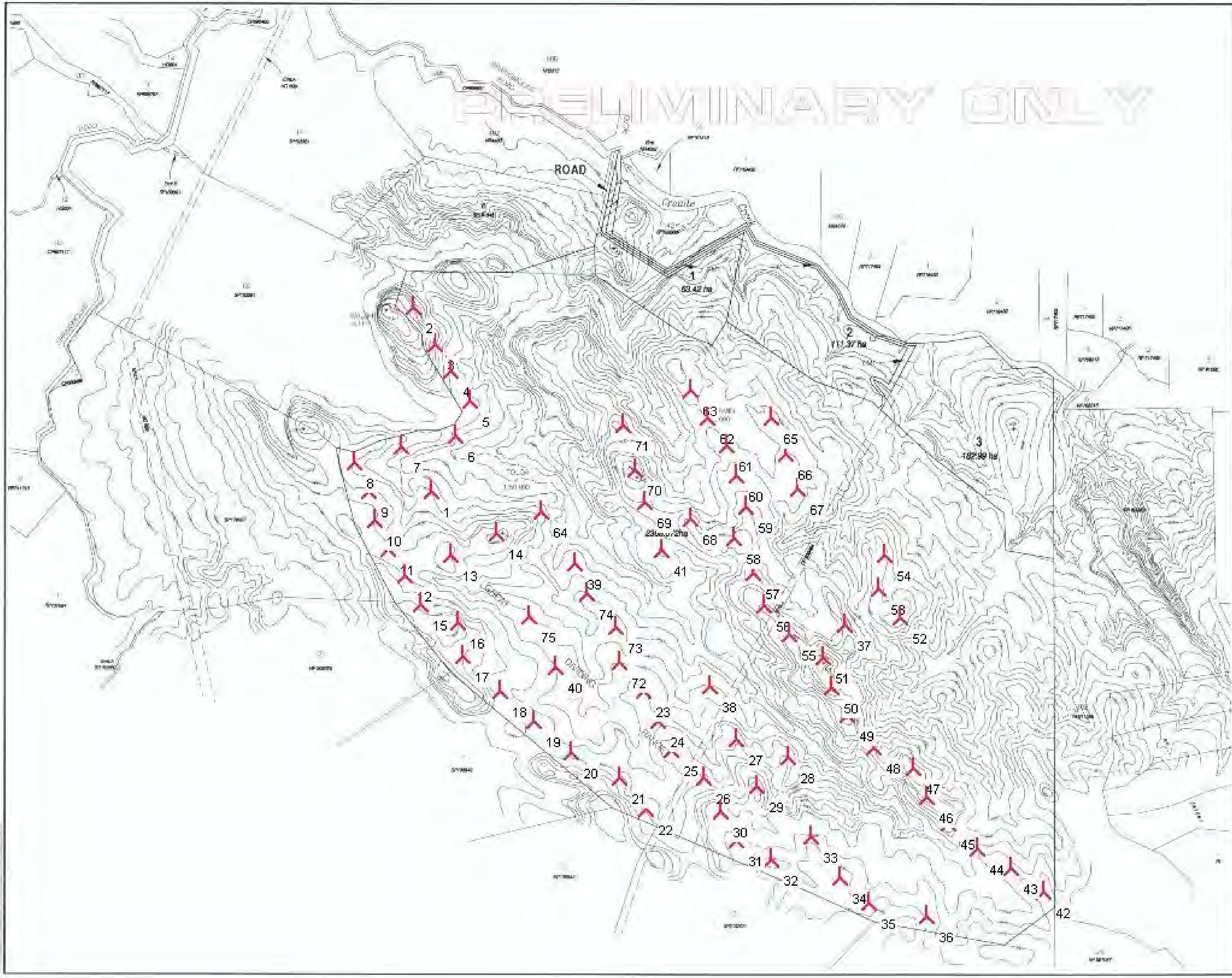
VHF omni-directional radio range (VOR): A VHF radio navigation aid which provides a continuous indication of bearing from the selected VOR ground station. It provides 360 degree radial tracks to the beacon corresponding to the points of the magnetic compass and which may selected at one degree intervals by the pilot.

Visual flight rules (VFR): Rules of flight to permit operations on a see and be seen basis in visual meteorological conditions (VMC). These rules are prescribed in Part XII of the CAR.

Airport Consulting

APPENDIX A

SITE LAYOUT



CONICS
DESIGN - PLANNING - SURVEYING
ECONOMICS - ADVISORY

PORT BAJOOL PTY LTD

PROPOSED RECONFIGURATION
LOT 7 ON SP181543
Parish of CULGAR
County of HODGKINSON

1:15000		62956-3	B

A1

REHBEIN Airport Consulting

APPENDIX B

WIND TURBINE SITE ELEVATIONS

WIND TURBINE SITE	EASTING	NORTHING	SITE ELEVATION AHD (m)	TURBINE ELEVATION AHD (m)
1	325809	8102197	817.8	946.8
2	325803	8103785	881.1	1010.1
3	325956	8103457	850.3	979.3
4	326073	8103207	803.7	932.7
5	326217	8102937	796.9	925.9
6	326064	8102645	787.7	916.7
7	325581	8102596	804.8	933.8
8	325167	8102500	822.8	951.8
9	325263	8102243	834.1	963.1
10	325299	8101986	839.7	968.7
11	325387	8101730	845	974.0
12	325507	8101485	856.1	985.1
13	325916	8101631	851.4	980.4
14	326327	8101782	854.7	983.7
15	325617	8101231	870	999.0
16	325929	8101048	892.7	1021.7
17	325934	8100748	871.7	1000.7
18	326232	8100427	850.2	979.2
19	326493	8100143	845.1	974.1
20	326789	8099837	847.8	976.8
21	327190	8099583	869.3	998.3
22	327386	8099294	860.4	989.4
23	327471	8100310	831.5	960.5
24	327570	8100046	837.2	966.2
25	327652	8099781	855	984.0
26	327915	8099518	858.8	987.8
27	328230	8099829	848.3	977.3
28	328656	8099631	851	980.0
29	328367	8099407	902.9	1031.9
30	328029	8099220	925.8	1054.8
31	328146	8098962	971	1100.0
32	328425	8098766	1011.6	1140.6
33	328786	8098927	974.3	1103.3
34	329002	8098559	1050.5	1179.5
35	329234	8098320	1012.8	1141.8
36	329717	8098155	999.6	1128.6
37	329260	8100722	860	989.0
38	328046	8100298	815.6	944.6
39	326981	8101460	789.7	918.7
40	326734	8100584	831.3	960.3
41	327737	8101507	810.7	939.7
42	330749	8098278	978.6	1107.6
43	330489	8098504	949	1078.0
44	330207	8098696	886.8	1015.8
45	329988	8098935	869.7	998.7

WIND TURBINE SITE	EASTING	NORTHING	SITE ELEVATION AHD (m)	TURBINE ELEVATION AHD (m)
46	329823	8099182	893.9	1022.9
47	329729	8099441	923	1052.0
48	329404	8099649	855.9	984.9
49	329203	8099946	902.3	1031.3
50	329091	8100198	926.1	1055.1
51	329040	8100460	932	1061.0
52	329738	8100745	842.7	971.7
53	329581	8101006	810	939.0
54	329659	8101299	814.6	943.6
55	328773	8100681	885.4	1014.4
56	328578	8100955	874.8	1003.8
57	328506	8101239	846.8	975.8
58	328368	8101559	840	969.0
59	328507	8101817	824.8	953.8
60	328450	8102087	818.2	947.2
61	328384	8102361	806.3	935.3
62	328250	8102610	799.4	928.4
63	328123	8102866	813.6	942.6
64	326730	8101936	812.6	941.6
65	328792	8102560	825	954.0
66	328891	8102237	812.2	941.2
67	328964	8101930	807.8	936.8
68	328019	8101756	835.5	964.5
69	327636	8101937	817.9	946.9
70	327578	8102225	841.7	970.7
71	327508	8102611	809.8	938.8
72	327279	8100581	821.7	950.7
73	327284	8100882	806.8	935.8
74	327063	8101191	801.4	930.4
75	326543	8101038	823.5	952.5

Appendix 28

Mount Emerald Wind Farm – Electromagnetic Interference Assessment

Prepared by Parsons Brinckerhoff Australia

Mount Emerald Wind Farm - Electromagnetic Interference Assessment

28 July 2011

Transfield Services Pty Ltd

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Revision	Details	Date	Amended By
00	Original	28 July 2011	We-Ki Chua

Author: We-Ki Chua ....

Signed: ....

Reviewer: Ross Cooper, Ben Inkster..

Signed: ....

Approved by: Taraz Saba...

Signed: ....

Date: 28 July 2011 ....

Distribution: Transfield, PB Library...

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Our reference 2161336A-REP-001

28 July 2011

Terry Johannesen
Transfield Services
Level 13, 90 Albert Street
Brisbane
QLD 4000

Dear Terry

Mount Emerald Wind Farm - Electromagnetic Interference Assessment

Please find attached the draft report for the Mount Emerald Wind Farm Electromagnetic Interference Assessment using the 75 WTG, Enercon E-82 layout you have provided.

Please do not hesitate to contact me should you have any questions or wish to discuss this.

Yours sincerely

We-Ki Chua
Wind Engineer
Parsons Brinckerhoff Australia Pty Limited

Contents

Appendices

Parsons Brinckerhoff Australia Pty Limited

ABN 80 078 004 798

Glossary

ACMA	Australian Communications and Media Authority
AM	Amplitude Modulation
Transfield	Transfield Corporation Pty Ltd
MEWF	Mount Emerald Wind Farm
EMI	Electromagnetic Interference
FM	Frequency Modulation
GIS	Geographic Information System
OD	Omnidirectional (in relation to an antenna radiation pattern)
RADCOM	ACMA Registry of Licensed Radio Communicators
RF	Radio Frequency
TV	Television
UHF	Ultra High Frequency
VHF	Very High Frequency
SHF	Super High Frequency

Parsons Brinckerhoff Australia Pty Limited

ABN 80 078 004 798

Executive summary

As part of the development of the Mount Emerald Wind Farm, Transfield Services Australia (Transfield) engaged Parsons Brinckerhoff (PB) to investigate the potential impact of the wind farm to radio communication services in the area. The scope of the assessment was to consider potential impacts to registered point-to-point services, point-to-multipoint services and broadcast.

For this investigation, PB identified existing radio communication sites and services and their associated paths. This data was obtained from the Australian Communication and Media Authority's database of registered radio communication licenses (RADCOM).

28 radio communication sites were found within a 10 km distance of the wind farm boundary, with an associated 222 registered assignments. This data was mapped against the proposed wind farm layout, provided by Transfield. Communication towers and service paths that were within three kilometres of the wind farm were selected for further investigation. To this selected data, standard exclusion zones were calculated and the wind farm was assessed considering these zones. No turbines were assessed to intrude on near field exclusion zones surrounding the identified radio towers.

At the time of writing of this report, PB is attempting to contact all potentially impacted licensees that operate services within three kilometres of the wind farm boundary and notify them of the proposed development. These licensees are being consulted to verify the correctness of the data in the RADCOM database and ascertain their position on the proposed wind farm development. A number of items were identified for clarification with licensees including the operational status and tower coordinates.

PB recommends that, to avoid obstruction interference, no turbines intrude on the calculated 2nd Fresnel zone for point-to-point radio links. PB suggests if the consulted licensees verify the RADCOM data is correct and there is agreement over radio path and tower setback distances, Transfield investigates mitigation options to avoid any interference. PB has determined that one turbine is located 4 m away from a 2nd Fresnel exclusion zone, presenting the possibility of the turbine encroaching on the exclusion zone depending on the orientation of the rotor. PB is in the process of seeking more precise coordinates from the relevant telecommunications tower operators/licensees.

As per the assessment scope, reflection and scattering impacts were not calculated. It is recommended that these are calculated, if required, following receipt of any special requirements of the identified licensees.

PB believes point-to-multipoint impacts should be minimal. However, PB recommends the position of registered point-to-multipoint license holders is sought with respect to the wind farm development. PB has initiated consultation with these license holders that are located within 3 km of the wind farm.

1. Introduction

Transfield Services Pty Ltd (Transfield) is developing the Mount Emerald Wind Farm (MEWF) in Queensland, in between the towns of Atherton and Mareeba (see Figure 1). Transfield has advised that the wind farm consists of 75 Enercon E82 wind turbines – a 2.3 MW machine with an 82 m rotor diameter.

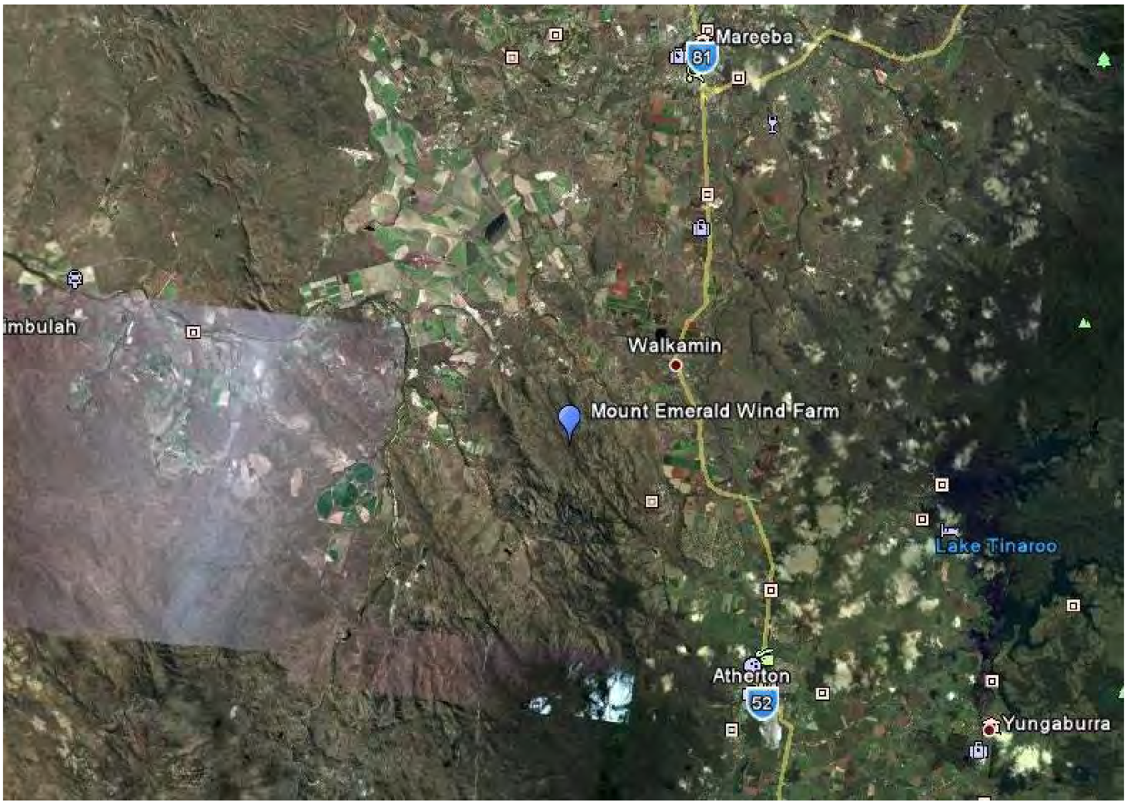


Figure 1: Location of Mount Emerald Wind Farm relative to local population centres (source: Google Earth)

As part of the site development, Transfield requested PB undertake an assessment of potential impacts to radio telecommunication services in the area. The scope of the investigation included the following:

1. *Identifying existing radio communication services and the related communication paths near to the wind farm site.*
2. *Determining high risk issues and constraints posed by the presence and operation of identified communications services with respect to the MEWF layout.*
3. *Initial contact with potentially impacted communications licensees.*
4. *Provide recommendations on any further steps to be taken to mitigate telecommunication impact risks.*

This report documents the undertaking of this scope.

GIS data has been supplied to Transfield for their own use. This data includes the radio towers, paths and exclusion zones derived in this assessment.

2. Wind farms and electromagnetic interference

Communication systems using radio waves are heavily utilised in Australia. Mobile phones, television, commercial radio, land mobile radio and emergency radio are common examples of systems that rely on radio communication. These systems generally use radio towers to help transmit and receive signals across a wide area. In the context of wind farm development, electromagnetic interference is the impact of a wind farm on radio communication services resulting in an unacceptable detrimental effect to the radio communication service. Radar services (civil and weather) can potentially be impacted by wind farms as well.

The objective in considering electromagnetic interference during the wind farm development stage is to mitigate potential impacts caused by locating wind turbines in the vicinity of radio communication services.

2.1 Types of impacts

The different effects wind farms can have on communication services are summarised below.

- *Near field impact*
  A property of a transmitting and/or receiving antenna is a "near field" zone that is present around the antenna. Any object that can conduct or absorb radio waves, placed within the near field zone, can alter the behaviour of the antenna.

- *Obstruction impact*
  If an conductive object is placed within the advancing wavefront of a radio wave, wave energy can be absorbed, detrimentally affecting the signal detected at the receiver.

- *Reflection and scattering impacts*
  If an object that's reflective to radio waves exists in the advancing wavefront, it may reflect energy away. The reflected signal may be reflected to the transmitting or receiving antenna which can interfere with the desired signal.

- *Electromagnetic fields / RF interference*
  The operation of a wind turbine generator, and associated electrical transmission infrastructure, creates an electromagnetic emission that can, theoretically, interact with radio communication.

2.1.1 Characterising impact with exclusion zones

In many cases, impacts can be sufficiently characterised and mitigated using calculated "exclusion zones" and ensuring these zones are free from wind turbines. In other cases, such as when exclusion zones are not feasible to calculate or not appropriate for the communication service, other options are available. Details of the calculated exclusion zones are given below.

- *Near field impact*
  Recommendations for determining exclusion zones to mitigate near field impacts are

given by Bacon (2002). Exclusion zones for the MEWF site have been calculated using this method and are discussed in Section 4.2. In many cases, these exclusion zones are very small. However, PB recommends a minimum standard 500 m radio tower exclusion zone as a precautionary measure for any reflection and scattering impacts that may be produced. In general, this is easily achievable and has been achieved at MEWF.

- *Obstruction impact*
  Recommendations for determining exclusion zones to mitigate obstruction are given by Bacon (2002). Exclusion zones have been calculated at MEWF using this method (2^{nd} Fresnel zone method) and are discussed in Section 4.3.

- *Reflection and scattering impacts*
  The accepted methods for calculating these impacts generally require information on signal performance requirements specific to each service and client. Additionally, impact calculations from this effect require complex modelling to determine. PB has consulted the licensees with services that would be susceptible to these impacts to determine their position regarding the development. The scope of this assessment does not include the calculation of reflection / scattering impacts. The recommendations for considering these impacts are given in Section 3.1.

- *Electromagnetic emissions / RF interference*
  These effects are not considered in this assessment. Providing appropriate standards and guidelines are observed in the wind turbine and balance of plant design, these electromagnetic fields are not expected to cause impacts that are relevant to this assessment. PB's scope does not include assessing this type of interference.

The possible wind farm electromagnetic impacts have only been briefly discussed. See the supplied references (Section 6) for further information.

2.2 Relevant categories of radio communication services

In assessing radio communication impact by wind farms, radio systems are commonly broken into a number of different categories based on type. For the purposes of electromagnetic impact investigation, the following categories of services are considered: point-to-point, point-to-multipoint, and radar.

- *Point-to-point*
  Radio links that transmit and receive between two fixed points fall under this category. For example, network backhaul commonly utilises point-to-point communication.

- *Point-to-multipoint*
  A central location transmits to, and sometimes receives from, a number independent of locations. Television and radio broadcasting and reception, mobile phones (to the cell site mast) and land mobile systems fall under this category.

- *Radar*
  Radar transmits a signal which is reflected back to the transmitting station (some systems involve communication between a radar station and a transponder). Services that utilise radar technology include aircraft detection and weather services.

Point-to-point and point-to-multipoint impacts are considered separately in this assessment. Radar impacts are not part of the scope of this assessment; however PB suggests Transfield consults with the following radar operators (PB can provide further assistance with this consultation) to determine their position on the MEWF development:

- Department of Defence
- Air Services Australia
- Bureau of Meteorology

2.3 Impacts and mitigation

The objectives of investigating wind farm electromagnetic interference is to identify potential electromagnetic impacts based on the information available, and also to reach agreement with impacted radio licensees. This is so the design of the wind farm, including any impact mitigation strategies, will allow the wind farm to coexist with the present radio services.

This is achieved using a variety of methods, depending on the radio service category in question.

- *Point-to-point*
  Abide by calculated and recommended minimum exclusion zones.

  Consult with relevant licensees that may be affected by the wind farm development.

- *Point-to-multipoint*
  Abide by calculated and recommended minimum near-field exclusion zones from the base station radio tower.

  Consult with relevant, registered point-to-multipoint licensees that may be affected by the wind farm development. Users of radio equipment under a Class C license will not be present in the ACMA database and therefore cannot be assessed. It is believed the potential impact to these users will be low, however, PB recommends Transfield includes discussion of EMI impacts with these users in their community consultation process.

Generally, mitigation of radio impacts involves manipulation of the turbine layout so that impacts are acceptably controlled. However, the wind farm proponent’s considerations may make other options feasible (providing there is agreement amongst the relevant parties). The Draft National Wind Farm Development Guidelines (see Section 6 for reference) provides the following hierarchy of mitigation options (in order of most preferable to least preferable):

1. Re-location / removal of turbines
2. Replacement of existing radio communications service equipment with another less affected type (e.g., replace UHF link with microwave link; replace analogue TV with digital TV)
3. Re-location of radio communications services to another existing radio communications site
4. Re-location of radio communications services to a new telecommunications site

5. Substitute radio communication for underground or overhead optical fibre
6. Enhance radar filters

2.4 Construction, maintenance and decommissioning

It is recommended that the exclusion zones, that are established and applied to the final layout be respected during construction, maintenance and decommissioning. These exclusion zones should be agreed upon by the license holders and the wind farm proponent, Crane booms and the raising and lowering of turbine parts may cause interference. It is recommended that management plans for these activities include these considerations.

3. Methodology

Based on a number of existing guidelines (see Section 6), and considering PB's knowledge of the MEWF status, PB has taken the course outlined below.

1. Identify any registered, licensed radio communication sites and services within a 10 km distance from the wind farm boundary

2. Investigate sites and services within a 5 km distance from the wind farm boundary, determine near-field and obstruction exclusion zones using standard methods

3. Assess the wind farm layout against the exclusion zones calculated in step 2

4. Identify local commercial broadcasting stations and their location relative to the wind farm and assess potential shadow zones

5. For point-to-multipoint (including broadcast) services, determine potential zones of signal shadowing

6. Contact any registered and licensed radio communication site (and service) clients within a 3 km distance from the wind farm boundary notifying them of the proposed development and request their impact mitigation requests (if applicable)

3.1 Reflection and scattering impacts

These impacts were not determined as part of this assessment. PB generally suggests these impacts are calculated, if required, following the receipt of any specific requirements from the potentially impacted radio stakeholders.

3.2 Australian Communications and Media Authority

The Australian Communications and Media Authority (ACMA) is the Australian government body that regulates the use of Australia's radio spectrum. They maintain a register of radio licenses, radio communication towers and radio services (RADCOM).

PB utilised the ACMA issued RADCOM CD dated 1/07/2011 to conduct the assessment.

ACMA also maintains a register of licensed commercial broadcasters which was accessed via the ACMA webpage[1].

The ACMA RADCOM database has been known to contain inaccurate information. Additionally, the precision of some tower location measurements can be considered low for the purposes of this assessment. As part of the consultation process, PB is requesting verification of the ACMA information relevant to each of the contacted stakeholders (see Section 5).

[1] *http://www.acma.gov.au/WEB/STANDARD/pc=PC_9150; accessed 18/07/2011*

3.3 Inputs to assessment

PB received a turbine layout from Transfield for the MEWF. This layout is shown in Figure 2, and supplied in Appendix A. Transfield also advised that the turbine expected to be used is the Enercon E82. This turbine is noted to have an 82 m rotor diameter or alternatively a 41 m rotor radius.

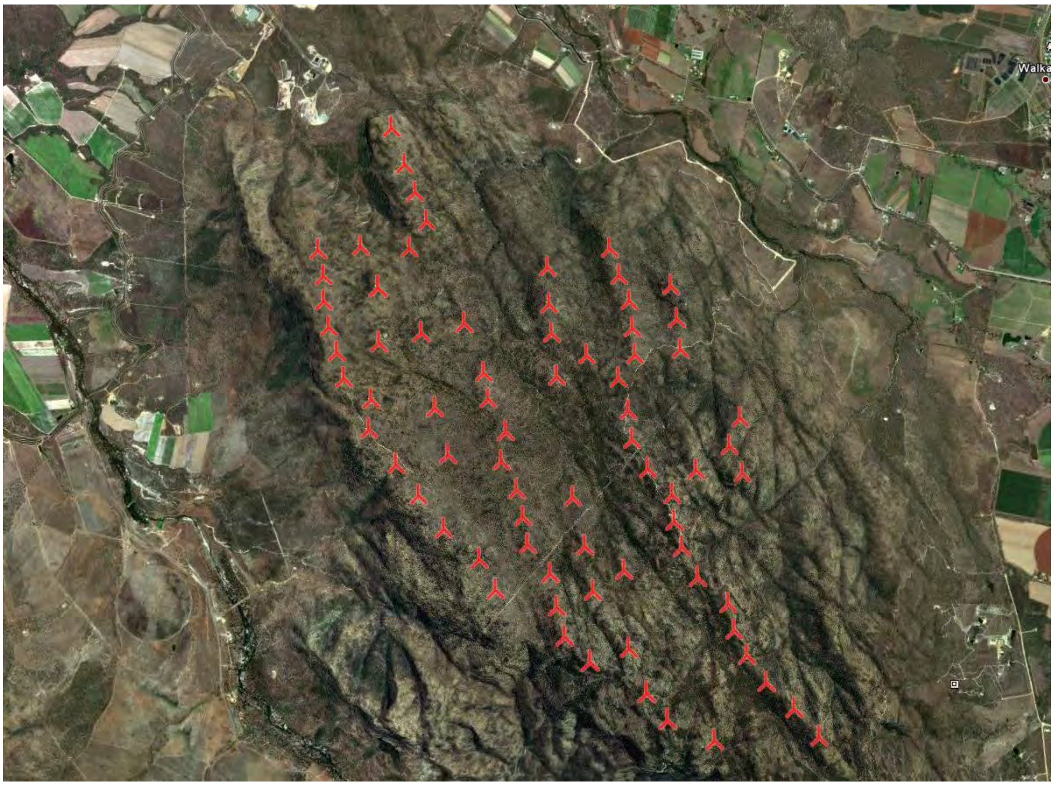


Figure 2: Mount Emerald Wind Farm layout

4. Assessment results

4.1 Assignment search

A search of the RADCOM database was conducted using a defined search area of 10 km from the wind farm boundary. Ten sites were found within the defined search area, bound in blue as shown in Figure 3. A total of 28 sites are associated with assignments that intersect the 10km search area. Details of these sites can be found in Appendix B.

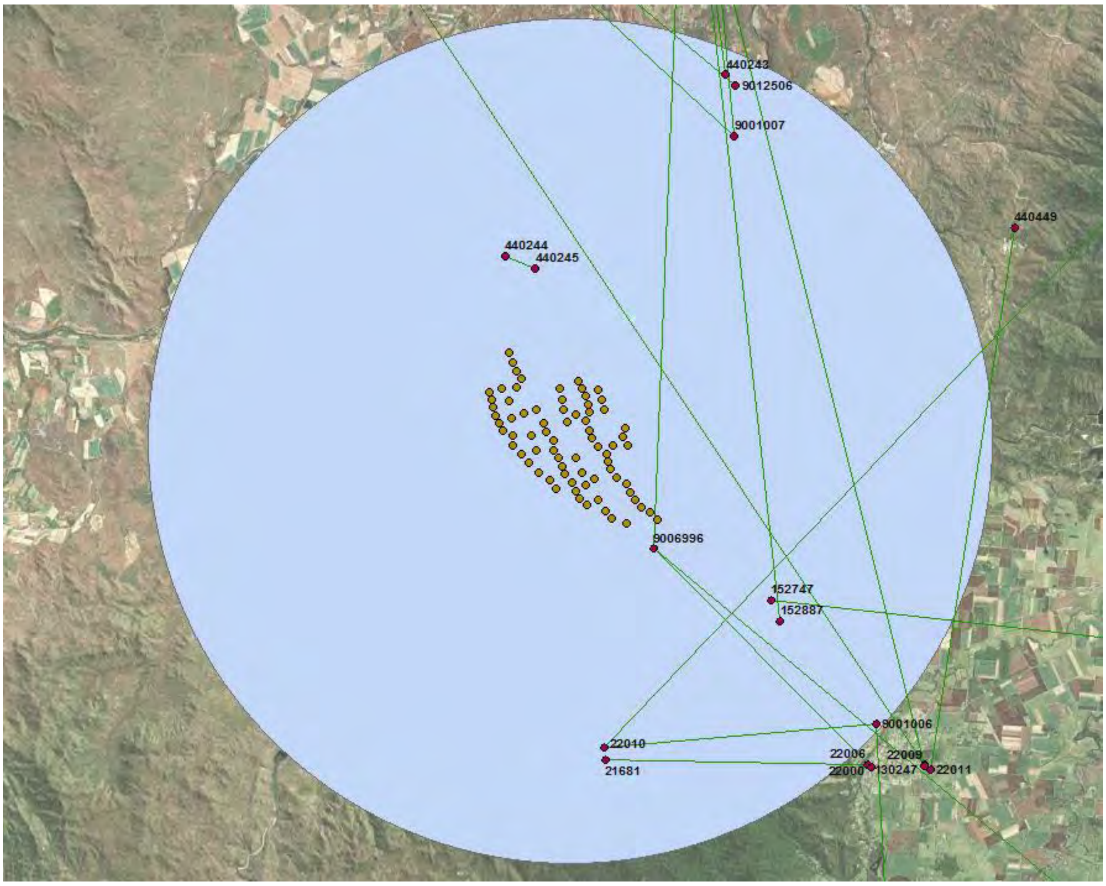


Figure 3: MEWF (yellow) and surrounding radio sites (maroon)

Associated with these 28 sites were 222 registered assignments. These sites and assignments were mapped to determine those radio communication services that were proximal to the wind farm site. Within this mapped dataset, PB identified all sites and assignments within a 5 km radius of the wind farm boundary, with the sites shown in Figure 4. PB has also identified all links (including towers further than 10 km away) that intercept the 5 km radius of the wind farm boundary. An analysis of these sites and assignments is given below.

Table 1: Sites within a 5km radius of the MEWF boundary (coordinates AGD66 Zone 55)

Site ID	Easting	Northing	Site Name	Distance to nearest turbine
				m
440244	325680	8106990	Lotus Glen Prison via MAREEBA	3214
440245	326680	8106600	Lotus Glen Prison Farm via MAREEBA	2955
9006996	330611	8097300	Council Site 8 km WNW of Tolga (off Kennedy Highway) MT EMERALD	981
152747	334500	8095600	Broadcast Site Bones Knob TOLGA	4606

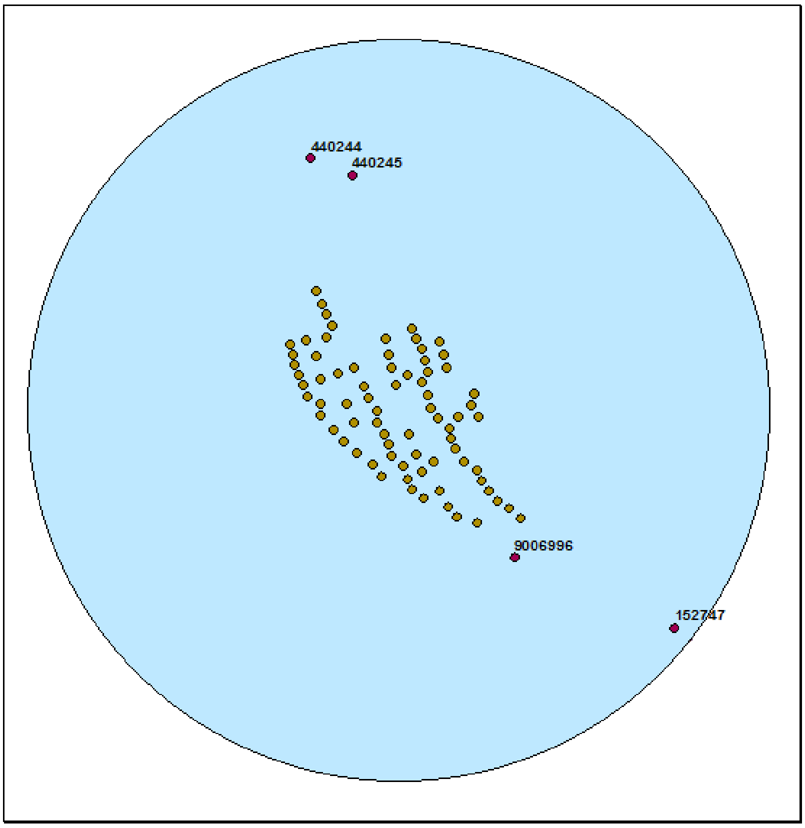


Figure 4: Sites within a 5km radius of the MEWF boundary

As part of PB's consultation work, it has specifically requested confirmation of the coordinates of these towers from the licensee to gain a greater degree of accuracy.

4.1.1 Site ID 440244 – Lotus Glen Prison via MAREEBA

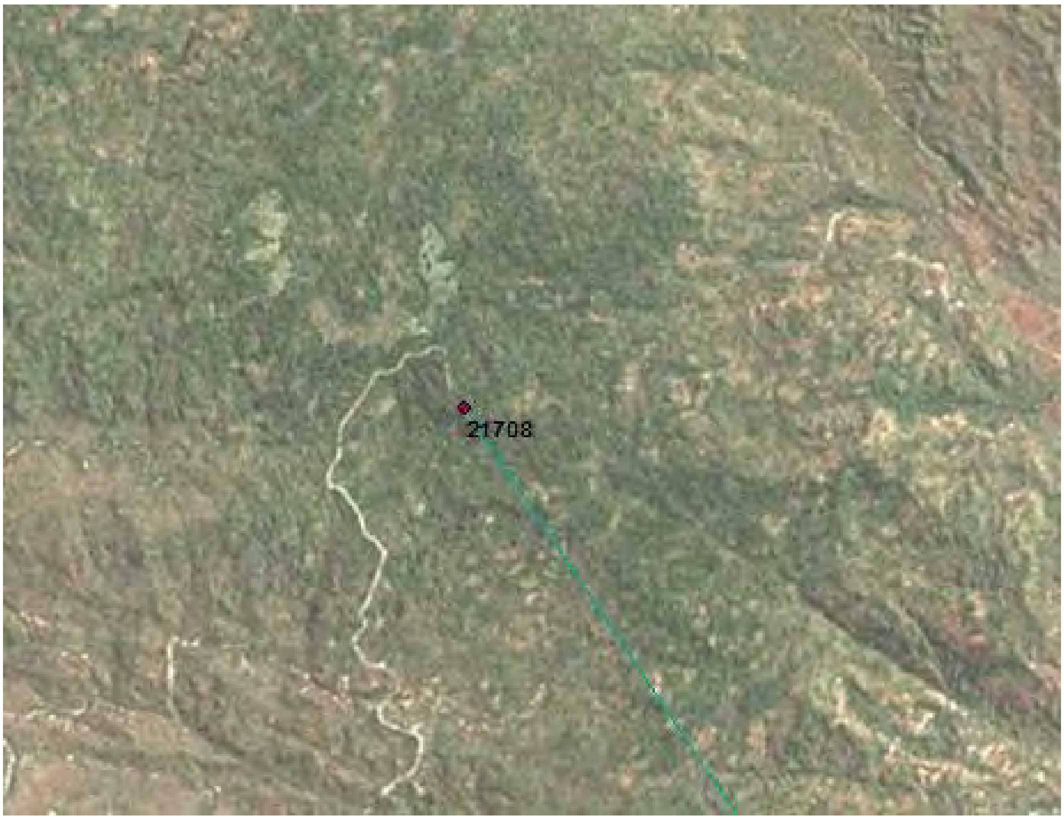
Figure 5: Lotus Glen Prison via MAREEBA and associated radio paths

- **111 degrees**
  There are two assignments directed in the 111 degree bearing and are operated by the Queensland Corrective Services Commission. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.2 Site ID 440245 – Lotus Glen Prison Farm via MAREEBA

- **291 degrees**
  There are two assignments directed in the 291 degree bearing and are operated by the Queensland Corrective Services Commission. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.3 Site ID 21708 – QAS Site HANN TABLELAND



- **146 degrees**
  There are two assignments directed in the 146 degree bearing and are operated by the Department of Community Safety. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.4 Site ID 441034 – 2 Middlemiss Street MAREEBA

- **163 degrees**
  There is an assignment directed in the 163 degree bearing and is operated by Coastal Broadcasters Pty Ltd. The tower and its associated assignment are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.5 Site ID 130248 - Optus/Vodafone Site Water Tower Basalt Street MAREEBA

- **165 degrees**
  There are two assignments directed in the 165 degree bearing operated by Vodafone Australia Pty Ltd. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.6 Site ID 440803 – 65 Rankine Street MAREEBA

- **182 degrees**
  There are two assignments directed in the 182 degree bearing operated by Tablelands Regional Council. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.7 Site ID 20804 – Miles Site LAMBS HEAD

- **223 degrees**
  There are two assignments directed in the 223 degree bearing operated by the Department of Community Safety (Queensland Fire and Rescue Service). The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.8 Site ID 21158 - Radio Terminal 38 km SSE of Cairns MT BELLENDEN KER

- **277 degrees**
  There is an assignment directed in the 277 degree bearing operated by Tablelands Broadcasting Pty Limited. The tower and its associated assignment are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.9 Site ID 9006997 - 331 James Street MALANDA

- **310 degrees**
  There are two assignment directed in the 310 degree bearing operated by the Tablelands Regional Council. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.10 Site ID 22010 - Powerlink Site 8.7 km W of Atherton MT WALLUM

- **43 degrees**
  There are two assignment directed in the 43 degree bearing operated by the Department of Community Safety (Queensland Fire and Rescue Service). The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.11 Site ID 22000 – 45 Mabel Street ATHERTON

- **315 degrees**
  There are two assignment directed in the 315 degree bearing operated by the Tablelands Regional Council. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.12 Site ID 22009 – QAS Site Hallorans Hill ATHERTON

- **326 degrees**
  There are two assignment directed in the 326 degree bearing operated by the Department of Community Safety. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.13 Site ID 130247 – Optus Site Dalziel Avenue ATHERTON

- **345 degrees**
  There are two assignments directed in the 345 degree bearing operated by Vodafone Australia Pty Limited. The tower and its associated assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.14 Site ID 152887 – Broadcast Site Lot 1 Griffin Rd TOLGA

- **343 degrees**
  There is an assignment directed in the 343 degree bearing operated by Coastal Broadcasters Pty Ltd. The tower and its associated assignment are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.15 Site ID 152747 – Broadcast Site Bones Knob TOLGA

- **97 degrees**
  There is an assignment directed in the 97 degree bearing operated by Tablelands Broadcasting Pty Limited. The tower and its associated assignment are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.1.16 Site ID 9006996 – Council Site 8 km WNW of Tolga (off Kennedy Highway) MT EMERALD

- **2 degrees**
  There are two assignments directed in the 182 degree bearing operated by the Tablelands Regional Council. The 2nd Fresnel Zone Analysis was conducted for this assignment and the results are discussed in Section 4.3.1. A Near Field Exclusion Zone analysis was undertaken for this site and WTG 42 was found to be outside this exclusion zone.

- **130 degrees**
  There are two assignments directed in the 2 degree bearing operated by the Tablelands Regional Council. These assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

- **135 degrees**
  There are two assignments directed in the 2 degree bearing operated by the Tablelands Regional Council. These assignments are sufficiently far away from the wind farm and have been excluded from the Fresnel Zone and Near Field Exclusion Zone analyses.

4.2 Near field exclusion

For the services attached to towers discussed in Section 4.1, the near field exclusion zones were calculated. The exclusion zones were mapped with respect to the MEWF layout. As discussed in Section 2.1.1, PB recommends an exclusion zone equal to the maximum of the calculated near field exclusion zone and 500 m (whichever is the greater). No turbines are located within these defined exclusion zones.

4.3 Point-to-point services

When investigating impact to point-to-point services, PB recommends that turbines do not intrude on the 2nd Fresnel exclusion zone. If turbines are found to intrude on exclusion zones, there are a number of mitigation options available (see Section 2.3). However, before investigating mitigation options for the MEWF, PB recommends the coordinates of the transmitting and receiving towers, the status of the services and requirements of the licensees are verified during the consultation phase. The tower coordinates may not be accurate, the services may not be active or the requirements of the licence holders may influence the requirements for layout adjustment. PB has contacted or attempted to contact the licensees of links discussed in this section (see Section 5 for information on consultation).

Based on the search results in Section 4.1, PB calculated the recommended obstruction exclusion zones (2nd Fresnel exclusion zone) for assignments that are potentially intercepted by the wind farm. As shown in Figure 6, there is only one assignment that is possibly intercepted by the wind farm, which is discussed in more detail in Section 4.3.1.

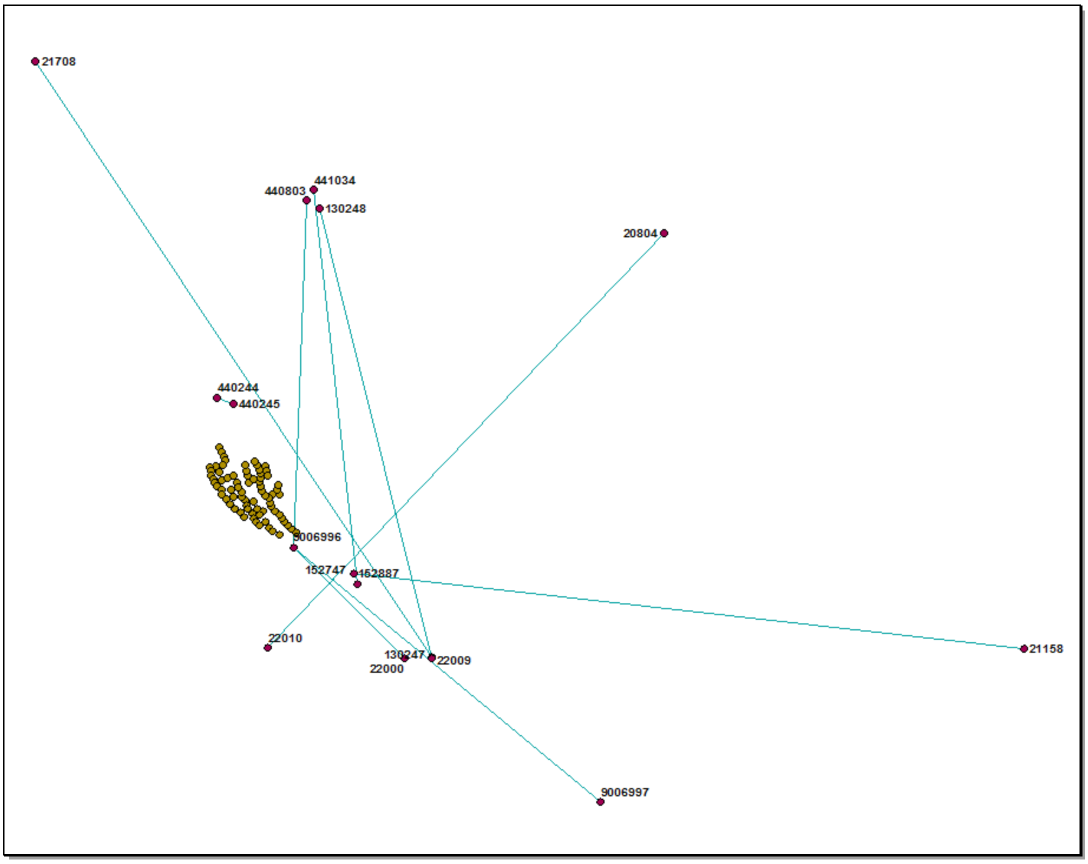


Figure 6: Assignments of nearby radio communications towers relative to the MEWF

The Fresnel Zone analysis shows that one turbine possibly encroaches on the 2nd Fresnel Zone of the link between Site 9006996, which is within the 5 km radius of the wind farm boundary, and Site 440803, which is approximately 15 km from the wind farm boundary. This is discussed in the following subsection.

There are six other links that pass through the 5 km radius from the wind farm boundary, but these links have a significant distance between the outermost 2nd Fresnel Zone point and the MEWF and hence are not expected to be impacted by the wind farm, and are not discussed any further in this report.

4.3.1 Council Site 8 km WNW of Tolga (off Kennedy Highway) MT EMERALD (Site ID 9006996) to 65 Rankine Street MAREEBA (Site ID 440803)

The links on this radio path are licensed to the Tablelands Regional Council and occupy the 8 GHz frequency band (see Appendix C). PB is attempting to contact the operators of both these sites at the time of writing to confirm the precise coordinates of the sites. PB has calculated that there is a 4 m distance from the edge of the 2nd Fresnel Zone to the centre of WTG 42. The blades and nacelle of the WTG are within the 2nd Fresnel Zone. It should be noted that this analysis is based solely on the information provided by ACMA which has an accuracy of +/- 100 m. PB has also compared the coordinates of these towers with alternative sources of information such as satellite imagery and found inconsistencies in telecommunication tower locations. PB is in the process of confirming the precise coordinates of the telecommunications towers with the operators/licensees.

Figure 7: 2nd Fresnel Zone of links between 9006996 and 440803

4.4 Point-to-multipoint

Point-to-multipoint links are similarly susceptible to the types of impacts discussed in Section 2.1. However, because of the nature of many uses of point-to-multipoint radio communication, the likelihood of a wind farm causing unacceptable impacts is generally low.

For example, for land mobile systems a mobile receiver can generally get an adequate signal by moving a short distance to an unobstructed area. However, there may be point-to-multipoint services with fixed receivers that can be impacted. Any registered services will be present and accounted for in the ACMA database used in this assessment. However, unregistered operators (such as Class licensees[2]) may not be detected. PB has consulted point-to-multipoint and broadcast licensees on towers within a 3 km distance from the wind farm boundary to determine their position on the development. PB recommends Transfield gathers information on fixed Class license receivers during their community consultation phase to determine if there are any users in the area.

4.4.1 AM and FM radio broadcasting

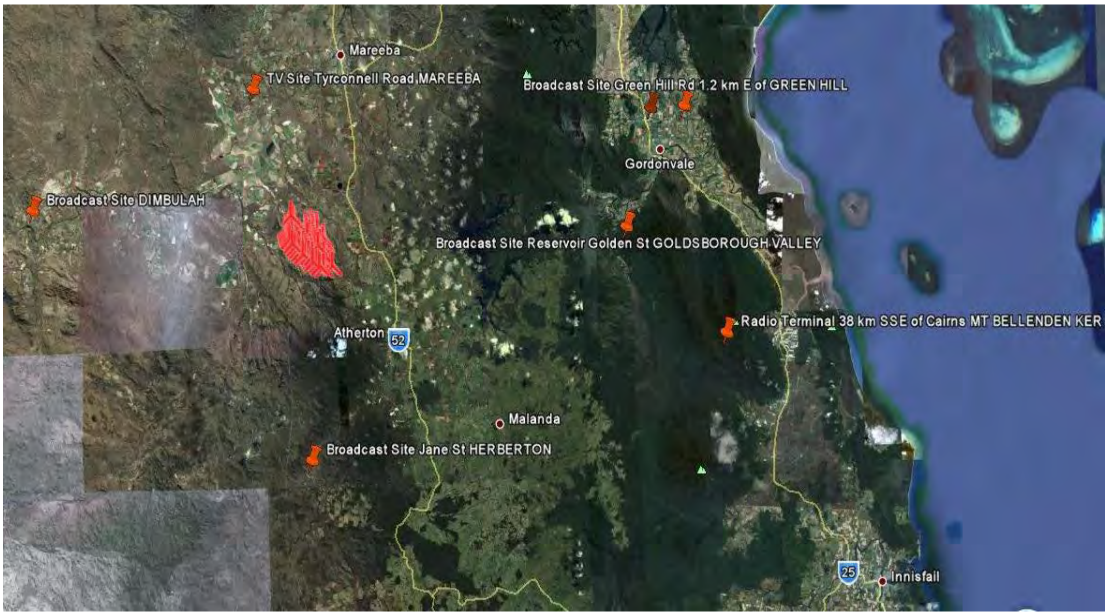
The impact to FM radio broadcasting reception is considered to be negligible. The impact to AM radio broadcasting is considered to be negligible beyond the boundary of the wind farm. In general, there are no known effects on AM/FM services caused by the wind farm as the wavelength of these services are relatively large compared to the size of the WTGs; hence any effect will be negligible.

4.4.2 Mobile radio

Mobile radio may be affected by the shadowing effects of the MEWF. However, if this is the case, any problems can usually be rectified through a minor adjustment in the position of the receiver.

4.5 Digital and analogue television

Reflection of an analogue video signal can result in impact to analogue television services. A search of the analogue television broadcast stations in the area was completed (see Figure 8). Based on ACMA information and the coverage patterns given by the Australian Broadcast Corporation[3], the likely tower being used for transmission in the area would be the Mount Bellenden-Ker site, the Hallorans Hill site, and the Dimbulah Broadcast site. Further information would be required to determine which site(s) is being used by local receivers.



[2] http://www.acma.gov.au/WEB/STANDARD/pc=PC_481 accessed on 22/07/2010
[3] http://www.abc.net.au/reception/freq/

Figure 8: MEWF, populated areas (red circles) and the surrounding broadcast stations (orange pins)

A number of townships lie in close proximity to the wind farm. No population centre lies such that the MEWF is obstructing either of these broadcast stations lines of sight. PB does not expect the townships east of the site, namely Mareeba, Atherton and Walkamin to be affected by the MEWF.

Residences close to MEWF may experience interference to their analogue television signals in the form of multipath reflections. Further modelling would need to be undertaken to determine the extent of that impact, if required. However, a potential mitigation option for analogue television impact is converting an analogue television receiver to digital. The Australian government has declared analogue television will be phased completely out of service by the end of 2013 with service in many areas ceasing operation before that time. Given a reasonable construction schedule for MEWF, many television users will likely have converted to digital television when construction has commenced. Digital television signals are more immune to interference from wind turbines compared to analogue signals .

Residences may also be located near the wind farm such that there is line of sight obstruction between the residence and the broadcast site. More information would be required to determine if this is the case.

5. Licensee consultation

All the potentially impacted licensees within Appendix C are being contacted by PB to give them opportunity to comment on the development.

Additionally, clarification will be sought for the following items:

- Coordinate precision for Site 9006996 and the azimuths of its associated links.
- Coordinate precision for Site 440803 and the azimuths of its associated links.

PB will reassess the impact of the wind farm on the two sites above following confirmation of precise coordinates from the operators/licensees.

6. References

1. Bacon, D. F. (2002) – Fixed link wind turbine exclusion zone method. Ofcom.

2. National Wind Farm Development Guideline, Public Consultation Draft (2009) – Environment Protection and Heritage Council

3. ERA Technology (2009) - RF Measurement Assessment of Potential Wind Farm Interferences to Fixed Links and Scanning Telemetry Devices. ERA Technology Ltd.

Appendix A

Proposed wind farm layout (WGS 84, Zone 55)

Wind farm layout coordinates (WGS 84, Zone 55)

Turbine Number	East	North
1	325809	8102197
2	325803	8103785
3	325956	8103457
4	326073	8103207
5	326217	8102937
6	326064	8102645
7	325581	8102596
8	325167	8102500
9	325263	8102243
10	325299	8101986
11	325387	8101730
12	325507	8101485
13	325916	8101631
14	326327	8101782
15	325617	8101231
16	325929	8101048
17	325934	8100748
18	326232	8100427
19	326493	8100143
20	326789	8099837
21	327190	8099583
22	327386	8099294
23	327471	8100310
24	327570	8100046
25	327652	8099781
26	327915	8099518
27	328230	8099829
28	328656	8099631
29	328367	8099407
30	328029	8099220
31	328146	8098962
32	328425	8098766
33	328786	8098927
34	329002	8098559
35	329234	8098320
36	329717	8098155
37	329260	8100722
38	328046	8100298
39	326981	8101460
40	326734	8100584
41	327737	8101507
42	330749	8098278
43	330489	8098504
44	330207	8098696
45	329988	8098935
46	329823	8099182
47	329729	8099441

Turbine Number	East	North
48	329404	8099649
49	329203	8099946
50	329091	8100198
51	329040	8100460
52	329738	8100745
53	329581	8101006
54	329659	8101299
55	328773	8100681
56	328578	8100955
57	328506	8101239
58	328368	8101559
59	328507	8101817
60	328450	8102087
61	328384	8102361
62	328250	8102610
63	328123	8102866
64	326730	8101936
65	328792	8102560
66	328891	8102237
67	328964	8101930
68	328019	8101756
69	327636	8101937
70	327578	8102225
71	327508	8102611
72	327279	8100581
73	327284	8100882
74	327063	8101191
75	326543	8101038

Appendix B

ACMA RADCOM site search results (AGD 66, Zone 55)

Site ID	Site Name	Easting	Northing
20804	Miles Site LAMBS HEAD	354700	8117700
21158	Radio Terminal 38 km SSE of Cairns MT BELLENDEN KER	378034	8090678
21679	Ergon Energy Site LONGLANDS GAP	339090	8069311
21681	Forestry Site 8.7 km W of Atherton MT WALLUM	329000	8090300
21708	QAS Site HANN TABLELAND	313870	8128894
22000	45 Mabel Street ATHERTON	337850	8090055
22006	DPI Office Main Street ATHERTON	337700	8090150
22009	QAS Site Hallorans Hill ATHERTON	339575	8090130
22010	Powerlink Site 8.7 km W of Atherton MT WALLUM	328960	8090735
22011	Telstra Radio Terminal Hallorans Hill ATHERTON	339804	8089984
39608	Ergon Site LYONS LOOKOUT	327630	8170840
39610	Ergon Site HANN TABLELAND	313870	8128879
130247	Optus Site Dalziel Avenue ATHERTON	339613	8090103
130248	Optus/Vodafone Site Water Tower Basalt Street MAREEBA	332300	8119300
152747	Broadcast Site Bones Knob TOLGA	334500	8095600
152887	Broadcast Site Lot 1 Griffin Rd TOLGA	334797	8094912
440241	Pump Station Kennedy Hway MAREEBA	332250	8118500
440243	Reservoir Kennedy Hway MAREEBA	333000	8113000
440244	Lotus Glen Prison via MAREEBA	325680	8106990
440245	Lotus Glen Prison Farm via MAREEBA	326680	8106600
440449	Telstra Customer Mr CD Dudeck Lot 1322 Tinaroo Creek Rd TINAROO	342580	8107950
440803	65 Rankine Street MAREEBA	331500	8119850
441034	2 Middlemiss Street MAREEBA	331960	8120540
9001006	Ergon Substation off Grant St ATHERTON	337985	8091485
9001007	Ergon Substation Turkinje via MAREEBA	333282	8110968
9006996	Council Site 8 km WNW of Tolga (off Kennedy Highway) MT EMERALD	330611	8097300
9006997	331 James Street MALANDA	350548	8080712
9012506	Substation Substation Accs Rd off Kennedy Hwy MAREEBA	333340	8112657

Appendix C

Registered assignments within 5 km of MEWF

Site ID 20804 – Miles Site LAMBS HEAD

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
54761	450000000	56	Miles Electronics Pty Ltd
57096	414000000	208	Queensland Police Service
350640	405000000	208	Queensland Police Service
171149	414000000	197	Department of Community Safety
171152	405000000	197	Department of Community Safety
1440514	414000000	45	Department of Community Safety (Queensland Fire and Rescue Service)
1440515	404000000	45	Department of Community Safety (Queensland Fire and Rescue Service)
1440518	414000000	223	Department of Community Safety (Queensland Fire and Rescue Service)
1440519	404000000	223	Department of Community Safety (Queensland Fire and Rescue Service)
1441665	414000000	55	Queensland Police Service
1441666	405000000	55	Queensland Police Service
8153065	404000000	198	Department of Community Safety (Queensland Fire and Rescue Service)
8153066	414000000	198	Department of Community Safety (Queensland Fire and Rescue Service)
8157092	10600000000	60	Miles Electronics Pty Ltd
8157093	10600000000	60	Miles Electronics Pty Ltd
8158744	461000000	285	Ergon Energy Corporation Limited
8158745	451000000	285	Ergon Energy Corporation Limited
8158805	461000000	63	Department of Transport and Main Roads (Queensland Transport)
8158806	451000000	63	Department of Transport and Main Roads (Queensland Transport)
8158807	461000000	63	Department of Transport and Main Roads (Queensland Transport)
8158808	451000000	63	Department of Transport and Main Roads (Queensland Transport)
8172632	414000000	51	Ergon Energy Corporation Limited
8172642	405000000	51	Ergon Energy Corporation Limited
8200929	404000000	317	Department of Community Safety (Queensland Fire and Rescue Service)
8200933	414000000	317	Department of Community Safety (Queensland Fire and Rescue Service)
8225556	414000000	285	Department of Community Safety (Queensland Fire and Rescue Service)
8225565	404000000	285	Department of Community Safety (Queensland Fire and Rescue Service)

Site ID 21158 – Radio Terminal 38 km SSE of Cairns MT BELLENDEN KER

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
40016	6700000000	129	Telstra Corporation Limited
340752	7040000000	129	Telstra Corporation Limited
40018	6800000000	129	Telstra Corporation Limited
340754	6460000000	129	Telstra Corporation Limited
44500	1870000000	118	Telstra Corporation Limited
345035	1750000000	118	Telstra Corporation Limited
1103604	7520000000	347	Airservices Australia
1103605	7690000000	347	Airservices Australia
1444514	461000000	347	Department Of Transport And Main Roads (Main Roads)
1444515	451000000	347	Department Of Transport And Main Roads (Main Roads)
8156900	6500000000	129	Southern Cross Telecommunications Pty Ltd
8156901	6840000000	129	Southern Cross Telecommunications Pty Ltd
8156902	6580000000	129	Southern Cross Telecommunications Pty Ltd
8156903	6920000000	129	Southern Cross Telecommunications Pty Ltd
8181810	7480000000	347	Australian Broadcasting Corporation
8181813	7640000000	347	Australian Broadcasting Corporation

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8194398	7760000000	74	Telstra Corporation Limited
8194404	8070000000	74	Telstra Corporation Limited
8223539	848000000	347	Australian Broadcasting Corporation
8294743	849000000	277	Tablelands Broadcasting Pty Limited

Site ID 21708 – QAS Site HANN TABLELAND

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
56588	155000000	224	Queensland Police Service
350453	151000000	224	Queensland Police Service
61575	414000000	76	Department of Community Safety
1440017	404000000	76	Department of Community Safety
1442154	414000000	18	Mossman Central Mill Company Limited
1442156	405000000	18	Mossman Central Mill Company Limited
1444694	932000000	256	Queensland Rail Limited
1444695	856000000	256	Queensland Rail Limited
1444696	933000000	115	Queensland Rail Limited
1444697	857000000	115	Queensland Rail Limited
1481778	461000000	146	Department of Community Safety
1481779	451000000	146	Department of Community Safety
1481780	461000000	224	Department of Community Safety
1481781	451000000	224	Department of Community Safety
1444980	150000000	317	Department of Community Safety
1444981	155000000	317	Department of Community Safety
1444982	155000000	77	Department of Community Safety
1444983	150000000	77	Department of Community Safety
8225556	414000000	105	Department of Community Safety (Queensland Fire and Rescue Service)
8225565	404000000	105	Department of Community Safety (Queensland Fire and Rescue Service)

Site ID 22000 – 45 Mabel Street ATHERTON

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8195353	18300000000	315	Tablelands Regional Council
8195355	19300000000	315	Tablelands Regional Council

Site ID 22009 – QAS Site Hallorans Hill ATHERTON

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1481778	461000000	326	Department of Community Safety
1481779	451000000	326	Department of Community Safety
1481784	460000000	181	Department of Community Safety
1481785	451000000	181	Department of Community Safety

Site ID 22010 – Powerlink Site 8.7 km W of Atherton MT WALLUM

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1440518	414000000	43	Department of Community Safety (Queensland Fire and Rescue Service)
1440519	404000000	43	Department of Community Safety (Queensland Fire and Rescue Service)
8169114	451000000	85	Ergon Energy Corporation Limited
8169117	460000000	85	Ergon Energy Corporation Limited

Site ID 130247 – Optus Site Dalziel Avenue ATHERTON

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1134606	7590000000	345	Vodafone Australia Pty Limited
1134607	7430000000	345	Vodafone Australia Pty Limited
1442232	7660000000	346	Optus Mobile Pty Limited
1442237	7500000000	346	Optus Mobile Pty Limited
8260173	6030000000	346	Optus Mobile Pty Limited
8260183	6290000000	346	Optus Mobile Pty Limited
8260174	6000000000	346	Optus Mobile Pty Limited
8260177	6260000000	346	Optus Mobile Pty Limited
8260175	5970000000	346	Optus Mobile Pty Limited
8260184	6230000000	346	Optus Mobile Pty Limited
8260182	5950000000	346	Optus Mobile Pty Limited
8260188	6200000000	346	Optus Mobile Pty Limited
8263321	7880000000	136	Optus Mobile Pty Limited
8263325	8190000000	136	Optus Mobile Pty Limited

Site ID 130248 – Optus/Vodafone Site Water Tower Basalt Street MAREEBA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1134606	7590000000	165	Vodafone Australia Pty Limited
1134607	7430000000	165	Vodafone Australia Pty Limited
1442232	7660000000	166	Optus Mobile Pty Limited
1442237	7500000000	166	Optus Mobile Pty Limited
1426233	15100000000	266	Optus Mobile Pty Limited
1426234	14500000000	266	Optus Mobile Pty Limited
8260173	6030000000	166	Optus Mobile Pty Limited
8260183	6290000000	166	Optus Mobile Pty Limited
8260174	6000000000	166	Optus Mobile Pty Limited
8260177	6260000000	166	Optus Mobile Pty Limited
8260175	5970000000	166	Optus Mobile Pty Limited
8260184	6230000000	166	Optus Mobile Pty Limited
8260182	5950000000	166	Optus Mobile Pty Limited
8260188	6200000000	166	Optus Mobile Pty Limited
8295165	10700000000	266	Optus Mobile Pty Limited
8295168	11200000000	266	Optus Mobile Pty Limited

Site ID 152747 – Broadcast Site Bones Knob TOLGA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8294743	849000000	97	Tablelands Broadcasting Pty Limited

Site ID 152887 – Broadcast Site Lot 1 Griffin Rd TOLGA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
167941	851000000	343	Coastal Broadcasters Pty Ltd

Site ID 440244 – Lotus Glen Prison via MAREEBA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1440369	50900000000	111	QLD Corrective Services Commission
1440370	50400000000	111	QLD Corrective Services Commission

Site ID 440245 – Lotus Glen Prison Farm via MAREEBA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
1440369	50900000000	291	QLD Corrective Services Commission
1440370	50400000000	291	QLD Corrective Services Commission

Site ID 440803 – 65 Rankine Street MAREEBA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8195289	7730000000	2	Tablelands Regional Council
8195290	8040000000	2	Tablelands Regional Council

Site ID 441034 – 2 Middlemiss Street MAREEBA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
167941	851000000	163	Coastal Broadcasters Pty Ltd

Site ID 9006996 – Council Site 8 km WNW of Tolga (off Kenedy Highway) MT EMERALD

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8195286	7790000000	130	Tablelands Regional Council

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8195287	8100000000	130	Tablelands Regional Council
8195289	7730000000	182	Tablelands Regional Council
8195290	8040000000	182	Tablelands Regional Council
8195353	18300000000	135	Tablelands Regional Council
8195355	19300000000	135	Tablelands Regional Council

Site ID 9006997 – 331 James Street MALANDA

Access ID	Frequency Assignment	Antenna Azimuth	Licensee
8195286	7790000000	310	Tablelands Regional Council
8195287	8100000000	310	Tablelands Regional Council

Appendix 29

Mount Emerald Wind Farm Fire Management Plan

Prepared by RATCH Australia Corporation Limited

RATCH-Australia Corporation

MOUNT EMERALD WIND FARM

FIRE MANAGEMENT PLAN

REVISION 2
July 2013

REVISION	PREPARED	REVIEWED	STATUS
Revision 1	Terry Johannesen – 13 Feb 2012		Draft
Revision 2	Terry Johannesen – 20 Jul 2013		

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 OVERVIEW

The Fire Management Plan has been prepared to overview the approach to fire management during the Design, Construction and Operations Phases.

1.2 EXISTING SITE CONDITIONS

The site is situated at the northern most end of the Herberton Range, which forms part of the Great Dividing Range between the natural landmarks of Walsh Bluff and Mount Emerald, at a range of elevations between 750 to 1000 metres.

The land is dominated by of a series of three, approximately parallel ridges running in a south-east to north-west direction with a large area (~500 ha) of relatively flat country located in the north-western section.

The property is currently accessed via a 4WD only track which follows the path of a transmission line (Powerlink - Chulumbin to Woree 275kV) that roughly dissects the property. Two other vehicle tracks, branch from this track to access the northern and southern areas of the site.

The site is not currently grazed by domestic stock and consists entirely of remnant vegetation which can be described as relatively low open scrubland.

1.3 CLIMATIC CONDITIONS

The climate of the site as indicated by the long-term weather records obtained for the nearby township of Walkamin is monsoonal, with alternating wet and dry seasons that typically last for 4 and 8 months respectively (Weatherzone, 2011), although this can vary considerably depending on the severity of the El Nino/Southern Oscillation.

Statistics obtained for the nearby Bureau of Meteorology site at Mareeba Airport show a maximum temperature range from 19^{O}C in June to 39^{O}C in November whilst minimums range from 4^{O}C in July to 24^{O}C in November.

Average annual rainfall is 1032mm with the wettest month being February (250mm) and the driest month September (8mm). The majority of rainfall (80%) falls within the months of December to March.

1.4 RISK

The risk of a wind turbine catching fire is considered low. The greater risk is from fire during construction or a grass or bush fire entering the site.

Key aspects which will minimise the risk of fire include:

- A well designed and constructed road network through out the site.
- Personnel on site who understand how to respond quickly to a fire and use the equipment available on site.

- Accessible sources of water.
- Adequate fire fighting facilities.

1.5 MANAGEMENT PLANS

The Health and Safety Management Plan and the Emergency Response Plan will be developed and will be ready for implementation during the Construction Phase.

2 DESIGN PHASE

The Design Phase of the wind farm will initially involve siting the wind turbine generators (WTGs) and other associated infrastructure. WTGs will generally be placed in cleared areas on ridge lines and spurs. A network of high quality gravel roads suitable for large truck movements will interconnect the WTGs. The design of this road network will occur during the Design Phase.

Since the WTGs, roads and hardstands are located on cleared portions of the site, there is minimal fuel to feed a fire. The site road network does provide some form of fire break.

Road designs (generally 10m wide) will be suitable for regular large and heavy loads, travelling in both directions at the same time. Road gradients and cross falls will be suitable for large loads.

Site plans will locate water troughs, tanks, dams, and any other sources of water. A copy of the interim Site Plan is included in Appendix 1.

3 CONSTRUCTION PHASE

3.1 INDUCTIONS AND TRAINING

All personnel and visitors onto the site will be required to attend an induction when they first arrive on site. Part of this induction will include aspects of the Fire Management Plan.

The District Fire Warden will be invited to attend a Toolbox talk at the beginning of the dry season (April/May) with follow up “refresher” presentations conducted throughout the construction of the Project.

Representatives from each major contractor will be shown how to use the fire fighting equipment on the back of project vehicles.

Inductions will also address the smoking policy on site, emergency phone numbers, aspects of the Crisis Management Plan and the muster area.

3.2 SITE LAYOUT

The District Fire Warden will be taken on regular site tours and provided with site plans showing the project infrastructure such as WTGs, roads, main compound and substation.

GPS locations will be provided for all WTGs and water sources such as troughs, dams and tanks.

The major road in the area is the Kennedy Highway which links the towns of Mareeba, Walkamin, Tolga and Atherton. Road access to site from the Kennedy Highway will be via Hansen Road - Springmount Road – Kippin Drive.

The project area is contained within Rural Fire Brigade zone of the Springmount District Fire Warden, and shares boundaries with Atherton (east), Walkamin (north-east), Narcotic Creek (north) and Arriga (north-west).

The site is located within the following road distances to local fire and rescue services;

- Mareeba 28km
- Atherton 30km
- Dimbulah 48km

All site roads and hardstands will be maintained in good condition and can act as firebreaks.

3.3 VEHICLES

Diesel powered vehicles shall be used on site and petrol driven vehicles shall only be used if fitted with spark arrestors.

Vehicles shall be driven on formed roads and surfaces wherever possible to avoid the collection of debris under the vehicle that may cause a fire to start.

All project vehicles will contain a fire extinguisher and CB radios. The two project utilities from the Contractors will be fitted with a water tank, diesel pump, 30m fire hose and a knapsack spray.

3.4 FIRE FIGHTING FACILITIES

The main compound will contain a water tank (approx. 50,000 litres capacity) collecting water from the buildings in the compound. The tank will be fitted with outlets allowing fire trucks to connect to the tank. Should the water level drop below a set point a water truck will deliver water to the tank.

Adjacent to the water tank will be a fire hose reel (30m) and a diesel pump to provide coverage in and around the buildings. All buildings will be fitted with smoke detectors and contain portable fire extinguishers. All fire extinguishers will be checked on a 12 monthly basis.

Any landscaping around the buildings will include native plants with fire retardant characteristics.

Access to water troughs, dams and tanks throughout the properties will provide alternative sources of water should they be required.

Each WTG contains a fire extinguisher in the base of the tower and up in the nacelle.

If the civil works contractor is working on site at the time of the fire, the use of graders, water trucks, front end loaders and bobcats may be possible.

3.5 SIGNAGE

Signage at the main compound will state the emergency numbers for the Owner's Operations Manager, Contractor's Service Manager, District Fire Warden, and the radio channel to contact the Fire Brigade. CB radios are located in the Administration Building and the project vehicles.

3.6 HOT WORK PERMITS

No waste materials shall be burnt on site. All rubbish shall be disposed of in the appropriate manner.

Where it may be necessary to undertake "hot works" e.g. welding, cutting, a "hot work permit" shall be issued. This will set procedures to be followed regarding where the work is undertaken, fire fighting equipment and personnel to be in attendance and the timing for the work to be well defined.

No naked flames will be permitted on site.

3.7 SMOKING

Smoking on site will be restricted to designated smoking areas and cigarettes are to be extinguished in ashtrays only. Cigarettes are not to be thrown on the ground or from vehicles.

3.8 EMERGENCY RESPONSE PLAN

An Emergency Response Plan will be prepared for the Construction Phase. This Plan will detail the procedures to be followed in the event of a fire.

In the event of a fire all resources and expertise available on site are to be made available to the local Fire Brigade. Personnel on site will comply with directions given by the local Fire Brigade.

Personnel are only expected to fight small fires within their level of competence. The local Fire Brigade will be called immediately if the fire cannot be controlled.

4 OPERATIONS PHASE

4.1 INDUCTIONS AND TRAINING

All personnel and visitors onto the site will be required to attend an induction when they first arrive on site. Part of this induction will include aspects of the Fire Management Plan.

Inductions will also address the smoking policy on site, emergency phone numbers, aspects of the Emergency Response Plan and the muster area.

4.2 SITE LAYOUT

The Fire Brigade will be taken on regular site tours during the Operations Phase and provided with site plans showing the project infrastructure such as WTGs, roads, main compound and substation.

GPS locations will be provided for all WTGs and water sources such as troughs, dams and tanks.

The major road in the area is the Kennedy Highway which links the towns of Mareeba, Walkamin, Tolga and Atherton. Road access to site from the Kennedy Highway will be via Hansen Road - Springmount Road – Kippin Drive.

The project area is contained within Rural Fire Brigade zone of the Springmount District Fire Warden, and shares boundaries with Atherton (east), Walkamin (north-east), Narcotic Creek (north) and Arriga (north-west).

The site is located within the following road distances to local fire and rescue services;

- Mareeba 28km
- Atherton 30km
- Dimbulah 48km

All site roads and hardstands will be maintained in good condition and can act as firebreaks.

4.3 VEHICLES

Diesel powered vehicles shall be used on site and petrol driven vehicles shall only be used if fitted with spark arrestors.

Vehicles shall be driven on formed roads and surfaces wherever possible to avoid the collection of debris under the vehicle that may cause a fire to start.

All project vehicles will contain a fire extinguisher and CB radios. One utility will be fitted with a water tank, diesel pump, 30m fire hose and a knapsack spray.

4.4 FIRE FIGHTING FACILITIES

The main compound will contain a water tank (approx. 50,000 litres capacity) collecting water from the buildings in the compound. The tank will be fitted with outlets allowing fire trucks to connect to the tank. Should the water level drop below a set point a water truck will deliver water to the tank.

Adjacent to the water tank will be a fire hose reel (30m) and a diesel pump to provide coverage in and around the buildings. All buildings will be fitted with smoke detectors and contain portable fire extinguishers. All fire extinguishers will be checked on a 12 monthly basis.

Any landscaping around the buildings will include native plants with fire retardant characteristics.

Access to water troughs, dams and tanks throughout the properties will provide alternative sources of water should they be required.

Each WTG contains a fire extinguisher in the base of the tower and up in the nacelle.

4.5 SIGNAGE

Signage at the main compound will state the emergency numbers for the Owner's Operations Manager, Contractor's Service Manager, District Fire Warden, and the radio channel to contact the Fire Brigade. CB radios are located in the Administration Building and the project vehicles.

4.6 HOT WORK PERMITS

No waste materials shall be burnt on site. All rubbish shall be disposed of in the appropriate manner.

Where it may be necessary to undertake "hot works" e.g. welding, cutting, a "hot work permit" shall be issued. This will set procedures to be followed regarding where the work is undertaken, fire fighting equipment and personnel to be in attendance and the timing for the work to be well defined.

No naked flames will be permitted on site.

4.7 SMOKING

Smoking on site will be restricted to designated smoking areas and cigarettes are to be extinguished in ashtrays only. Cigarettes are not to be thrown on the ground or from vehicles.

4.8 EMERGENCY RESPONSE PLAN

An Emergency Response Plan will be prepared for the Operations Phase by the Operations Team during the Construction Phase. This Plan will detail the procedures to be followed in the event of a fire.

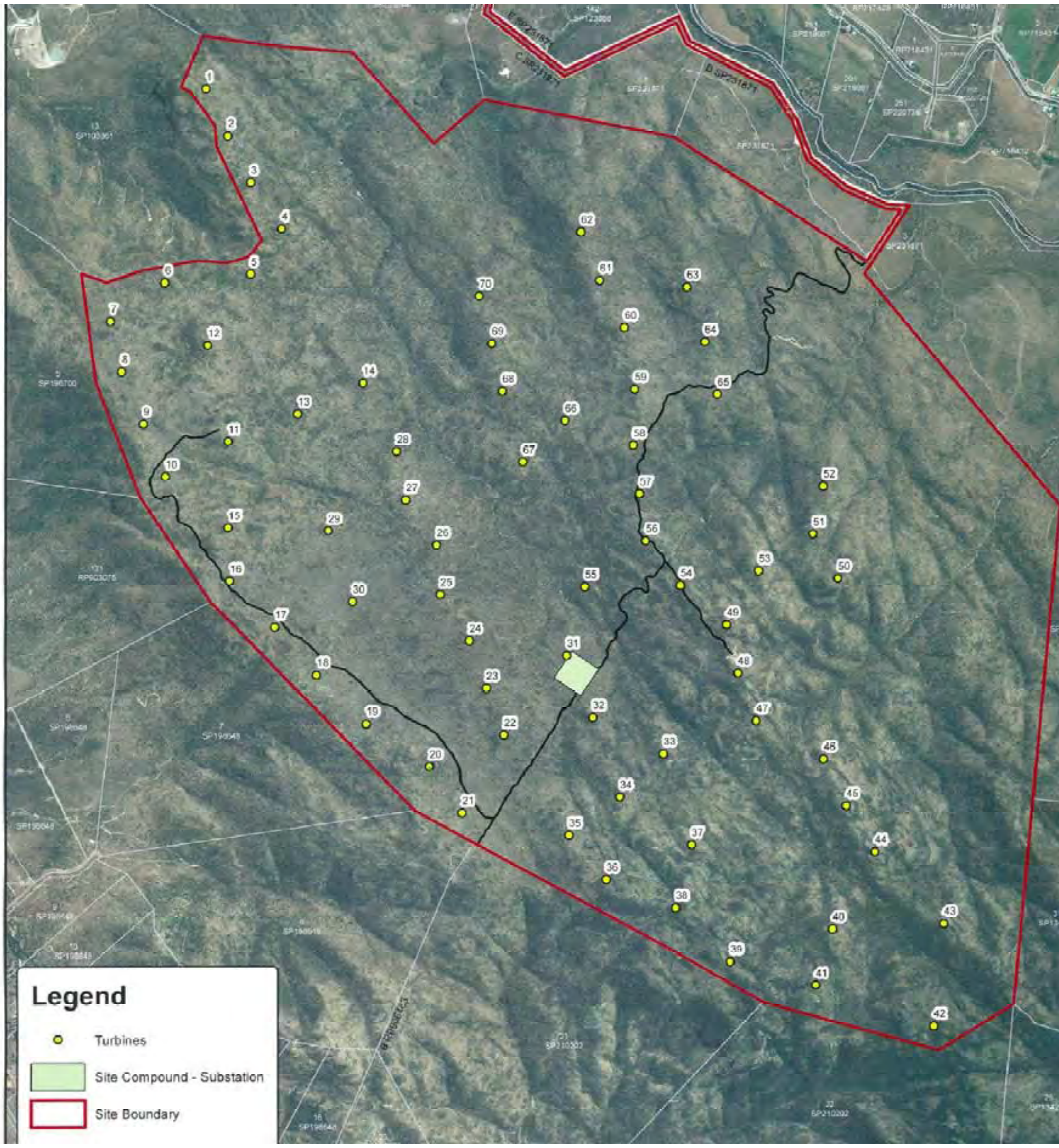
In the event of a fire all resources and expertise available on site are to be made available to the local Fire Brigade. Personnel on site will comply with directions given by the local Fire Brigade.

Personnel are only expected to fight small fires within their level of competence. The local Fire Brigade will be called immediately if the fire cannot be controlled.

4.9 FLUID STORE

All fluids will be stored with a designated building. Adequate ventilation will be incorporated into the design of the building. The appropriate types of fire extinguishers will also be installed on the outside of the building.

APPENDIX 1 – INTERIM SITE PLAN



Appendix 30

Mount Emerald Wind Farm Shadow Flicker Assessment

Prepared by Parsons Brinckerhoff Australia

RATCH-Australia Corporation

Mount Emerald Wind Farm Shadow Flicker Assessment

22 July 2013

PARSONS BRINCKERHOFF

Document information
Client: RATCH-Australia Corporation Title: Mount Emerald Wind Farm Shadow Flicker Assessment Document No: 2158894A-REP-001 Date: 22 July 2013

Rev	Date	Details
A	15/03/2013	Draft
B	27/03/2013	Inclusion of shadow flicker and receptor map, and operational hours per direction sector
C	22/07/2013	Inclusion of worst case shadow flicker map

Author, Reviewer and Approver details			
Prepared by:	We-Ki Chua	Date: 27/03/2013	Signature:
Reviewed by:	Ben Inkster	Date: 27/03/2013	Signature:
Approved by:	Taraz Saba	Date: 27/03/2013	Signature:

Distribution
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A GRI Rating: Sustainability Report 2011

22 July 2013

Terry Johannesen
Project Development Manager
Wind Projects & Engineering, Development Group
RATCH Australia Corporation Limited
Level 4, 52 Merivale Street,
South Brisbane QLD 4101

Our ref: 2158894A-REP-001

By email
terry.johannesen@ratchaustralia.com

Dear Terry

Mount Emerald Wind Farm Shadow Flicker Assessment

Please find enclosed the Mount Emerald shadow flicker assessment as per the scope agreed upon by Parsons Brinckerhoff and RATCH Australia Corporation Limited (RATCH). This assessment was based on the wind farm layout provided by RATCH, wind data collected from the Mount Emerald wind farm and the Walkamin BoM long-term reference site. The methodologies and results are detailed herein.

Should you have any questions, please contact me at your convenience.

Yours sincerely

Ben Inkster
Wind Engineer
Parsons Brinckerhoff

Contents

Glossary

Bureau of Meteorology	Australia's national weather, climate and water agency
Shadow flicker	The fluctuating light levels caused by intermittent (moving or changing) shadows casted by the turbine blade

Abbreviations

BoM	Bureau of Meteorology
d	day
h	hour
kW, MW, GW	Kilowatt, Megawatt, Gigawatt
m/s	Metres per second
mAGL	Metres above ground level
mASL	Metres above sea level
MEWF	Mount Emerald Wind Farm
MWh	Megawatt hour
RATCH	RATCH Australia Corporation Limited
WTG	Wind Turbine Generator
y	year

Executive summary

RATCH Australia Corporation Limited (RATCH) has requested Parsons Brinckerhoff Australia Pty Ltd (Parsons Brinckerhoff) perform a shadow flicker assessment for the proposed Mount Emerald Wind Farm (MEWF). This report is a shadow flicker assessment of a single turbine layout at a nominal hub-height of 80 m and the location of 123 receptors, as specified by RATCH.

The shadow flicker assessment has been conducted using on-site monitored data from the 9530 monitoring tower as it records closest to the nominated hub height of 80 m. Parsons Brinckerhoff has used the sheared and long-term adjusted dataset from an energy yield assessment previously undertaken for this site as an input to determine the WTG orientation and operational hours.

The shadow flicker assessment conducted by Parsons Brinckerhoff consisted of a worst case and a realistic case for shadow flicker impact on each receptor. The realistic case was performed using conservative assumptions using monitored data from the Bureau of Meteorology to represent average sunlight hours per day; however, a number of parameters were still set at what are considered conservative values. Several sites were considered for realistic data, but the Walkamin Research Station was selected as the most appropriate reference site to use in the realistic shadow flicker calculation due to its proximity to the MEWF site, geographic similarity and duration of recorded data.

However, the worst case assessment uses conservative model parameters that are very unlikely to occur in combination over annual timescales. The results show that for most residences, even under these conservative conditions, shadow flicker is below recommended levels of both aggregate annual hours and maximum daily hours of shadow flicker time.

Of the 123 receptors assessed, four have been predicted to experience levels of shadow flicker due to MEWF. No receptors are expected to experience more than 5 hours of shadow flicker in the realistic case and for the worst case, no receptors are expected to experience over 10 hours of shadow flicker per year, as seen in the table below.

No.	GPS Coordinates		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R05	325,084	8,099,119	4:24	0:13	2:22
R26	327,385	8,104,239	5:27	0:15	2:43
R49	331,555	8,100,953	8:39	0:13	4:53
R78	327,662	8,103,902	9:49	0:14	5:00

The shadow hours per day provide an estimate of the maximum shadow experienced by a receptor on a single day of the year. There is no realistic and worst case scenarios associated with this parameter since, unlike shadow hours per year where the actual occurrence is cumulated over an entire year (and hence a range of environmental conditions), the shadow hours per day may well occur on a day that is conducive to the worst case for shadow flicker (i.e. assuming no cloud cover is present on the given day that this occurs).

Based on these results, the calculated levels of shadow flicker caused by MEWF on the receptors listed is substantially less than the limits prescribed by the appropriate guidelines for wind farm developments in Australia.



1. Introduction

RATCH has requested Parsons Brinckerhoff conduct a shadow flicker assessment for the Mount Emerald Wind Farm (MEWF), located in Northern Queensland, southwest of Cairns. RATCH has nominated a layout consisting of 70 WTGs with a nominal hub height of 80 m for evaluation and prediction of the shadow flicker at MEWF, using the Siemens 101-3.0 WTG.

Shadow flicker occurs when the sun passes behind the blades of a WTG casting an intermittent shadow. This affect is known to cause annoyance when this shadow is received at a dwelling. The severity and frequency of shadow flicker will decay with the distance from a WTG and if the location of a dwelling is within 2 km of a WTG, there is potential for this intermittent shadow to be frequent enough to cause annoyance.

This assessment has evaluated shadow flicker on nearby receptors to MEWF in accordance with the draft National Wind Farm Development Guidelines – July 2010, which includes a worst case and realistic evaluation of shadow flicker to a distance of 265 times the maximum chord length from all WTGs.

This assessment has been conducted using a layout consisting of 70 WTGs, and the location of 123 shadow receptors (including surrounding dwellings), as specified by RATCH. It was found that no receptors are expected to exceed the recommended shadow flicker limits of the guidelines.

1.1 Description of shadow flicker

Shadow flicker is the fluctuating light levels caused by intermittent (moving or changing) shadows. If a location is in the shadow of a moving object, then there will be a momentary reduction in light intensity as the shadow passes by. This is most noticeable in an enclosed room that is lit by the sun, when the shadow falls across the window that is providing the light. Wind turbines can cause shadow flicker from the moving shadow of the wind turbine blades. Shadow flicker can also be caused by any moving objects that cast a shadow, such as vehicles or aeroplanes.

The rate of flicker for a three bladed, horizontal axis wind turbine is 3 times the rotational speed of the wind turbine rotor. For example a three bladed wind turbine with a rotor speed of 20 revolutions per minute (rpm) results in a flicker frequency of 1 Hertz (once per second). If the alternating light levels caused by the shadow flicker are of significant intensity and affect the whole light source of a room (i.e. the whole window is shadowed), it can disturb reading and other light-sensitive tasks, thus causing annoyance.

In order for a wind turbine to cause shadow flicker at a given location, the following conditions have to be satisfied. If any one of these conditions is not met, then shadow flicker will not occur, or will have a diminished impact, at that location.

- The sun must be in the correct position in the sky to cast a shadow of the turbine onto the location. This will only occur for certain times of day and days of the year.

- Wind direction will have an impact on shadow flicker impact, as the area of the shadow cast by the wind turbine will depend on which direction the wind turbine is pointing (yaw), which in turn is dependent on the wind direction.
- There has to be unobstructed line of sight between the wind turbine and the location.
- The sun must not be significantly obscured by cloud or diffused by the atmosphere (significant diffusion typically occurs for angles of less than 3° above the horizon).
- The wind turbine has to be operating (i.e. the blades rotating).
- The dimension of the part of the blade causing the shadow has to be large enough to cast significant shadow. The largest dimension of blades is the chord near the root, which may be up to 3.5 m on large turbines, and the smallest is the depth of the blade near the tip, which may be 0.3 m or less. The latter is not sufficient to cast any noticeable shadow. If the blade is edge-on to the sun, then the shadow will be very small.
- The shadow must fall over most of a room's natural light source, i.e. window or skylight. If the windows are large (compared to the size of the shadow), or do not face the wind turbine, then the room's light levels will not vary significantly.

The sun's position varies with the time of day and the time of year. This means that the locations affected by shadow flicker from wind turbines vary with the time of day and time of the year.

The shadow flicker usually occurs to the east and west of the turbines or to the south if there is a large height difference between the turbines and the observer location.

Flicker effects will be strongest closest to the WTGs, as the shadows cast by the rotating blades will be strongest. As the distance from the WTGs increases, the shadows cast by the rotor blades will become less distinct, reducing the impact of the flicker. At about 10 times the rotor diameter (1 km for a 100 m rotor diameter) the effect is reduced, and at a distance of 2 kilometres the proportion of light blocked by the WTG blades becomes so small that flicker is not discernible. Therefore, Parsons Brinckerhoff has not evaluated shadow flicker beyond 2 km from any WTG at MEWF.

1.2 Scope of work

The scope undertaken in this assessment has been agreed between Parsons Brinckerhoff and RATCH in the email *MEWF – Shadow Flicker Assessment* on 6 March 2013, and is as follows:

- Parsons Brinckerhoff will perform a shadow flicker assessment based on:
  - A single turbine layout with a single hub height and rotor diameter, as specified by RATCH;
  - Daily sunshine data from the closest or most applicable BoM site;
  - A list of coordinates of residences that RATCH wishes to be included in the assessment.
- Parsons Brinckerhoff will detail the results of this assessment in a single report, which will include:
  - A discussion of methodology and best practices;
  - A discussion on calculation inputs;
  - Documentation of the results for each residence for Worst Case Shadow Flicker per day and per year, and Realistic Shadow Flicker hours per year.

1.3 Input data

The following has been supplied by RATCH to produce the shadow flicker model:

- List of shadow receptors
- 70-WTG layout

From Parsons Brinckerhoff's previous involvement in the MEWF, additional inputs such as valid wind data and digital contours have been incorporated in the shadow flicker assessment.



2. Methodology

Parsons Brinckerhoff has used WindPRO to assess shadow flicker on supplied receptors at the MEWF. The model used for the calculation of flicker effects contains a mathematical model of the sun's position in the sky for a given location and time of year. Also contained in the model is information relating to the three-dimensional positions and sizes of the turbines and the locations where the flicker is to be calculated. This information is combined to calculate the times for which the turbine rotors will cast shadows over the locations of interest. Shadow flicker is assumed to occur when the centre of the sun passes behind any part of a turbine rotor.

A comparison between the realistic and worst case assessment assumptions are summarised in Table 2-1.

Table 2-1 Comparison of realistic and worst case scenario assumptions

Assessment assumptions		
	Realistic scenario	**Worst case scenario**
Sunlight cover	Data obtained from Walkamin Research Station.	Direct sunlight during all daylight hours (i.e. no clouds are ever experienced over the wind farm site).
WTG operational hours	Operational hours based on power curve and 9530 mast data; as a conservative measure, Parsons Brinckerhoff has not modified the power curve to account for hysteresis.	The wind turbines are always operating (i.e. it is always windy, and the turbines are never inoperable due to maintenance or faults).
WTG orientation	WTG orientation based on 9530 mast data.	The wind turbines are always turned in the horizontal plane to face the sun (i.e. the turbine rotor casts the maximum possible shadow).
WTG visibility	All the WTGs are visible except those screened by the topography.	
Maximum distance for influence	2 km	
Minimum sun height over horizon for influence	3°	
Dimensions of receptor window	Represented by a vertical rectangle facing each turbine; termed as a "Greenhouse" configuration, 10 m wide and 2 m high, centred 1.5 m off the ground (any shadow on any part of this rectangle is included in the count).	

In addition to the above assumptions, these calculations are based on the following WTG parameters:

- WTG rotor diameter 101 m
- WTG hub height 80 m (as requested by RATCH)
- WTG blade chord of 3.4 m

Parsons Brinckerhoff has considered a conservatively large receptor window of 10 m in width and 2 m in height to adequately include borderline situations where a receptor is just marginally exempt from experiencing the effects of shadow flicker. The Draft National Wind Farm Development Guidelines – July 2010 suggest that the effects of shadow flicker are dependent on the blade dimensions and recommend an assessment distance of 265 times the maximum blade chord. Based on the maximum blade chord of the Siemens 101-3.0 WTG of 3.4 m, the assessment distance is 901 m; however, Parsons Brinckerhoff has used a more conservative assumption of 2 km in this assessment to account for the varying levels of human sensitivity to the intensity of shadow flicker.

The worst case assessment for each receptor results in the number of shadow flicker hours that the dwelling could potentially experience in a year. However, the occurrence of all these assumptions at one time is considered highly unlikely as cloud cover will occur over the project site, for example. Therefore, the worst case shadow flicker results serve as a starting point from which a more realistic situation is derived using measured data from reference sites recording sunlight information.

Parsons Brinckerhoff has applied a reduction factor to account for cloud cover at the MEWF to convert the worst case shadow flicker results to a more realistic annual estimate. This is based on recorded information on sunlight and cloud cover by the Bureau of Meteorology (BoM). The closest reference site is the Walkamin Research Station, located 6 km northeast of MEWF. This information is applied to the worst case shadow flicker assessment on a monthly average basis, measured using a Campbell-Stokes device. The average daily sunshine hours for Walkamin Research Station are shown in Table 2-2.

Table 2-2: Average daylight hours per day on a monthly mean basis (Bureau of Meteorology)

Average daylight hours per day												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Walkamin Research Station	6.8	6.0	6.6	7.2	7.2	7.4	7.7	8.5	9.2	9.6	8.9	7.9

The cloud cover reduction factor is applied to the worst case results for the annual aggregate value only. The worst case shadow hours experienced in a day remains a realistic assumption as a dwelling may experience no cloud cover on the day of the year that has the maximum shadow flicker.

The location of the Walkamin Research Station relative to the MEWF site is shown in Figure 2-A.

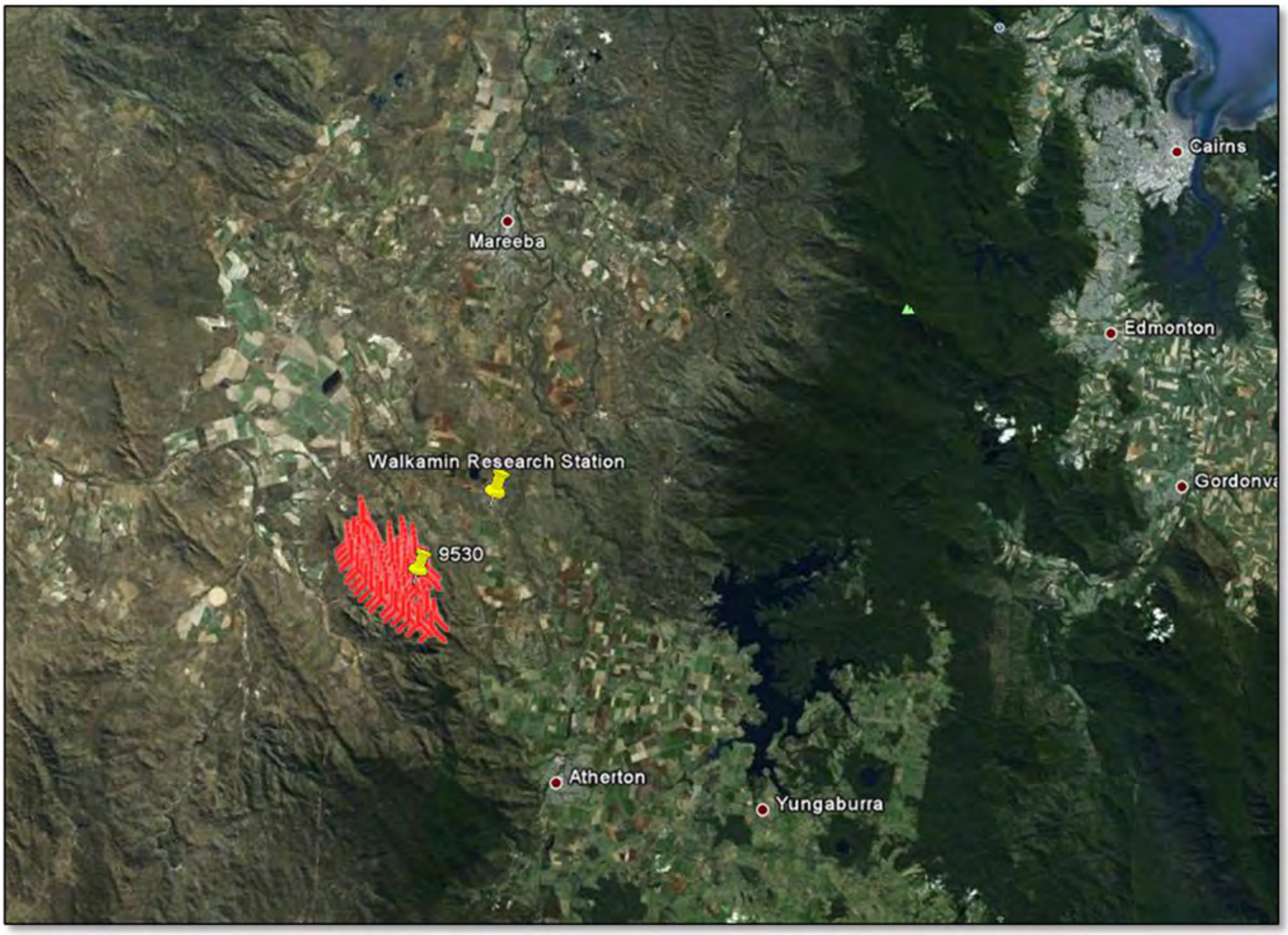

Figure 2-A Location of Walkamin Research Station (Image source: ©2010 Google, Image ©DigitalGlobe, ©2013 Google, ©2013 Whereis® Sensis Pty Ltd)

As discussed above, wind speed and direction data recorded at the 9530 mast has been used as an input to this study. The operational hours have been determined by applying the power curve to the wind speed data at 80 m, and the availability is estimated to be 97%. The operational hours per direction sector have been calculated by grouping the operational hours in 30 degree direction sectors.

The WTG power curve and operational hours per direction sector are presented in the tables below.

Table 2-3 WTG power curve

Siemens SWT3.0-101 WTG power curve		
Wind Speed	Power	Thrust Coefficient
m/s	kW	Ct
0	0	0
1	0	0
2	0	0
3	48	0.887
4	128	0.890
5	263	0.885
6	469	0.888
7	757	0.884
8	1138	0.887
9	1620	0.885
10	2189	0.872

Siemens SWT3.0-101 WTG power curve		
Wind Speed	**Power**	**Thrust Coefficient**
11	2697	0.801
12	2933	0.532
13	2991	0.391
14	2999	0.303
15	3000	0.242
16	3000	0.198
17	3000	0.165
18	3000	0.140
19	3000	0.119
20	3000	0.103
21	3000	0.090
22	3000	0.079
23	3000	0.070
24	3000	0.063
25	3000	0.056

Table 2-4 Operational hours per direction sector

Operational hours per direction sector based on 9530 data												
N	**NNE**	**ENE**	**E**	**ESE**	**SSE**	**S**	**SSW**	**WSW**	**W**	**WNW**	**NNW**	**SUM**
78	334	381	2,026	4,689	275	51	63	172	261	110	52	**8492**

3. Results

The results of the shadow flicker assessment including worst case results and realistic results using average sunshine statistics are shown below in Table 3-1 and it can be observed that none of the receptors are expected to experience shadow flicker for more than 30 hours per year in both the worst and realistic case scenarios, or 30 minutes per day in the worst case scenario. Based on these results, the calculated levels of shadow flicker caused by MEWF on the receptors listed are substantially less than the limits prescribed by the Draft National Wind Farm Development Guidelines. The shadow flicker and receptor map is shown in Appendix A.

Table 3-1 MEWF Shadow Flicker Results

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R01	327,108	8,094,240	0:00	0:00	0:00
R02	323,399	8,101,041	0:00	0:00	0:00
R03	322,551	8,100,377	0:00	0:00	0:00
R04	322,401	8,100,614	0:00	0:00	0:00
R05	325,084	8,099,119	4:24	0:13	2:22
R06	324,402	8,099,053	0:00	0:00	0:00
R07	324,438	8,098,311	0:00	0:00	0:00
R08	324,461	8,097,943	0:00	0:00	0:00
R09	324,552	8,097,638	0:00	0:00	0:00
R10	324,741	8,097,351	0:00	0:00	0:00
R11	325,824	8,096,858	0:00	0:00	0:00
R12	326,812	8,094,840	0:00	0:00	0:00
R13	322,913	8,101,970	0:00	0:00	0:00
R14	323,526	8,098,996	0:00	0:00	0:00
R15	322,190	8,101,228	0:00	0:00	0:00
R16	323,417	8,099,332	0:00	0:00	0:00
R17	321,385	8,101,835	0:00	0:00	0:00
R18	322,861	8,105,817	0:00	0:00	0:00
R19	323,237	8,105,869	0:00	0:00	0:00
R20	324,011	8,106,789	0:00	0:00	0:00
R21	327,346	8,105,105	0:00	0:00	0:00
R22	327,532	8,105,458	0:00	0:00	0:00
R23	327,320	8,105,720	0:00	0:00	0:00
R24	327,836	8,105,651	0:00	0:00	0:00
R25	328,105	8,105,059	0:00	0:00	0:00
R26	327,385	8,104,239	5:27	0:15	2:43

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R27	328,640	8,104,706	0:00	0:00	0:00
R28	328,814	8,104,996	0:00	0:00	0:00
R29	329,227	8,104,783	0:00	0:00	0:00
R30	329,632	8,104,345	0:00	0:00	0:00
R31	329,738	8,105,254	0:00	0:00	0:00
R32	329,821	8,104,154	0:00	0:00	0:00
R33	329,870	8,104,536	0:00	0:00	0:00
R34	330,044	8,104,444	0:00	0:00	0:00
R35	330,166	8,103,957	0:00	0:00	0:00
R36	330,281	8,103,655	0:00	0:00	0:00
R37	330,744	8,104,165	0:00	0:00	0:00
R38	331,053	8,103,796	0:00	0:00	0:00
R39	331,012	8,103,431	0:00	0:00	0:00
R40	331,286	8,103,732	0:00	0:00	0:00
R41	331,610	8,103,457	0:00	0:00	0:00
R42	331,773	8,103,467	0:00	0:00	0:00
R43	331,900	8,103,216	0:00	0:00	0:00
R44	332,241	8,103,249	0:00	0:00	0:00
R45	332,142	8,103,035	0:00	0:00	0:00
R46	331,667	8,102,969	0:00	0:00	0:00
R47	331,836	8,102,949	0:00	0:00	0:00
R48	331,981	8,102,675	0:00	0:00	0:00
R49	331,555	8,100,953	8:39	0:13	4:53
R50	333,099	8,102,820	0:00	0:00	0:00
R51	333,372	8,102,564	0:00	0:00	0:00
R52	333,849	8,102,111	0:00	0:00	0:00
R53	333,977	8,101,981	0:00	0:00	0:00
R54	334,001	8,101,907	0:00	0:00	0:00
R55	334,143	8,101,119	0:00	0:00	0:00
R56	334,828	8,100,860	0:00	0:00	0:00
R57	332,290	8,102,160	0:00	0:00	0:00
R58	333,082	8,100,051	0:00	0:00	0:00
R59	332,424	8,099,580	0:00	0:00	0:00
R60	332,526	8,098,770	0:00	0:00	0:00
R61	333,441	8,099,268	0:00	0:00	0:00
R62	332,750	8,099,348	0:00	0:00	0:00
R63	333,180	8,098,115	0:00	0:00	0:00
R64	333,966	8,098,486	0:00	0:00	0:00
R65	334,769	8,098,473	0:00	0:00	0:00
R66	333,273	8,097,584	0:00	0:00	0:00
R67	333,769	8,097,741	0:00	0:00	0:00
R68	333,818	8,097,418	0:00	0:00	0:00
R69	333,759	8,097,284	0:00	0:00	0:00
R70	333,858	8,097,008	0:00	0:00	0:00
R71	333,837	8,096,819	0:00	0:00	0:00
R72	334,122	8,096,447	0:00	0:00	0:00
R73	334,300	8,097,467	0:00	0:00	0:00

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R74	334,315	8,097,097	0:00	0:00	0:00
R75	334,312	8,096,814	0:00	0:00	0:00
R76	334,510	8,096,570	0:00	0:00	0:00
R77	333,420	8,095,349	0:00	0:00	0:00
R78	327,662	8,103,902	9:49	0:14	5:00
R79	326,084	8,095,615	0:00	0:00	0:00
R80	326,633	8,095,887	0:00	0:00	0:00
R81	322,227	8,102,228	0:00	0:00	0:00
R82	328,862	8,104,954	0:00	0:00	0:00
R83	331,064	8,103,659	0:00	0:00	0:00
R84	328,138	8,105,207	0:00	0:00	0:00
RANGEVIEW	335,269	8,097,070	0:00	0:00	0:00
WALKAMIN	332,711	8,105,470	0:00	0:00	0:00
R87	324,029	8,106,539	0:00	0:00	0:00
R88	325,804	8,107,243	0:00	0:00	0:00
R89	324,925	8,104,393	0:00	0:00	0:00
R90	323,839	8,105,103	0:00	0:00	0:00
R91	333,946	8,102,712	0:00	0:00	0:00
R92	334,049	8,103,397	0:00	0:00	0:00
R93	333,585	8,103,544	0:00	0:00	0:00
R94	333,738	8,103,749	0:00	0:00	0:00
R95	333,737	8,103,972	0:00	0:00	0:00
R96	333,543	8,104,296	0:00	0:00	0:00
R97	333,476	8,104,424	0:00	0:00	0:00
R98	333,652	8,104,597	0:00	0:00	0:00
R99	332,659	8,104,989	0:00	0:00	0:00
R100	332,380	8,105,473	0:00	0:00	0:00
R101	332,447	8,105,917	0:00	0:00	0:00
R102	333,013	8,104,126	0:00	0:00	0:00
R103	332,934	8,104,276	0:00	0:00	0:00
R104	332,397	8,104,339	0:00	0:00	0:00
R105	330,771	8,106,228	0:00	0:00	0:00
R106	330,687	8,106,366	0:00	0:00	0:00
R107	330,802	8,106,936	0:00	0:00	0:00
R108	331,175	8,107,484	0:00	0:00	0:00
R109	328,594	8,107,639	0:00	0:00	0:00
R110	328,212	8,107,130	0:00	0:00	0:00
R111	328,314	8,106,195	0:00	0:00	0:00
R112	327,666	8,106,205	0:00	0:00	0:00
R113	327,055	8,106,025	0:00	0:00	0:00
R114	327,675	8,108,169	0:00	0:00	0:00
R115	327,309	8,108,440	0:00	0:00	0:00
R116	324,316	8,109,076	0:00	0:00	0:00
R117	320,884	8,102,947	0:00	0:00	0:00
R118	321,231	8,101,117	0:00	0:00	0:00
R119	321,148	8,101,136	0:00	0:00	0:00
R120	321,240	8,101,684	0:00	0:00	0:00

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	**Northing**	**h/year**	**h/day**	**h/year**
R121	319,947	8,100,527	0:00	0:00	0:00
R122	333,913	8,094,653	0:00	0:00	0:00
R123	334,862	8,095,248	0:00	0:00	0:00



4. Bibliography

Bureau of Meteorology. (2013). *Climate statistics for Australian locations; Walkamin Research Station.* Retrieved 3 7, 2013, from http://www.bom.gov.au/climate/averages/tables/cw_031108.shtml

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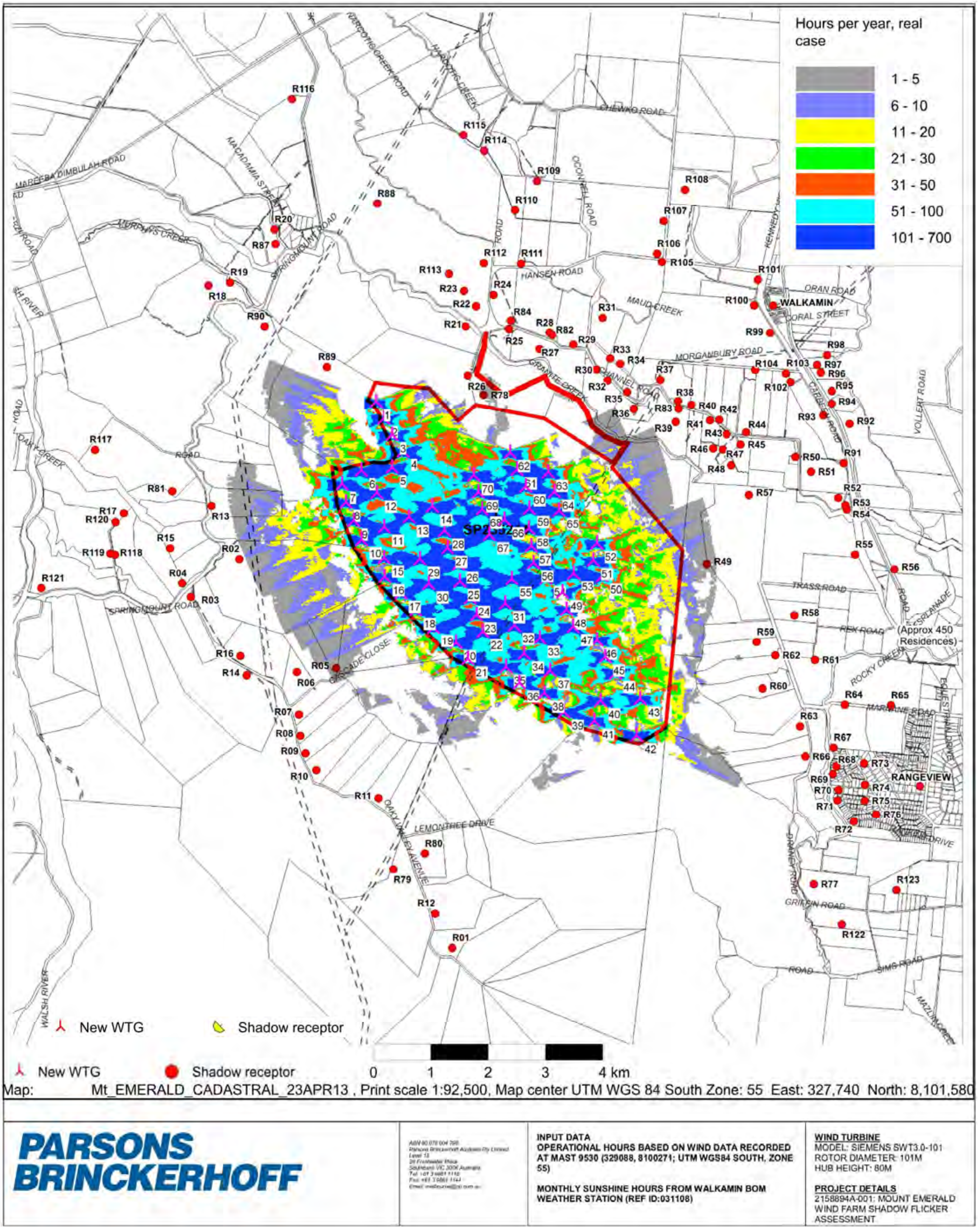
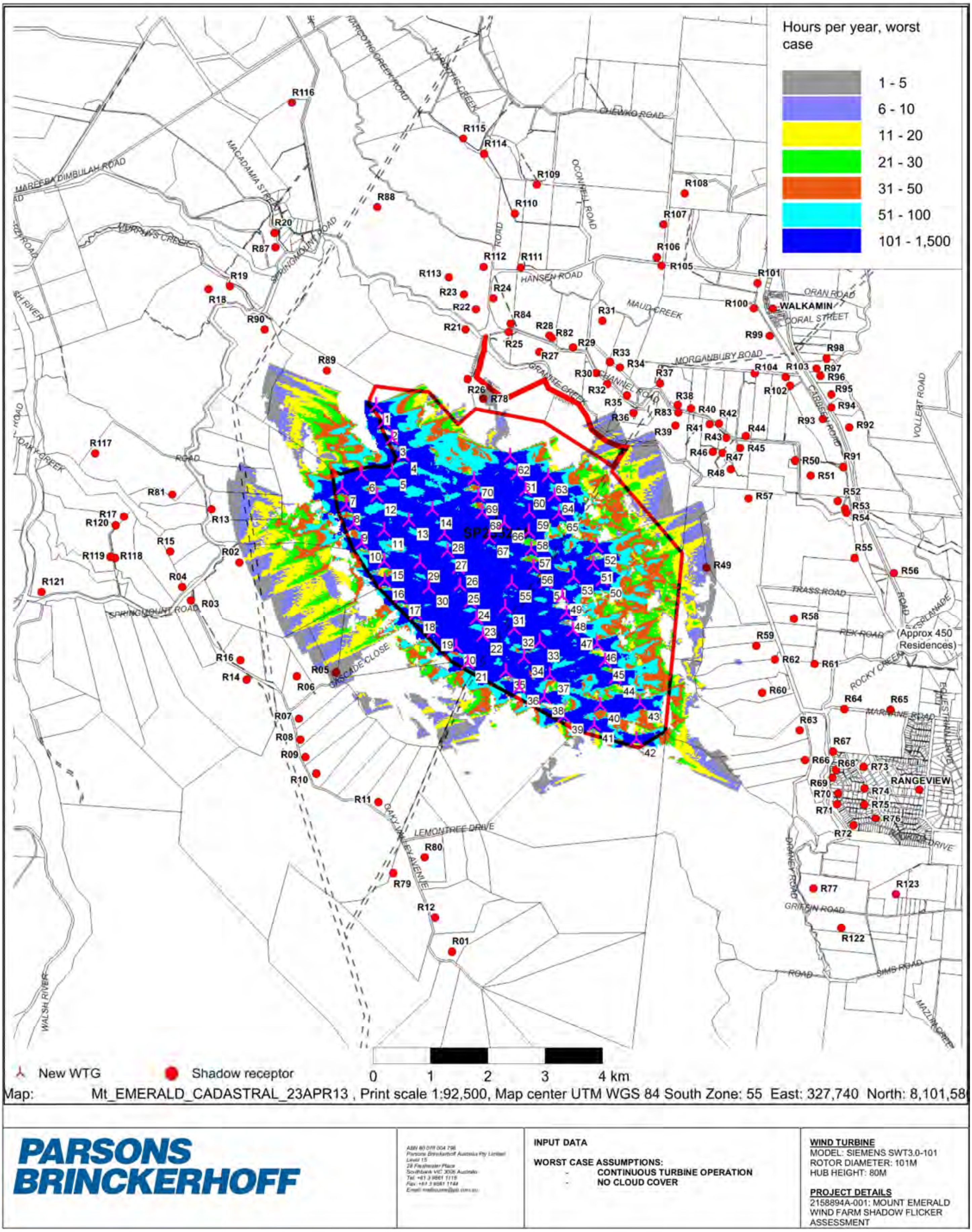
Appendix A

Shadow flicker maps

PARSONS BRINCKERHOFF



Appendix A.1: Mount Emerald shadow flicker map of realistic case shadow flicker hours with receptor locations.



Appendix A.2: Mount Emerald shadow flicker map of worst case shadow flicker hours with receptor locations.

Appendix B

WTG Layout (supplied by RATCH)

70 WTG Layout (supplied by RATCH)		
WTG number	Easting	Northing
	UTM WGS 84, Zone 55	
1	325792	8103791
2	325927	8103500
3	326071	8103211
4	326263	8102926
5	326071	8102642
6	325535	8102589
7	325197	8102351
8	325266	8102037
9	325402	8101713
10	325539	8101383
11	325930	8101603
12	325803	8102201
13	326364	8101775
14	326771	8101965
15	325931	8101065
16	325941	8100734
17	326222	8100448
18	326484	8100150
19	326793	8099845
20	327187	8099577
21	327392	8099290
22	327652	8099773
23	327542	8100066
24	327436	8100361
25	327254	8100649
26	327232	8100956
27	327039	8101238
28	326982	8101539
29	326556	8101046
30	326708	8100606
31	328045	8100267
32	328206	8099881
33	328648	8099655
34	328376	8099384
35	328058	8099149
36	328292	8098872
37	328824	8099088
38	328726	8098695
39	329067	8098362
40	329705	8098561
41	329600	8098212
42	330338	8097956
43	330401	8098594
44	329970	8099041
45	329790	8099328
46	329648	8099620
47	329228	8099859

70 WTG Layout (supplied by RATCH)		
WTG number	Easting	Northing
48	329113	8100157
49	329043	8100457
50	329738	8100745
51	329581	8101021
52	329644	8101320
53	329242	8100793
54	328753	8100703
55	328157	8100695
56	328537	8100981
57	328498	8101272
58	328458	8101575
59	328466	8101926
60	328402	8102310
61	328248	8102601
62	328130	8102902
63	328792	8102560
64	328903	8102219
65	328983	8101892
66	328031	8101732
67	327768	8101472
68	327640	8101915
69	327574	8102211
70	327496	8102505

Appendix 31

Desk Study for Potential Historic Unexploded Ordnance Contamination

Prepared by RPS Explosives Engineering Services

RPS

RATCH Australia Corporation Limited

Mt Emerald Wind Farm, Arriga, Queensland

Desk Study for Potential Historic Unexploded Ordnance Contamination

Date:	16th January 2013
Project Ref:	EES0394
Report No:	EES0394-R-01-02

RATCH Australia Corporation Limited

Mt Emerald Wind Farm, Arriga, Queensland

Desk Study for Potential Historic Unexploded Ordnance Contamination

Prepared by:
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16th January 2013

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PROJECT REF: EES0394		**REPORT NUMBER:** EES0394-R-01-00	**REPORT TITLE:** Desk Study for Potential Historic Unexploded Ordnance Contamination		
DATE	**VERSION**	**DESCRIPTION**	**PREPARED**	**CHECKED**	**APPROVED**
15.01.13	01	Initial	Brendan Twine	Lawrence Millett	
16.01.13	02		Brendan Twine		

Contents

Appendices

Glossary

ADF	Australian Defence Force
Allied Forces	The Allies of World War II were the countries officially opposed to the Axis powers during the Second World War
bgl	Below Ground Level
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
HE	High Explosive
Kg	Kilogram
mbgl	Metres Below Ground Level
RPS	RPS Group
SI	Site Investigation
Sqm	Square Metres
UXO	Unexploded Ordnance
WWII	Second World War (1939 – 1945)

Terminology

Explosive Ordnance Disposal (EOD) - The detection, identification, evaluation, rendering safe, recovery and disposal of UXO.

Fuze- A designed and manufactured mechanism to activate munitions. It can be designed for use by electrical, chemical or mechanical systems, by push, pull, pressure, release and time activation, singly or in combination. Usually consists of an ignite and detonator.

High Explosive (HE) - An explosive that normally detonates rather than burns; that is, the rate of detonation exceeds the velocity of sound.

Initiation - A physical process that sets in motion a cascade of chemical reactions of ever increasing energy (the explosive chain) that will eventually generate sufficient energy (the velocity of detonation) to allow the main charge to detonate in a violent, explosive chemical reaction, releasing energy in the form of heat and blast.

Unexploded Ordnance (UXO) - Explosive Ordnance that has been primed, fuzed, armed or otherwise prepared for action, and which has been fired, dropped, launched, projected or placed in such a manner as to constitute a threat to the safety and/or security of people, animals, property or material and remains unexploded either by malfunction or design or for any other reason.

UXO Contamination - UXO that is present, within any given physical context that is considered to be an impediment to the safe on-going or intended use of a facility, including geological features. Safety in this instance is measured against an acceptable level of exposure to the potential risks that UXO present.

Executive Summary

SITE DESCRIPTION

The proposed works consist of the construction of the Mt Emerald Wind Farm, comprising 75 individual wind turbines at Arriga, Far North Queensland. Once constructed, the facility will span the Herberton Range on the Atherton Tablelands, west of the Kennedy Highway between Atherton and Walkamin, approximately 50km southwest of Cairns, Queensland.

The proposed works will take place in a rural zoned area with adjoining regional landscape territory occupied by access roads, water infrastructure and power transmission lines. Active farmland borders the northern and eastern boundaries of the site with the nearest residential building in excess of 1000m from the proposed works.

POTENTIAL SOURCES OF CONTAMINATION

RPS has assessed that there may be the following potential types of Unexploded Ordnance (UXO) contamination on site, which are detailed below:

- ***Allied Mortars and Grenades* –** It has been identified that the proposed site was formally utilised for live firing purposes by Allied forces during training and deployment phases of World War II. As such, there is the potential for High Explosive (HE) Mortars (primarily 2, 3 and 4.2 inch) and hand grenades to have landed within the boundaries of the project site.

RISK ASSESSMENT

Based on the identified and available information, it has been determined that there is a risk from UXO during the potential future works being undertaken at the site, with the highest identified risk being **High** from Allied projected ordnance.

RPS has identified that a high level of Allied firing practices occurred in and around the project area, with one dedicated HE impact area within the boundaries of the site. State and Federal records confirm the presence of numerous firing points, areas where mortars would be fired *from*, in conjunction with recoded discoveries of UXO in close proximity to the site.

Due to the nature of the site, being predominantly rural regional landscape, it is considered unlikely for any UXO landing / penetrating the ground in such areas to have been readily identified, and as such may have remained until the present day.

RECOMMENDATIONS FOR FUTURE INTRUSIVE WORKS

Based on the risk assessment carried out for the site, RPS recommended that the following mitigation strategies be implemented in support of works taking place on site:

- ***Explosives Safety & Awareness Briefings / Explosives Site Safety Guidelines*** - It is recommended that all personnel conducting intrusive works should attend an ***Explosives Safety & Awareness Briefing***.

- ***Explosives Engineer Supervision*** - It is recommended that an Explosives Engineer should be present during any excavations/trial pits taking place at the site.

- ***Intrusive Magnetometer Survey -*** it would be prudent to conduct an intrusive Magnetometer survey ahead of proposed piling and borehole locations across the site to reduce the risk of encountering deep buried UXO. The type of survey methodology required would be dependent upon ground conditions and the works taking place.

- ***Non-Intrusive Magnetometer Survey -*** As an alternative to *Explosives Safety Engineer Supervision*, and considering the specific conditions on site, it may be feasible to carry out a Non-Intrusive Magnetometer survey ahead of shallow excavations/works in certain areas.

- ***Final Works Programme -*** RPS EES would recommend that, once the full extent of the works has been confirmed / finalised, we are contacted to discuss the most suitable mitigation approach. RPS would take into account further details regarding the specific locations, site conditions and methodologies of the proposed works to determine the most practical and pragmatic approach available to deliver the required mitigation.

1 Introduction

1.1 Instruction

RPS Explosives Engineering Services (RPS EES), part of RPS Energy Ltd, has been commissioned by RATCH Australia Corporation to conduct a desktop study for potential historic Unexploded Ordnance (UXO) contamination for the proposed Mt Emerald Wind Farm, Arriga, Far North Queensland.

1.2 Scope of Work

This study comprises a desk-based collation and review of available documentation and records relating to historic ordnance and live firing activities. Certain information obtained by RPS EES is either classified or restricted material or considered to be confidential to RPS EES. Therefore summaries of such information have been provided.

The purpose of this study is to assess the likelihood of buried historic air delivered ordnance and/or unexploded ordnance (UXO) related items to be present within the footprint of the site. Moreover, to then evaluate the implications of potential items during any future land use.

The site is considered to offer a potential explosives risk based on the following:

- ***Allied Live-Fire Practices* –** Sections of this site were regularly utilised by Allied forces as live fire ranges during pre-deployment training throughout World War II.

1.3 Definitions

The term ’site’ refers to the area encompassing the extent of the works associated with the proposed Mt Emerald Wind Farm site in Arriga. This report will generally focus on activities that occurred on site and its immediate surroundings. A location map is presented at *Appendix 001*, which details the extent of the site.

1.4 Reporting Conditions

It must be emphasised that a desk study can only indicate the potential for UXO related items to be present on site; a geophysical survey and subsequent intrusive investigation may be necessary to provide confirmation of any potential UXO contamination, and may be advisable prior to any future redevelopment. This desk study did not involve any non-intrusive survey or intrusive site investigation works.

Please note that our appraisal relies on the accuracy of the information contained in the documents consulted and that RPS EES will in no circumstances be held responsible for the accuracy of such information or data supplied.

1.5 Objectives

The primary objective of this document is to ensure the safety of personnel and civilians in the vicinity of the site, with regard to any impacts from potential UXO contamination and to identify the potential risk of uncovering either buried unexploded ordnance or explosive devices.

1.6 Legislation

Whilst undertaking this desk study the requirements of the following articles of legislation were considered:

- Environmental Protection Act (Queensland) 1994
- Explosives Act (Queensland) 1999
- Work Health and Safety Act 2011

In accordance with the definitions of the Environmental Protection Act (Queensland) 1994, UXO is considered a contaminant under the scope of the legislation, but not a hazardous contaminant according to the regulations, and requires that the contaminant be handled as such.

The Explosives Act (Queensland) 1999 does not specifically relate to Commonwealth (Military) explosives and UXO, but rather to the safety procedures and requirements associated with the storage and transport of items containing explosive compounds. Even though this legislation is not directly applicable to site works where UXO may be encountered, there are several pertinent points which may be borne in mind when undertaking works on sites which pose a risk from encountering UXO, for example:

- Before an employer employs someone to do something allowing the employee to have access to explosives, the employer must ensure, as far as practicable, the person is an appropriate person.

- A person must not store or hold an explosive at a place other than on licenced premises by a licenced person.
- A person who is doing an act involving explosives must take reasonable precautions and use reasonable care to avoid endangering any person's safety, health or property

Work Health and Safety Act 2011 highlights the requirement to ensure that;

- Any person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of its workers.

- In addition any dangerous incident, such as an uncontrolled explosion as described in the Act is a reportable incident that must be reported to Workplace Health and Safety authorities.

Although the Work Health and Safety Act 2011 and the Explosives Act (Queensland) 1999 do not specifically require a search for unexploded ordnance, there is an obligation on those responsible for intrusive works to ensure that comprehensive assessment and risk mitigation measures are enforced with regard to all underground hazards on site.

These points reinforce that when significant risks from UXO are identified on a site, it is essential for proper procedures to be put in place. In higher risk scenarios it is essential for trained Explosives Safety Personnel to be present on site to mitigate the risks, and be on hand to handle the situation in the event of a suspicious item/UXO discovery.

2 Research

2.1 Research Objectives

Research into the history of the site and its immediate surroundings, has been undertaken to establish the following:

- Review of military activity in the area.
- Records of Explosive Ordnance Clearance tasks or bomb disposal activities during and after WWII.
- The potential for UXO to remain on site.

2.2 Sources of Information

The main sources of information consulted included:

- RPS related site records.
- RPS Company records.
- State and Local Government records.
- National Archives.
- Historic maps, photographs and records.
- Internet Research.

2.2.1 Supplemental Sources of Historical Information Consulted

The following additional sources were consulted for general background information.

Wilson, P (1988) North Queensland – WWII 1942-1945. Department of Geographic Information: Brisbane

Plunkett, G (2007) Chemical Warfare in Australia. Australian Military History Publications: Loftus

3 Site Details and Description

3.1 Site Location & Description

The proposed works consist of the construction of the Mt Emerald Wind Farm, comprising 75 individual wind turbines in Far North Queensland. Once constructed, the facility will span the Herberton Range on the Atherton Tablelands, west of the Kennedy Highway between Atherton and Walkamin, approximately 50km southwest of Cairns, Queensland.

The proposed works will take place in a rural zoned area with adjoining regional landscape territory occupied by access roads, water infrastructure and state power transmission lines. Active farmland borders the northern and eastern boundaries of the site with the nearest residential building in excess of 1000m from the proposed works.

RPS has identified the Powerlink Chalumbin to Woree 275kV transmission line that traverses the Herberton Range within the boundaries of the project site. In the event that an uncontrolled high order detonation occurs this infrastructure may be subject to damage from flying debris. Whilst the chances of this event occurring remain low, it would be prudent to maintain awareness of this local infrastructure whilst conducting invasive works.

Due to the remote nature of the site and the limited intrusive works that have thus far been conducted since the introduction of UXO, educated assumptions have been made with regards to surface and sub-surface conditions in the region. Commissioning of intrusive site investigations and associated survey works would permit the establishment of baseline data, improving the accuracy of the depth penetration assessments contained within this document as well as establishing real time data as to the condition and volatility of any identified UXO improving risk assessment outcomes.

3.2 Geology

One of the most important factors in assessing the maximum ordnance penetration depth is to establish the site geology. The ground conditions will predominately determine the path of ordnance. Furthermore, the consistency and thickness of any pre WWII made ground should be considered, as this would have the potential to significantly limit the penetration. The ordnance penetration assessment will be discussed later in this report.

RPS understands at the time of writing that no detailed geotechnical study has been conducted of the Mt Emerald site, limiting the ability to estimate ordnance penetration depths. Once a data set of geotechnical information has been established RPS should be contacted to refine ordnance penetration predictions.

3.3 Historical Mapping

RPS EES has reviewed a series of historical maps, excerpts presented at *Appendix 002 and 003*, which cover the immediate area of the site. These have been reviewed to identify historic site conditions and usage (where possible), in light of the potential for UXO contamination. Information gleaned is as follows:

3.3.1 1943 (1:63,360)

This map shows the site to be bush land removed from local infrastructure. Roads to the north of Granite Creek depict access to framing structures and the gravel pit can be seen to the east. The vintage of this document correlates with the 1943 build-up of Allied forces in the region.

3.3.2 1982 (1:10,000)

No notable infrastructure developments within the project area. This excerpt does not show the Chalumbin to Woree transmission lines due to the projects 1998 completion date.

3.4 Summary

The maps reviewed show that there have been few changes to the general vicinity of the site since its employment by Allied forces as a live firing range. In support of Powerlink’s Chalumbin to Woree transmission lines a number of support towers were erected onsite, however no additional alterations or invasive works have been made. Due to the rural nature of the site, minimal development has taken place within the project footprint resulting in a largely unaltered state of the site.

4 Military Positions

4.1 General

The Atherton Tablelands was a strategically significant staging area for Allied forces during the second half of World War II. In excess of 100,000 troops passed through the area between 1942-1945 for pre-deployment or repatriation purposes where the region experienced significant exposure to live firing practices and subsequent potential UXO contamination.

Reports indicate that given the scale of operations in the vicinity of the project site the north western sector experienced heavy bombardment by Allied mortar forces resulting in significant UXO contamination. Despite Japanese attacks on the Australian mainland during WWII no direct bombing of the project site or surrounding lands took place. The nearest enemy bombing took place 75km North at Mossman, well outside the boundaries of the project.

4.2 Allied Camp Proximity

Tolga, 7km ESE of the southern end of the project boundary, was home to the 13th Army Advanced Ordnance Depot as well as the Rocky Creek Military Hospital, the largest military hospital in the country during the Allied services occupation of the Atherton Tablelands. As a result the Australian Defence Force (ADF) has categorised the eastern face and adjacent lowlands of Mt Emerald as both ‘Substantial’ and ‘Slight’ for the possibility of containing UXO contamination. Records show that areas subject to camp conditions of WWII era are prone to UXO discovery outside of those areas designated as firing ranges as ground forces were often prone to casual contamination of their surrounds.

4.2.1 Mortar Firing Positions

Mortar firing positions were located within the vicinity of the project site for the purpose of troop training and firing practice and were the primary source of site related UXO contamination. 2, 3 and 4.2 inch mortars were the primary choice of mortar weapon of Allied troops during WWII with a variety of ordnance options for these armaments.

The closest recorded mortar firing positions are detailed approximately as follows:

Mortar Firing Positions in the Local Area			
Location	**Approximate Distance from Site**	**Approximate Grid Reference Lat , Long**	**MGRS**
Firing Point #1	0.3km E	17°09'50"S, 145°24'54"E	55K CB 3141601626
Firing Point #2	0.3km E	17°09'54"S, 145°24'49"E	55K CB 3127001502
Firing Point #3	1.5km E	17°12'13"S, 145°25'52"E	55K CA 3316697244

Table 4.2.1 - Locations of Nearby Mortar Positions

The table presented above is not exhaustive of all mortar sites found within a 5km radius of the site however, it does represent the known and recorded locations and highlights the active nature of the impact areas situated around Mt Emerald. 2in and 3in mortars had an approximate maximum range of 500yds and 1,600yds respectively which corresponds with the recorded 'substantial' contamination of selected areas of the site.

In addition, artillery weapons were in frequent use on the Atherton tableland during the 1943-1945 period. With an approximate range of 16.5km for British 5.5inch Guns, it is conceivable that artillery ammunition could be found within the site boundaries, however no specific evidence has been uncovered to suggest their presence in the direct vicinity.

4.3 Training Ranges / Areas

Live firing or training ranges can include permanent facilities such as Rifle or Small Arms Ranges, Artillery Ranges or Close Assault Training / Battlefield Training Areas. RPS have reviewed military administrative maps, dated 1945, which depicts locations that were used for military training exercises in the region. Supporting these maps are ADF findings highlighting the existence of a mortar/grenade range within the project boundaries as presented in *Appendix 004*. Nine confirmed UXO contamination sites have been identified in vicinity of Tinaroo_Tolga with the Walkamin Mortar/Grenade range situated in the north-eastern quadrant of the project site as the closest source of 'substantial' contamination.

4.4 Document Limitations

Records of firing ranges, ordnance stores and the locations of UXO were rarely released into public domain in the interest of security and public safety. Furthermore, details relating to these records are often difficult to locate. Types of munitions fired within the boundaries of the site was not accurately recorded during the period the live firing range was active and as such accurate ratios of ordnance types likely to be found remains unknown. A lack of population density and associated invasive works in the immediate vicinity also lends the accuracy of information towards partial at best.

Requests for information submitted to the National Archives and the Australian War Memorial remain extant however due to 30-90 day wait times for some information requests are still pending. In some instances the information request has yet to vetted for public release compounding already lengthy delays. In light of these delays eye witness reports have been considered alongside compelling available data in support of these findings compiled and were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow..

4.4.1 WWII Records & Statistics

RPS records indicate that Allied forces fired an extensive variety of High Explosive (HE) filled mortars ranging in size from the relatively small 2lb man-portable mortar through to the 4.2lb vehicle mounted variety. The 4.2inch mortar was equipped with a chemical weapon capable munitions', however as discussed below no evidence was discovered to suggest that chemical weapons were fired and/or landed within the boundaries of the site.

Available records suggest that the majority of projectiles fired were HE or incendiary in nature. It remains widely accepted that a small percentage of approximately 10% of ammunition fired failed to function as designed resulting in the current situation of UXO contamination.

4.4.2 Chemical Weapon Storage and Use

Historical records confirm the use of chemical weapons, in particular mustard gas, in vicinity of the Atherton Tablelands throughout the 1940's. Weapons trials conducted in Innisfail, 120km SE of the project site, remained isolated to the township and surrounding bush lands for trials and training purposes. Once commercially manufactured these chemical weapons were stored within armament storage depots throughout the region and no evidence was located to suggest that chemical ordnance were fired within the vicinity of the site. Since the cessation of hostilities chemical ordnance has been discovered and reported to authorities within close proximity to active ordnance depots, such as the depot located in Tolga, 6km east of the project.

4.4.3 WWII UXO Mapping

RPS has reviewed a selection of WWII UXO mapping data for the Walkamin area. This data, under the management of the Australian Defence Force, relates to the area of Walkamin and Tolga and remains sensitive in nature. Excerpts of this data have been reproduced at *Appendix 004* marking the suspected contaminated sections in the vicinity of the impact area. Note that this data represents UXO discoveries reported to authorities by the public and that no known UXO has been reported. Military units and affiliated organisations have compiled this data resulting in the 'substantial' contamination level for this area without reporting individual ordnance discoveries.

5 Ordnance Details

5.1 Projectiles (Mortars)

Mortars come in many shapes and sizes depending on the intention of the firing mission. Generally, all these munitions are constructed the same and consist of a metal container (iron construction), a fuze (often in the nose of the projectile), and a stabilizing device or fin. The metal container (called the bomb body) holds the high explosive content. Once fired the body may appear in one or in multiple pieces. Examples of Allied High Explosive Mortars are presented at *Appendix 005*.

The main components of a mortar are:

- ***Mortar Body –*** This is the main item referred to as Unexploded Ordnance (UXO). Mortars will have a typical projectile (large bullet) shape with parallel sides in the front with a metal 'tail' section. Given the age and environmental conditions most mortars are found corroded and difficult to recognise. It is possible to mistake them for agricultural or water pipe.

- ***Tail Unit (Spigot) –*** As the UXO impacts with the ground this section often breaks off. The presence of a tail unit may indicate that UXO is buried at depth in the region.

- ***Fuze –*** Allied mortars commonly contained a mechanical or powder train fuse in the nose of the projectile. This fuse is considered the most dangerous component of the ordnance, however due to exposure to the elements over extended periods fuses can often appear considerable different to their original design and remain unpredictable.

5.1.1 High Explosive Munitions

This variety of munitions consisted primary of a HE payload for the purpose of producing blast and fragmentation effects upon it target. HE munitions present the largest explosive threat likely to be encountered within the project boundaries.

- ***2, 3 and 4.2 inch HE Mortar* -** The diameter ranges from 2–4.2 inches, and overall length not greater than 22 inches. The primary ewxplosive fill is Amatol/TNT.

5.1.2 Incendiary / Smoke / Illumination Munitions

This category of munitions usually consisted of a small component HE but a primary payload of phosphorous like compound for the purpose of producing intense flame or smoke. Similarly, illumination rounds were designed to illuminate the battlefield in a 'floating star' arrangement suspended below a parachute. These munitions have similar characteristics to HE mortars with their own unique hazards.

- ***2, 3 and 4.2 inch HE Mortar* -** The diameter ranges from 2–4.2 inches, and overall length not greater than 20.4 inches. The primary explosive fill is phosphorous compound.

5.1.3 Chemical Munitions

As discussed previously RPS is not aware of any chemical weapons being fired or identified within the boundaries of the site. Having dimensions and characteristics similar to smoke / illumination 4.2 inch projectiles, the 4.2 inch armament was the only mortar weapon in use in vicinity of the project site capable of firing chemical munitions.

- ***4.2 inch Chemical Mortar* -** The diameter is 2 inches, and over-all length 20.4 inches. The fill is an unspecified quantity of chemical irritant.

5.1.4 Grenades

Grenades likely to be discovered in the region consist of relative simple construction and firing mechanisms. Designed to be thrown by infantry soldiers grenades are considerably smaller than mortars and contain greatly reduced HE payloads. In use by Allied forces at the time and having been recovered by authorities throughout the region since 1945 were the British No. 69 and 36M grenades and the US Mk. II. Unlike mortars, grenades are smaller by design and subsequently will be difficult to identify on site.

- ***HE Grenades* –** Average diameter is 60mm, and average over-all length 60mm. The average fill is 0.90kg of Baratol or TNT high explosive.

6 Ordnance Ground Penetration

6.1 Background on Ordnance Penetration Depths

There are a number of factors applicable to predicting ordnance penetration depths, which can lead to variations in the penetration depths for projected ordnance, as follows:

- ***Shape & Weight of Ordnance –*** variations in the design of the delivered ordnance has a large impact on the depths to which it is able to penetrate. Generally speaking, the heavier the ordnance, the deeper the penetration, and when constructed in a streamlined shape this can also lead to an increased penetration depth.

- ***Geological Strata –*** variations in the composition, thickness and homogeneity of the geological strata can lead to significant variations in penetration depths.

- ***Height of delivery –*** the altitude at which the ordnance was released can lead to variations in the final penetration depth. A factor often considered for air delivered weapons, however is less prevalent for ordnance fired/delivered from ground level.

- ***Deflection –*** should an item of ordnance impacted onto an obstruction / structure prior to penetration into the ground, it may have deflected and as such behaved anomalously upon penetration, and thus the final resting position may potentially be atypical to what is normally expected.

The following table provides a guide on probable penetration depths of bombs in geological conditions that are likely to be expected in the region:

TYPICAL PROJECTILE PENETRATION DEPTHS				
GROUND TYPE		*Limestone*	*Sand*	*Clay*
PROJECTILE WEIGHT	2.2lb	0.03m	0.12m	0.24m
	10lb	0.21m	1.5m	3m
	20lb	0.33m	2.3m	4.7m

Table 7.1 Projectile Penetration Depths

The above information assumes:

a) That the projectile is stable in flight and on penetration.

b) That the soil type is homogenous.

6.1.1 UXO 'Offset'

Unlike the majority of air delivered weapons, mortars commonly impact the ground with a near vertical aspect reducing the offset associated with aerial delivery. The distance between the centre of the entry hole and the centre of the projectile at rest is known as the 'offset'. A marked lateral movement from the original line of entry is not uncommon. The average offset is one third of the penetration depth. Hard standing on the impact zone can result in an offset increasing by some four times.

6.2 Background on Ordnance Penetration Depths

6.2.1 General

When assessing the potential for ordnance ground penetration it is essential not to rely solely on either an empirical, statistical and arithmetical formula. Experience has shown that a realistic depth is gained by considering the above approaches supplemented by accounts of Bomb Disposal Tasks in the area.

6.2.2 High Explosive Bombs

For this assessment RPS has used a British 20lb HE Mortar Projectile as the benchmark for the maximum ordnance penetration, as this was the largest of the common munitions used on this range.

In the absence of geotechnical data for this site it should be considered that the maximum projectile penetration depth for the site is likely to be approximately up to **4.7m below ground level (bgl)**, dependant on the specific geological conditions encountered on a location by location basis. In addition, it should be noted that any penetrating UXO may have come to rest anywhere between ground surface and their maximum penetration depth.

Should mitigation be required on site, where applicable and possible, the bomb penetration depth may be able to be assessed by UXO personnel in attendance, on a location by location basis, when the sub surface strata become exposed.

Penetration depths detailed in the table and above are generic in nature. If levels have changed significantly since the creation of this data, this could have an effect on the likely depths that unexploded ordnance could be present relative to current ground levels in the area of the site.

7 Unexploded Bombs

Since the end of WWII, there have been a limited number of recorded incidents in the Australia where ordnance have detonated during engineering works, though a significant number of bombs have been discovered.

The major effects of partial or full detonation of a device are shock, blast, heat and shrapnel damage. It should be noted that the detonation of a 50kg buried bomb would damage brick or concrete structures up to 16m away and unprotected personnel on the surface up to 70m away. Larger ordnance is obviously more destructive, with an accepted safety distance for a 500kg HE device being 1km.

Once initiated, the effects of the detonation of explosive ordnance such as shells or bombs are usually extremely fast, often catastrophic and invariably traumatic to the personnel involved. The degradation of a shell or bomb may also offer a source of explosive contamination into the underlying soils. Although this contamination may still present an explosion hazard, it is not generally recognised that explosives offer a significant toxicological risk at concentrations well below that at which a detonation risk exists.

Unexploded bombs do not typically explode without outside disturbance under the environmental conditions experienced in Australia. UXO has lain un-disturbed for some 60 years and should not detonate unless they are significantly disturbed. All HE requires significant energy to create the conditions for detonation to occur. Intense impacts in intrusive engineering such as drilling/piling and mechanical excavations could initiate a detonation. There are a number of scenarios that may occur on sites which may potentially lead to the detonation of an encountered item of UXO, as follows:

- ***Direct impact upon the main body of the UXO*** – needs to be significant impact e.g. In the case of piling or large scale excavations.
- ***Restarting clock timer in a fuze*** – contact or vibration applied to a clock timer, in certain situations, may cause it to reinitiate. However, in the case of WWII (and pre-WWII) ordnance it is likely that such devices would be corroded and no longer able to function.
- ***Initiating Fuze Explosive*** – environmental factors, such as introduction of temperature fluctuations and water, can lead to degradation of explosives within

items of UXO, which may then exude from the main body of the device and crystallise. Certain resultant compounds from such processes can be very sensitive and volatile, and through application of a small amount of movement/energy through either vibration or impact may result in detonation of the main charge.

Apart from the explosives risk, the main concerns of UXO are threefold, these are:

- Heavy metal (Copper, Zinc etc) contamination from the bomb's casing.
- Organic aromatics (Toluene, Nitrosamines, daughter products etc) contamination from the degradation of the explosive charge.
- Heavy metal (Lead, Mercury) contamination from the degradation of the detonator charge.

8 Regulatory Authority Data

8.1 State and Local Authorities

State and Local authorities were consulted for supporting evidence of UXO contamination and land use for the project site. Mapping provided by the Queensland State Archive confirms that due to the nature of the site, being predominantly rural regional landscape, it is considered unlikely for any UXO landing / penetrating the ground in such areas to have been readily identified, and as such may have remained until the present day.

8.2 MoD Explosive Ordnance Disposal (EOD) Archives

Request for information from Defence EOD archives have yet to yield a response confirming precise locations of historical UXO discoveries. Local government records do confirm discovered UXO contamination confirming the presence of hazardous munitions. Local EOD technicians contest the accuracy of local government information.

9 Explosive Ordnance Contamination Risk Assessment

9.1 General

Risk assessment is a formalised process for assessing the level of risk associated with a particular situation or action. It involves identifying the hazards and the potential receptor that could be affected by this hazard. The degree of risk is associated with the potential for a pathway to be present linking the hazard to the receptor. This relationship is usually summarised as the Source – Pathway – Receptor.

9.2 Sources / Hazards

Previous sections of this report have highlighted a number of activities that are known to have occurred on / around the site. The following sections will assess if they have the potential to cause significant explosive ordnance contamination.

Source of Contamination	Contaminate
Allied Live Firing Practices	High Explosive Mortars
	Incendiary Mortars
	Smoke Mortars
	Illumination Mortars
	Grenades No's. 36, 69 and Mk II

Table 10.2 Sources of Contamination

9.3 Pathway

The pathway is described as the route by which the hazard reaches the site personnel. Given the nature of the site the only pathways would be during:

- Enabling Works.
- Intrusive Site Investigations (Trial holes/trenches, boreholes, window samples).
- Excavations and Piling Works

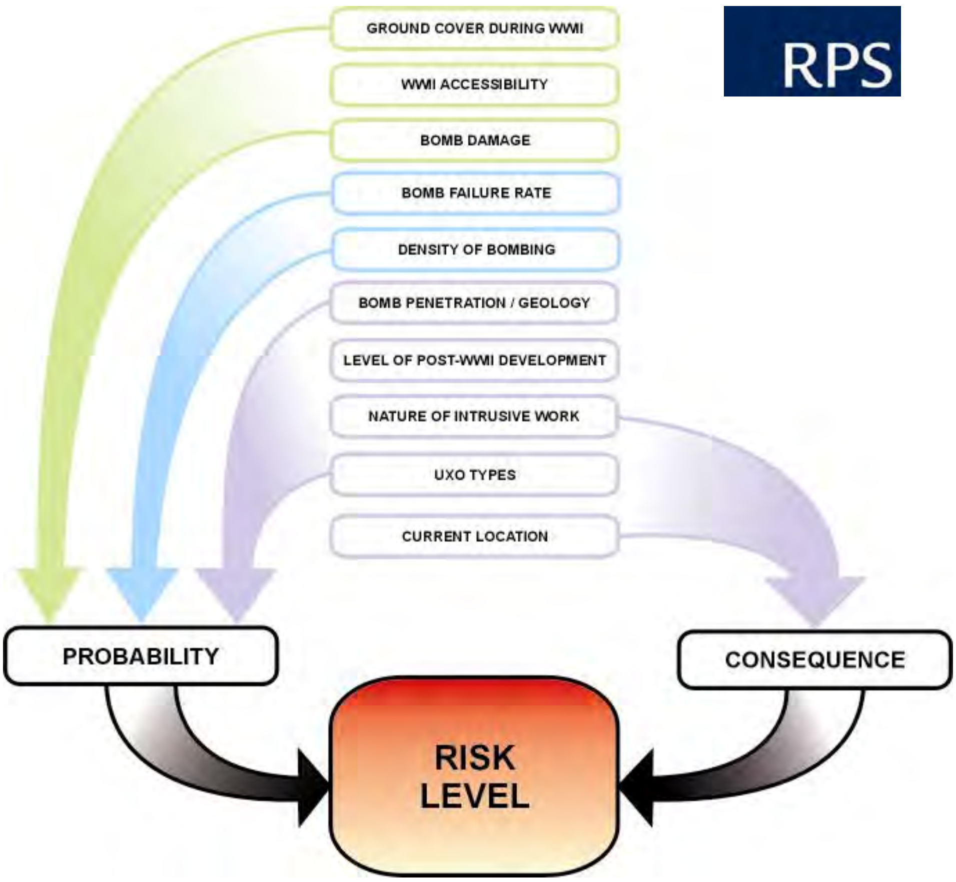
9.4 Receptors

Sensitive receptors applicable to this site would be:

- People (Site Personnel, Construction Works & General Public).
- Plant and Equipment.
- Infrastructure.
- Structures (Including existing school buildings and nearby properties).
- Environment.

9.5 Risk Assessment

The following sections contain the risk assessment for the site, prior to the implementation of any risk mitigation measures. For the risk to be properly defined, several factors have to be taken into account, including the consequences of initiation and the probability of encountering UXO on site. The technique used to assess level of risk is detailed in the diagram below:



9.5.1 Risk Assessment Matrices

In order to identify an appropriate risk mitigation strategy for the works it is now necessary to complete a semi-quantitative assessment of the identified risks.

Once the factors detailed above have been assessed for the site, the consequence level is obtained from the table presented in *Appendix 007 A*, which provides a consequence rating from 1 to 10, depending upon the severity. The probability is also deduced and given a rating between 'improbable' and 'frequent'. These two ratings are then combined to determine the final risk levels to the proposed site works from the various threat items, using the risk matrix in *Appendix 007 B*, taking into account the potential UXO threat items as detailed earlier.

Following are the risk assessment matrices for potential future site works, prior to the implementation of the any risk mitigation measures:

Risk Assessment Matrix								
Contaminate		**Hazard**	**Potential Pathway**		**Potential Sensitive Receptors**	**Likelihood of Encounter***	**Consequence of Initiation***	**Final Risk Level**
Allied Munitions	**High Explosive Mortars**	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	D	8	**H**
			Intrusive Activities	Excavations / Trial Pits		D	8	**H**
				Boreholes / Piling		D	8	**H**
	Phosphorous Mortars	Heat	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	D	5	**L**
			Intrusive Activities	Excavations / Trial Pits		D	5	**L**
				Boreholes / Piling		D	4	**L**
	Grenades	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	C	7	**M**
			Intrusive Activities	Excavations / Trial Pits		C	7	**M**
				Boreholes / Piling		C	7	**M**

KEY: **N: Negligible** **L: Low** **M: Moderate** **H: High**

*Table 9.5.1 - Risk Assessment Matrix (*See Appendix 007 B for assessment scheme)*

9.5.2 Risk Assessment Analysis

Based on the identified and available information, it has been determined that there is a risk from UXO during the potential future works being undertaken at the site, with the highest identified risk being **High** from Allied Live Firing Practices.

Due to the nature of the site, being predominantly mountainous uninhabited terrain, it is considered likely that fired UXO during live fire practices may have landed/penetrated the ground, remaining undiscovered until the present day.

10 Recommendations

10.1 The 'ALARP' Principle

On sites where a risk from UXO has been identified, an aim must be mitigate the UXO risk to as low as is reasonably practicable (ALARP); considering safety and cost vs. benefit.

ALARP has particular connotations in Health and Safety practices and the core concept of what is "*reasonably practicable*". This involves weighing a risk against the effort, time and costs needed to control it. For a risk to be reduced in line with ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be "*grossly disproportionate*" to the benefit gained. The ALARP principle arises from the fact that it would be possible to spend infinite time, effort and money attempting to reduce a risk to zero. Importantly, it is not simply a quantitative measure of benefit against detriment but a common practice of "*judgment*" of the balance of risk and social benefit.

Diagrammatic representations of the ALARP principles are presented at *Appendix 008*.

Based on the assessed risk the following mitigation is recommended to be implemented in support of works taking place across the site:

10.2 Field Verification

RPS recommends that prior to commencing invasive works a field verification assessment take place to validate this historical assessment of UXO contamination and justify any mitigation practices that may be required. Following field verification the potential exists to adjust and/or customise the risk assessment of this site into individual 'zones', dependent upon the results of the verification, particularly for turbines located within the 'substantial' contamination areas.

10.3 RPS Explosives Safety & Awareness Briefings / Site Safety Guidelines

It is recommended that all personnel conducting intrusive works, in any part of the site, should attend an ***RPS Explosives Safety & Awareness Briefing***. This should comprise part of the standard site induction briefing and would form a component of the Health and Safety Plan for the site adhering to the requirements of previously cited legislation. All personnel working on site would be briefed on UXO recognition and made aware of the possible risks. They would be informed of the actions to take to alert the site manager and to keep people and equipment away from the hazard.

RPS feels it may be cost effective and prudent to produce a set of ***RPS Explosives Site Safety Guidelines (ESSG)***, which would be provided to the client along with training. The guidelines are designed to aid the Project Team to plan the proposed works and potentially deal with the event of a suspicious item / UXO discovery incident. The guidelines would also enable the client to incorporate the Explosives Safety & Awareness Briefings into their standard site inductions.

The guidelines would address the risk to all of the specific proposed works and will inform all personnel how to undertake the works safely, and will refer to the specific risk items/hazards that have been identified for the site.

The guidelines would typically be provided to the client in the form of a 'Guidelines Document' along with a supporting PowerPoint slideshow.

However, it should be noted that if a significant / elevated risk is subsequently identified then a fully qualified Explosives Engineer should manage the situation on behalf of the client.

10.4 Explosives Engineer Supervision

It is recommended that an ***Explosives Engineer*** should be present during any excavations/trial pits taking place at the site.

The Engineer will confirm whether any suspicious item identified is ordnance related. If the item is ordnance related then the Engineer will aid with the incident management, until the appropriate authorities have control of the site.

The role of the Explosives Engineer would include:

- Visual reconnaissance across moderate risk areas to identify if any surface UXO is present prior to further mitigating or other works taking place.
- Using a magnetometer/locator to investigate in advance of the proposed works to ensure no ordnance is encountered.
- Managing the excavations/investigation of any anomalies identified by using magnetometers/locators.
- The monitoring of engineering works using visual recognition and instrumentation, where practical and advising staff of the need to modify working practices to take into account the ordnance risk.
- Providing an immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site.
- Aid in incident management, including liaison with the Local Authorities and Police, should ordnance be identified and present an explosive hazard.

10.5 Intrusive Magnetometer Survey

RPS consider it prudent to conduct an intrusive Magnetometer survey or Down-Hole magnetometer ahead of/in conjunction with any proposed piling or boreholes being undertaken across the site to reduce the risk of encountering deep buried UXOs. The type of survey methodology required would be dependent upon ground conditions and the details of the works taking place.

10.6 Non-Intrusive Magnetometer Survey

As an alternative to *Explosives Safety Engineer Supervision*, and considering the specific conditions on site, it may be feasible to carry out a Non-Intrusive Magnetometer survey ahead of shallow excavations/works in certain areas.

Non intrusive magnetometer surveys have the capability to detect shallow buried items of UXO. The actual performance of the equipment is dependent on ground conditions and the sizes of potential ordnance present. It should be appreciated that the success of the proposed methods will be dependent upon the geophysical contrast between the target and the background material.

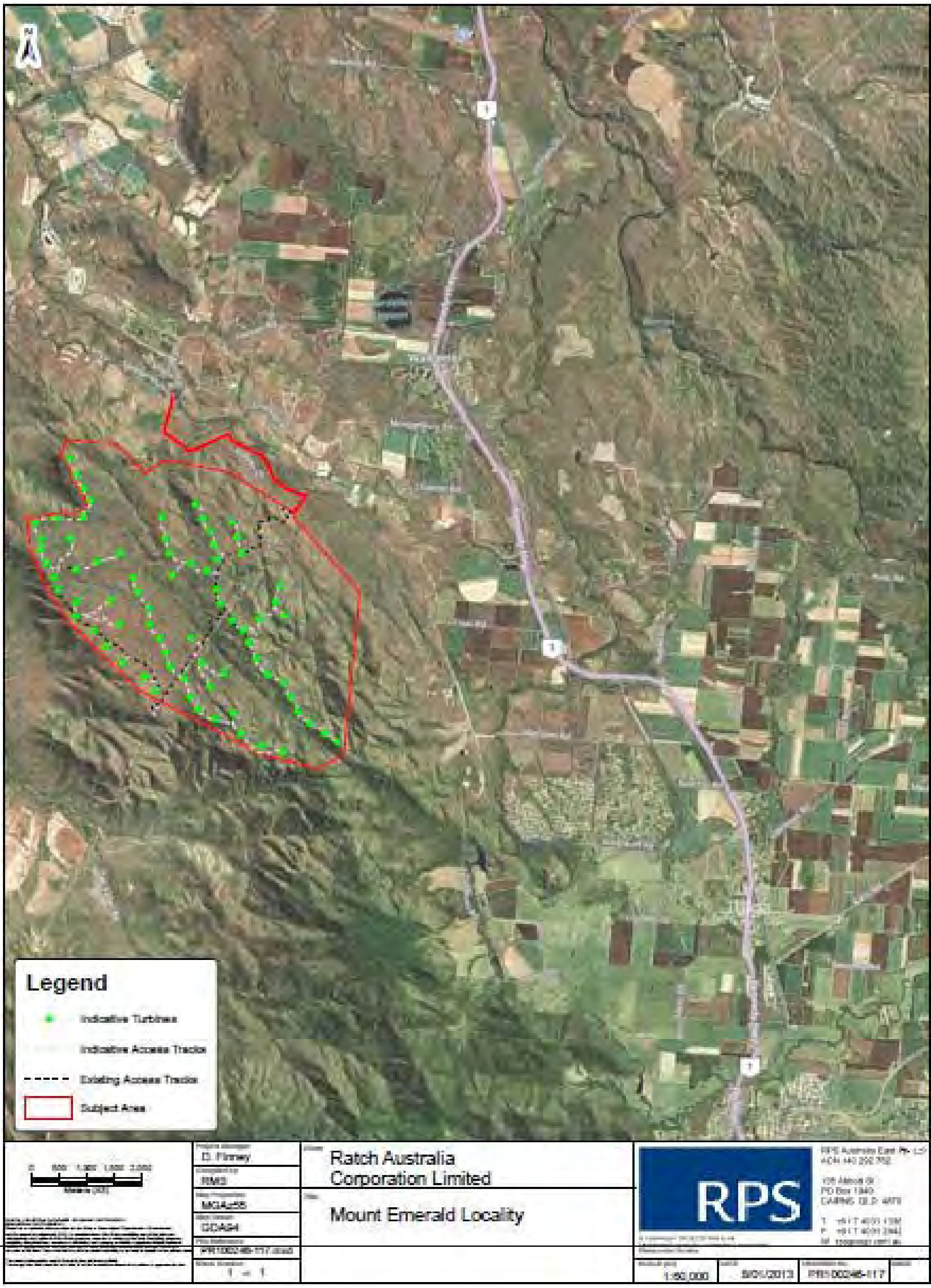
10.7 Final Works Programme

RPS EES would recommend that, once the full extent of the works has been confirmed / finalised, we are contacted to discuss the most suitable mitigation approach. RPS would take into account further details regarding the specific locations, site conditions and methodologies of the proposed works to determine the most practical and pragmatic approach available to deliver the required mitigation.

Appendices

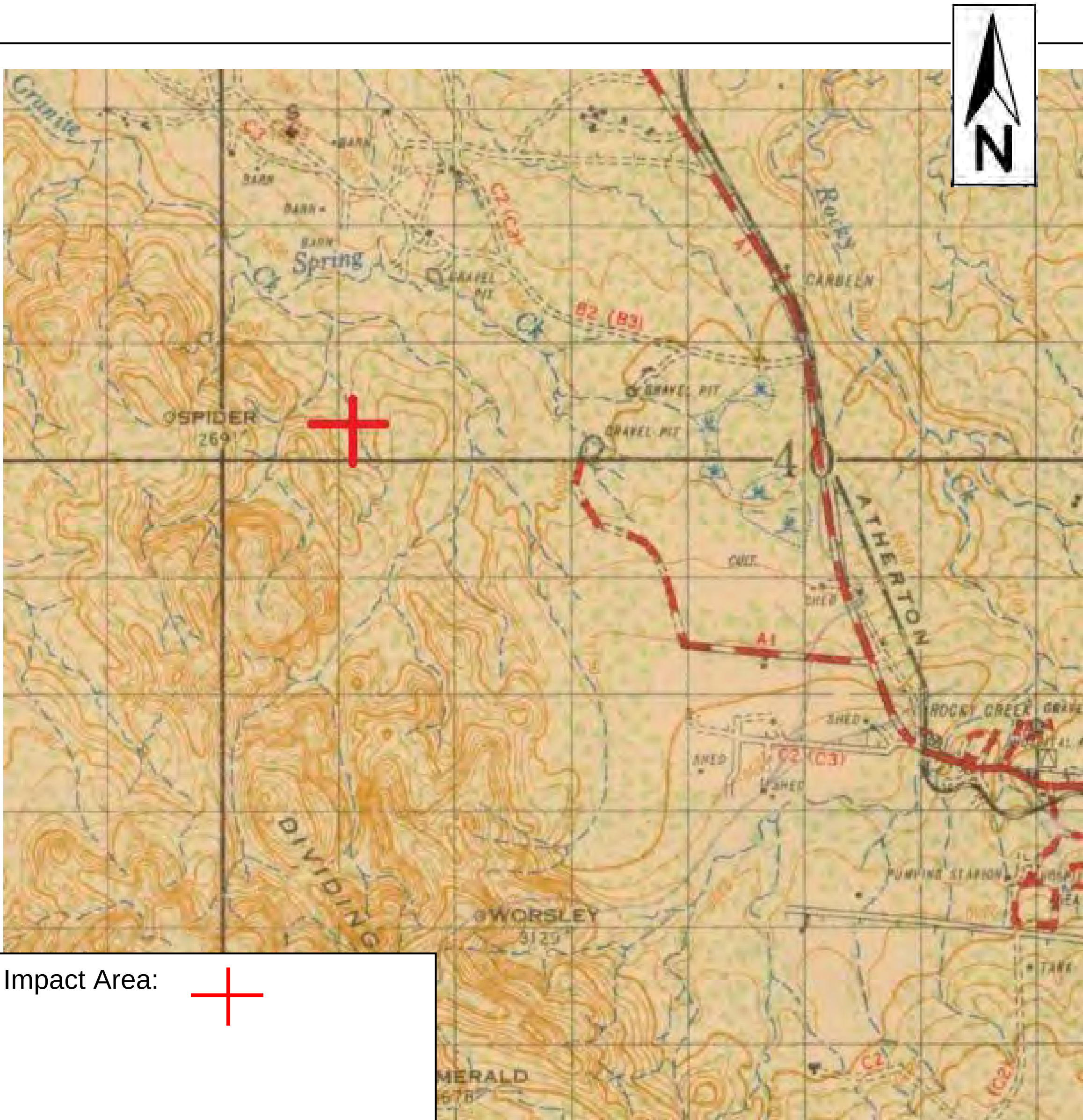
Appendix 001

Site Location



Appendix 002

Historical Mapping - 1943 (1:63,360)



Impact Area:

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 002: 1943 Site Mapping

Scale: Not to Scale

RPS Energy
Explosives Engineering Services

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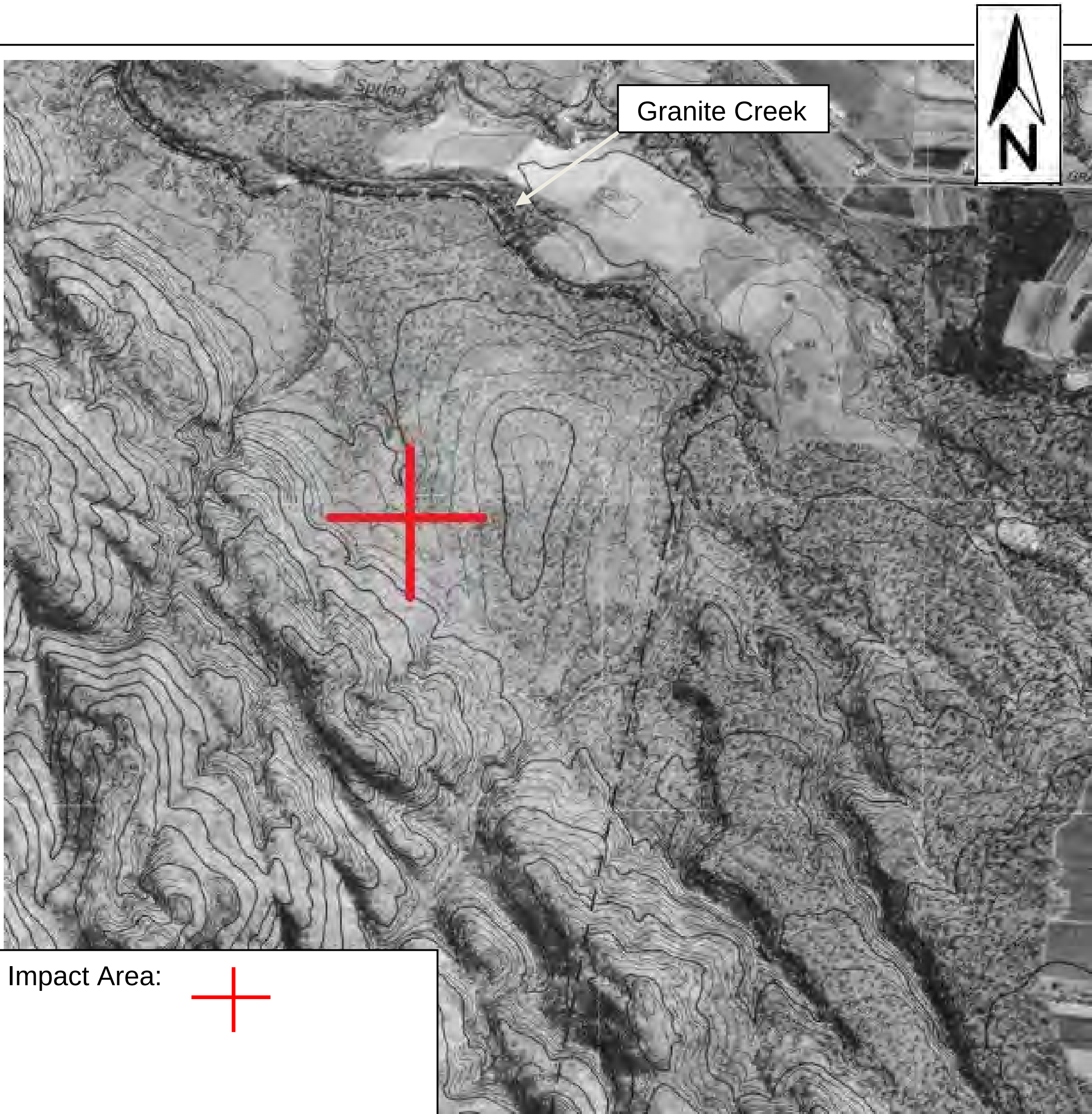
Appendix 003

Historical Mapping - 1982 (1:10,000)



Impact Area:

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 003: 1982 Site Mapping

Scale: Not to Scale

RPS Energy

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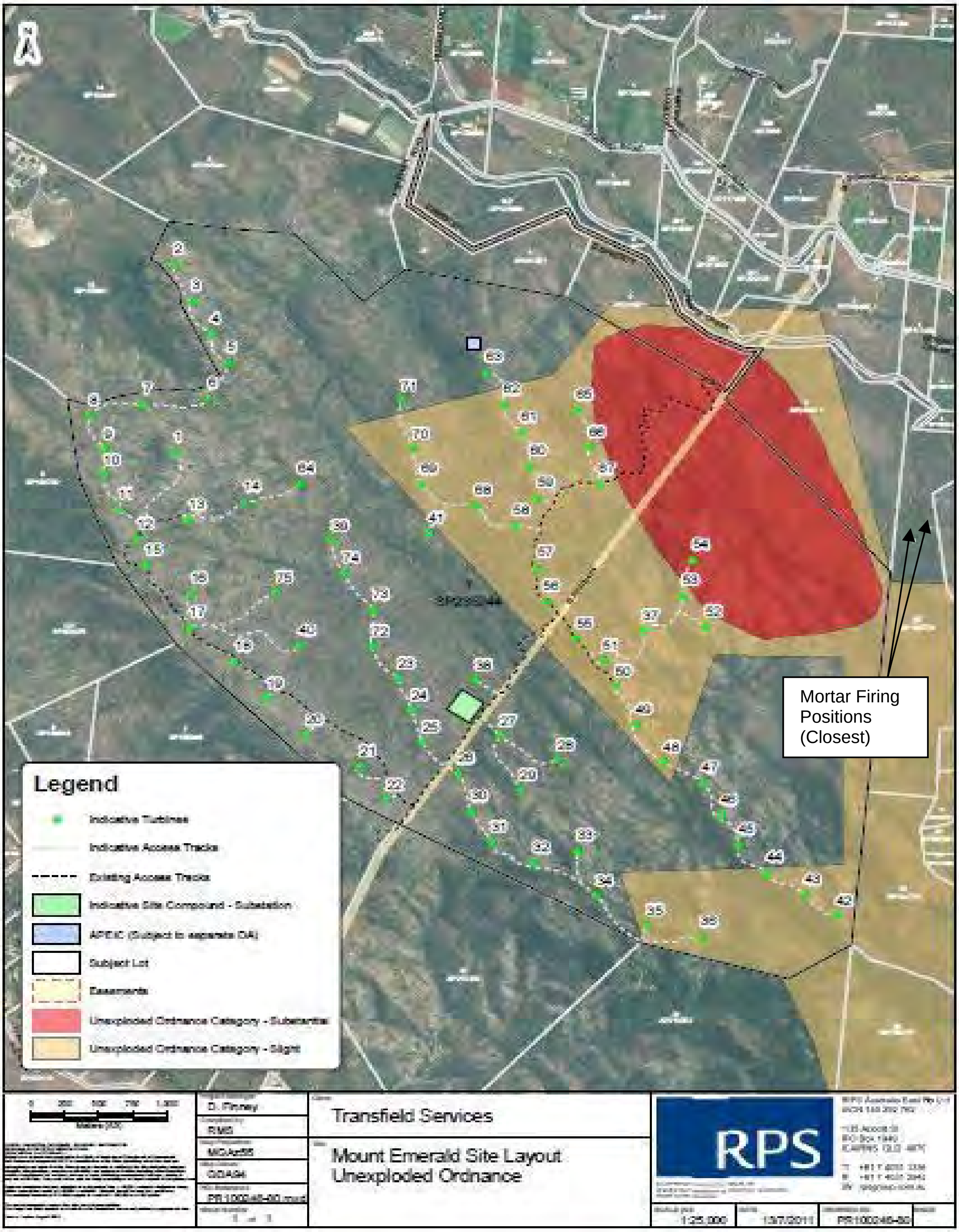
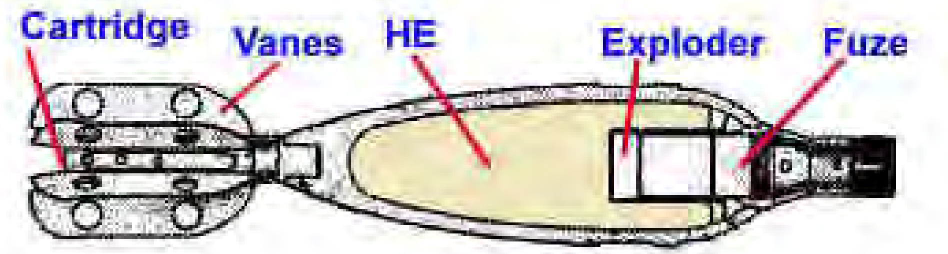
Appendix 004

Identified UXO Contamination Area Map



Appendix 005

Examples of Allied High Explosive Mortars



BRITISH 3 INCH MORTAR DATA

Mortar Weight: 13 lb (5.8 kg)

Length: 16.6 in (42.2 cm)

Diamiter: 3 in (7.6 cm)

Explosive: Amatol/TNT

NEQ: Various (Not greater than 10lb).

Fuse: Point Detonating (Impact)

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 005: Allied High Explosive Mortars

Scale: Not to Scale

RPS Energy
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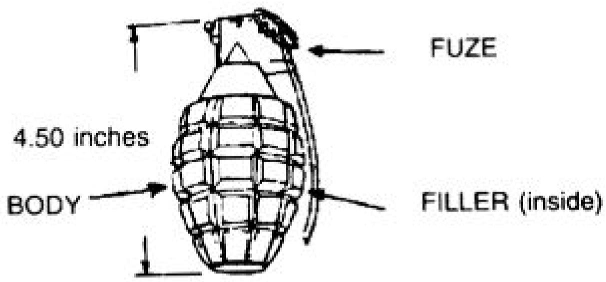
Appendix 006

Examples of Allied High Explosive Grenades



BRITISH 36M GRENADE DATA

Grenade Weight: 0.7 kg

Length: 4.5 in (11.4 cm)

Diamiter: 2.4 in (6 cm)

Explosive: Baratol or TNT

NEQ: 50g

Fuse:Time Delay

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 006: Allied High Explosive Grenades

Scale: Not to Scale

RPS Energy

Explosives Engineering Services

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Appendix 007 A

Risk Assessment Matrices - A

CONSEQUENCE LEVEL	EXPECTED CONSEQUENCES			
	Human Health	Plant and Equipment	Structures	Environment
1	No noticeable effect	No noticeable effect	No noticeable effect	No noticeable effect
2	First aid injury	No noticeable effect	No noticeable effect	No noticeable effect
3	Injury requiring medical treatment	No noticeable effect	No noticeable effect	Minor disturbance
4	Lost time injury < 3 days	Slight superficial damage	Slight superficial damage	Significant disturbance
5	Lost time injury ≥ 3 days	Moderate superficial damage	Moderate superficial damage	Slight damage to habitats.
6	Serious debilitating injury	Minor component replacement repair	Repairs - non-structural	Moderate damage to habitats.
7	Localised fatalities	Significant component replacement repair	Repairs - structural	Moderate damage to habitats. Some long term effects.
8	Multiple fatalities over extended area	Unit loss, un-repairable damage	Severe un-repairable damage	Severe damage to habitats. Some long term effects.
9	Multiple fatalities over extended area	Unit destruction	Localised structural failure and collapse	Localised destruction of habitats. Moderate long-term effects.
10	Multiple fatalities over extended area	Multiple unit destruction	Widespread structural failure and collapse	Destruction of habitats over extended area. Significant long-term effects.

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 007 A: Risk Assessment Matrices - A

Scale: Not to Scale

RPS Energy
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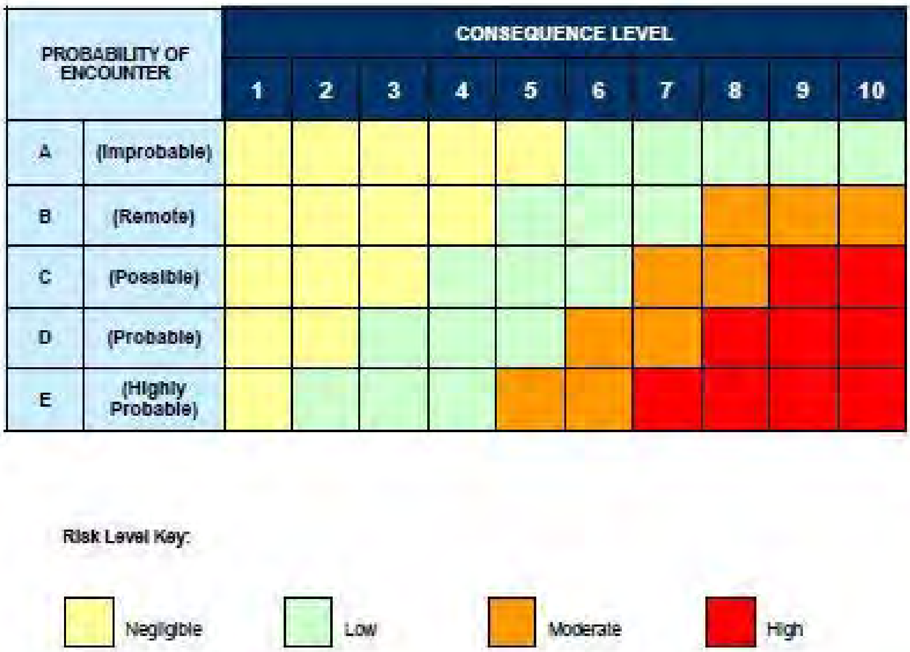
Appendix 007 B

Risk Assessment Matrices - B



Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 007 B: Risk Assessment Matrices - B

Scale: Not to Scale

RPS Energy
Explosives Engineering Services

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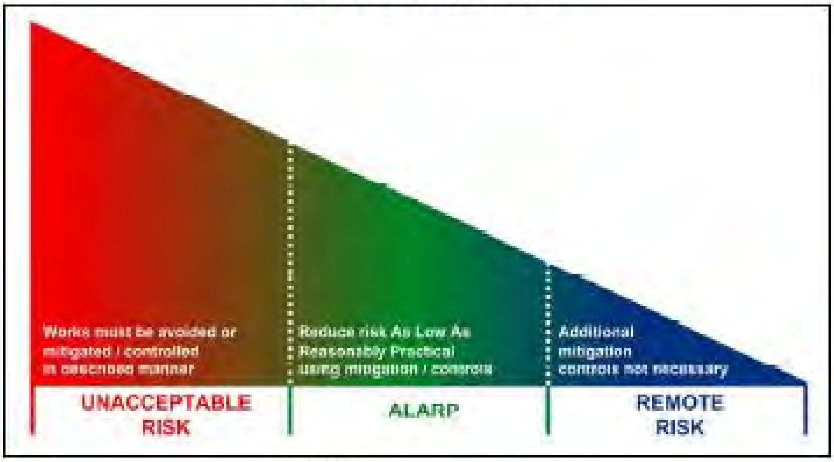
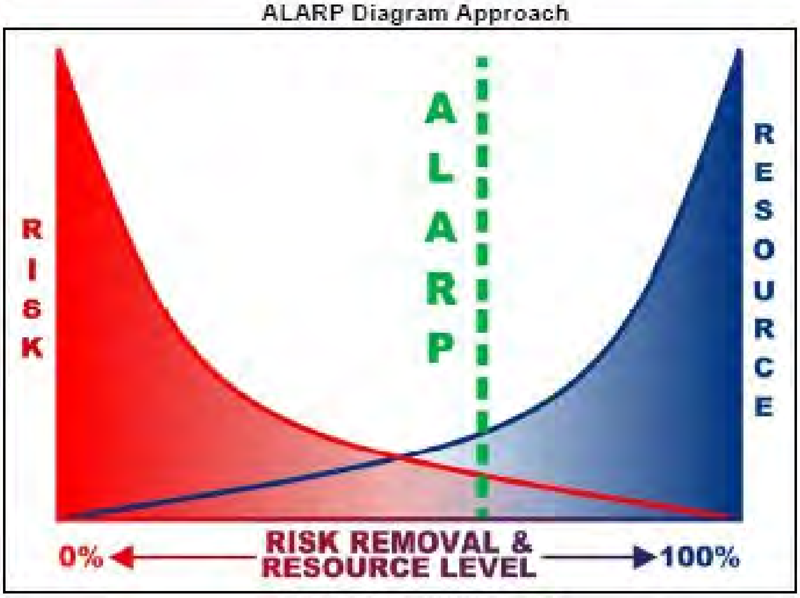
Appendix 008

'ALARP' Principle

'ALARP PRINCIPLE'



ALARP Diagram Approach



ALARP Resource Graph

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 008: 'ALARP' Principle

Scale: Not to Scale

RPS Energy
Explosives Engineering Services

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Appendix 32

DNRM Concurrent Agency Response to UXO Potential

Pike Maureen

RECEIVED
26 OCT 2012
BY: SR

From: Smith Geoffrey (Townsville Planning)
Sent: Thursday, 18 October 2012 5:06 PM
To: info@trc.qld.gov.au; PeterP@trc.qld.gov.au; sera.rohan@rpsgroup.com.au
Cc: Hodgon Kim; Pike Maureen; Scott Ranald
Subject: TRC ref MCU/11/0024 Mount Emerald Wind Farm DNRM is providing EHP's UXO permit and wetlands advice leaving only DNRM's vegetation management assessment outstanding
Attachments: CLU permit SPLC04099312.pdf; 091012 SPAR04099212 Wetlands Advice.pdf

DNRM references
EcoTrack Project 371068
EcoTrack Application 492050
TrackJob IC0412CNS0008
Veg M12/002982
eLVAS 2012/002982
KEEPER NOR/105304

TRC ref MCU/11/0024

RPS ref PR100246-3/SR/MLM/L70594

Chief Executive Officer
Tablelands Regional Council

Attention Peter Pattison

Dear Peter

Material Change of Use for a Wind farm maximum of 75 turbines
EHP Contaminated Land Unit permit and Wetlands advice provided; DNRM Veg clearing permit awaits further information

The former Department of Environment and Resource Management was referred the application for the material change of use. It was deemed properly referred on 4th April 2012.

The former DERM's jurisdictions were limited to remnant vegetation, contaminated land and wetlands.

EHP's contaminated land unit has now made their assessment and their permit SPCL04099312 is attached.

The wetland advice is also complete and advice SPAR04099212 is attached.

As for DNRM's remnant vegetation related jurisdiction (under the *Vegetation Management Act 1999*) the assessment of the application on the basis of the application is incomplete and will rely on a response to information request – timeframes for response to the Vegetation management information request has been extended.

Now that some time has passed since the de-amalgamation of DERM, and EHP's contaminated land and wetland assessments have been concluded – and won't conflict with any vegetation assessment – I am providing EHP Permit SPCL04099312 and advice SPAR04099212. This action concludes EHP's assessment. EHP requests that a copy of the decision notice be sent to them at Permits and Licence Management, GPO Box 2454, Brisbane Qld 4001 citing EcoTrack Application Number 492050.

Of the former DERM, only the Department of Natural Resources and Mines now has any outstanding assessment.

The department looks forward to receiving the proponent's further information on remnant vegetation on site.

Yours sincerely
Geoffrey Smith

cc
Mount Emerald Wind Farm Pty Ltd
Attention Ms Sera Rohan
RPS
PO Box 1048
Robina Qld 4226

Geoffrey Smith
Principal Natural Resource Officer (Planning & Environment)
Regional Planning and Information Management
North Region
Department of Natural Resources and Mines
Telephone: 4799 7032 [Q_net 37032], **Facsimile:** 4799 7641, **Mobile:** 0407 585 326
Email: geoffrey.t.smith@dnrm.qld.gov.au
187-209 Stanley Street
PO Box 5318 Townsville Qld 4810

EHP Permit [1] number: SPCL04185012

Assessment manager reference:	MCU/11/0024
Date application received:	17 April 2012
Permit type:	Concurrence agency response
Date of decision:	21 June 2012
Decision:	For a **concurrence agency response -** conditions must attach to any development approval
Relevant laws and policies:	*Environmental Protection Act 1994* *Sustainable Planning Act 2009*
Jurisdiction(s):	Material change of use - Contamination of land by unexploded ordnance (UXO) - *Sustainable Planning Regulation 2009* - Schedule 7, table 3, item 11

Development Description(s)

Property/Location		Development
Kippin Drive, ARRIGA, QLD	Lot 7 on SP7235244, Part of Lot 905 on CP896501 & Easement A in Lot 1, Easement C in lot 2 & Easement E in Lot 3 on SP231871	Material change of use - Wind Farm (Maximum of 75 Turbines)

Reason(s) for inclusion of conditions

In accordance with section 289 of the *Sustainable Planning Act 2009* and section 27B of the *Acts Interpretation*

1 Permit includes licences, approvals, permits, authorisations, certificates, sanctions or equivalent/similar as required by legislation administered by the Department of Environment and Environment Protection.

Act 1954, the reason(s) for inclusion of conditions stated in this permit required by the concurrence agency response for the application are as follows:

UXO is considered a contaminant under Section 11 of the *Environmental Protection Act 1994* (EP Act).

Significant portions of the site (the subject lot/s) are areas within which the Department of Defence (Defence) has assessed either a 'substantial' or 'slight' potential for residual UXO exists. For details, visit the Defence website http://www.defence.gov.au/uxo/ and Section 3.2.13 of the Development Application of March 2012 prepared by RPS Australia East Pty Ltd for the applicant, Mt Emerald Wind Farm Pty Ltd.

Defence advises that development or land use rezoning proposals for land within 'substantial' UXO areas should only proceed following the conduct of further UXO investigation activities and any necessary clearance. Defence maintains a list of commercial UXO investigation and remedial search contractors that it accredits to carry out this work.

Defence also recommends that owners or occupiers of UXO-affected land and workers and contractors employed on such land need to be aware of the procedure if an object suspected of being UXO is found.

EHP has no record of the site being further investigated or remediated and it is considered that there remains a possibility of UXO being found on it.

Ranald Scott
Delegate, Chief Executive administering the
Sustainable Planning Act 2009

Department of Environment and Heritage Protection (EHP)

21 June 2012

CONDITIONS

The following concurrence agency conditions are to be attached to any approval:

1 Prior to the commencement of any excavation, earthworks or other disturbance of land relative to the proposed development or to any natural and ordinary consequence of the development on the portion assessed as having a 'substantial' potential for UXO, those parts of the affected portion to be so worked are to be subjected to appropriate investigation and any necessary remedial action.

2 Any person employed on work associated with the proposed development, on any part of the site where a 'substantial' or 'slight' UXO potential exists and Condition 1 has not been satisfied, is to be forewarned in writing by the applicant.

This warning is to explain that information available to EHP indicates a potential for residual UXO may still exist on the site and work should proceed with due caution. It is to state the procedure to be followed by any person finding an object suspected of being UXO or component thereof:

- Do not disturb the object.
- Take action, where appropriate, to prevent it being disturbed by another person.
- Note its approximate dimensions and general appearance.
- Note the route to its location.
- Advise the Police as soon as possible.

3 Following action taken to satisfy Condition 1 above, the applicant is to submit a report, prepared in accordance with current guidelines, to EHP for assessment. EHP is to subsequently advise the Tablelands Regional Council and the applicant of its assessment in regard to Condition 1 being satisfied.

4 The applicant is to advise the owner and any occupier of the site of the above responsibilities.

General comments or advice about applications concerning land potentially affected by UXO

Applicants may visit Defence's website http://www.defence.gov.au/uxo/ or EHP's website http://www.derm.qld.gov.au/ for the details of current UXO investigation and remedial search contractors. EHP accepts reports based on investigative and remedial work carried out by these contractors.

Investigation and remedial action to satisfy Condition 1 typically involves sampling/search programs with detection equipment unless the use of such equipment is:

- considered unwarranted by a UXO contractor due to the extent of any prior excavation or earthworks or, conversely, of any filling proposed as part of the development program; or

- prevented or made impracticable by the presence of a structure, stockpile, natural barrier or metal waste.

In the latter case, alternative action may be appropriate to minimise the risk in the first instance. For example, where the risk of exposure to any UXO that may exist is reduced by the presence of a structure or natural barrier, issuance of the standard UXO warning (see Condition 2) may suffice while the structure, stockpile or barrier remains in place. Where a structure is to be removed or reduced as part of the development program, protective precautions, commensurate with any greater risk to which workers might then be exposed, may need to be considered. Progressive assessment will be necessary where such circumstances exist. Unless, at the completion of preliminary works, there is evidence then available to the UXO contractor that any residual risk is negligible, the use of detection equipment will typically be required to confirm the site's status.

Where investigation, along with any subsequent remedial action and assessment, is to be implemented by stages to satisfy Condition 1 and 3, a preliminary investigation report should be submitted by the applicant to

EHP along with a management plan for the proposed work. Staged investigation/remediation is most likely to be applicable where development of smaller, built-on lots (which can present circumstances such as those discussed above) or broadhectare sites is proposed. In such cases, EHP's assessment of the report and advice to Council in regard to approval of the development will be dependent on agreement with the management plan.

Where Condition 1 is to be satisfied by a whole lot or broadhectare development stage being subjected to investigation and any necessary remedial action, EHP, based on the subsequent investigation/remediation report's findings and recommendation/s, may reassess the lot, or that portion comprising the development stage, as being remediated or not needing remediation, and advise the applicant and Council accordingly. Otherwise, any balance of land that has not been further investigated will retain the risk assessment made by Defence and EHP's Area Management Advice will continue to apply. This is unless evidence obtained from the investigated part/s can be used to refute Defence's assessment in regard to all or part of the balance. In the latter case, EHP may reassess all of the balance or the applicable part/s as being unaffected by UXO.

Enquiries:
Ranald Scott, Project Manager (UXO) – Department of Environment and Heritage Protection
Ph: (07) 5459 6129 Fax: (07) 5459 6190 email: ranald.scott@ehp.qld.gov.au

END OF CONDITIONS

Advice Agency Response - Referable Wetland

This Referral Agency Response is issued by the Department of Environment and Heritage Protection pursuant to section 292 (advice agency response) of the Sustainable Planning Act 2009 *("the Act").*

Chief Executive Officer
Tablelands Regional Council

PO Box 573

Atherton QLD 4883

cc. Mt Emerald Wind Farm Pty Ltd
c/- RPS Australia East Pty Ltd

PO Box 1949

Cairns QLD 4870

Application number: 371068
EHP permit number: SPAR04099212

Application Details

Assessment Manager Reference:	MCU/11/0024 ATTN: Peter Pattison
Date properly referred to EHP:	17 April 2012
Development approval applied for:	Material change of use
Aspect of development:	Material Change of Use, other than for a domestic housing activity, if any part of the land is situated in a wetland management area Sustainable Planning Regulation 2009 - Schedule 7, Table 3, Item 21
Development description:	Wind farm – maximum of 75 turbines
Property/Location description:	Kippin Drive, Arriga QLD (Lot 7 on SP235244, lot 905 on CP896501, easement A in lot 1, easement B in lot 2 and easement E in lot 3 on SP231871)

[1] Permit includes licences, approvals, permits, authorisations, certificates, sanctions or equivalent/similar as required by legislation administered by the Department of Environment and Heritage Protection.

Recommendation

The Chief Executive, Department of Environment and Heritage Protection (EHP), makes the following recommendation to the assessment manager:

Wetland:

The assessment manager should consider the potential impacts of the proposed development on wetland values, including the water quality, natural hydrological flows and ecological functioning of the wetland. Development should meet the following outcomes:

- **Maintain ecological values of the wetland.** There is no loss of wetland habitat and adverse impacts on the functioning and integrity of a wetland from development are avoided. A report prepared and certified by an appropriately qualified professional may assist the assessment manager to consider the impacts of the development on the ecological values and functioning of the wetland. If adverse impacts are unavoidable, the assessment manager is encouraged to ensure that the values lost are offset in order to achieve an environmental outcome equal or better than the wetland values that are impacted. Refer to section 81A of the Environmental Protection Regulation 2008 for the list of wetland values.

  Where a wetland management area is mapped as being of 'high ecological significance under *the Queensland Coastal Plan* it should be assessed against State Planning Policy 3/11:Coastal Protection (SPP3/11). Refer to policy 3 *Nature Conservation* in SPP 3/11.

- **Maintain wetland water quality.** The water quality of any waters in and linked to the wetland is maintained and managed to protect the environmental values of the wetland, and to ensure that the water quality objectives listed under Schedule 1 of the *Environmental Protection (Water) Policy 2009* are achieved.

- **Maintain wetland water regime.** The existing water regime (including surface and groundwater) within and linked to the wetland is maintained and managed to protect existing natural hydrological processes within the wetland ecosystem. This includes safeguarding natural fluctuations in size and location of the wetland, and retaining and allowing for regeneration of native vegetation.

To ensure that the proposed development is able to meet the above outcomes, the assessment manager is encouraged to consider the requirement for a buffer area between any proposed works and the wetland. A wetland buffer has two components:

- a support area adjacent to the wetland that maintains and supports the environmental values of the wetland; and
- a separation area around the support area that protects the wetland from external threats such as sediment and nutrient discharge from surrounding landuse.

Buffer distances should be maximised in order to maintain existing biodiversity values, habitat connectivity and to minimise edge effects. Unless otherwise determined by a suitably qualified professional, the following buffer widths are accepted by Environment and Heritage Protection as precautionary buffer widths likeley to absorb impacts from external uses.

- within urban areas, a minimum 50m buffer to wetland
- outside of urban areas a minimum 200m buffer to wetland

Note: The Queensland Wetland Buffer Planning Guideline (2011) should be referred to when planning detailed buffer design to position development, determine any alternative buffer widths and establish operating measures that avoid adverse impacts on a wetland.

Where required, revegetation of the buffer is recommended using native species representative of the pre-clearing regional ecosystem, with preference given to endemic species. Plants should be of local provenance where possible. A rehabilitation/ revegetation management plan including weed management strategies may assist in determining the rehabilitiation requirements for the development. Conditioning of any approval with building or development envelope(s) may also be a useful way to give formal effect to any required buffer area.

The assessment manager should consider requiring applicants to provide a Stormwater Management Plan to demonstrate how stormwater, sediment and other run-off from the site (associated with the construction and operational phases of development) will be effectively managed to prevent adverse impacts on wetland values. Potential impacts are to be addressed through water sensitive urban design including compliance with *South East Queensland Regional Plan 2009-2031 Implementation Guideline No. 7: Water sensitive urban design – design objectives for urban stormwater management.* For areas outside of the South-east Queensland Regional Plan area any approval should recognise the requirements of The Urban Stormwater Quality Planning Guidelines 2010.

General information for assessment managers

The State's Native Title Work Procedures provide that responsibility for assessment of native title issues for an IDAS application rests with the assessment manager. Therefore, Environment and Heritage Protection as a referral agency for the relevant application has not provided notification to native title parties.

Additional information for applicants

It is a requirement of the *Environmental Protection Act 1994* that if an owner or occupier of land becomes aware of a Notifiable Activity (as defined in Schedule 3 and Schedule 4 of the *Environmental Protection Act 1994*) being carried out on the land, or that the land has been, or is being, contaminated by a hazardous contaminant, the owner or occupier must, within 22 business days after becoming so aware, give written notice to the Department of Environment and Heritage Protection.

Delegate
Scott Sullivan
Delegate for the Chief Executive administering the *Environmental Protection Act 1994*
Department of Environment and
Heritage Protection

4 October 2012

Enquiries:
Rochelle Basham
Cape Pallarenda Conservation Park
PO Box 5318
Townsville QLD 4810

Telephone: (07) 4722 5235
Facsimile: (07) 4722 5256
Email: rochelle.basham@ehp.qld.gov.au

Appendix 33

Mount Emerald Wind Farm – Preliminary Environmental Management Plan

Prepared by RPS

Mount Emerald Wind Farm

Preliminary Environmental Management Plan

Prepared by:

RPS AUSTRALIA EAST PTY LTD

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E: mellissa.jess@rpsgroup.com.au

Client Manager: Mellissa Jess
Report Number: PR100246 / R72893
Version / Date: Draft – November 2013

Prepared for:

RATCH AUSTRALIA CORPORATION LTD

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
A	EIS EMP	MJ/SG/JM	DF	

Approval for Issue

Name	Signature	Date
David Finney		29.11.2013

Contents

Tables

Figures

1.0 Introduction

This Preliminary Environmental Management Plan (EMP) has been prepared for RATCH Australia Corporation Ltd (RACL) for construction, operational and decommissioning activities proposed to be carried out on the Mount Emerald Wind Farm (MEWF), in response to the EIS Guidelines of April 2012. It should be noted the document presents a framework for further development following the outcomes of the EIS/EPBCA referral and Queensland Development Application processes. Similarly, commercial details of the construction and operation phases are yet to be finalised, therefore many system and operational details are not available. Nonetheless, the EMP aims to identify sources of actual and potential environmental harm identified through the EIS process and what actions, processes and/or strategies will be adopted to avoid, prevent or minimise the likelihood of environmental harm being caused. The EMP aims to provide for the review and 'continual improvement' in the overall environmental performance of the MEWF operations.

This EMP will form the basis from which detailed EMPs will be prepared by the construction, operational and decommissioning entities. The detailed EMPs to follow the project approval may contain project design modifications; however, basic elements will be adopted and presented in the form of the following stand alone plans:

- Construction Environmental Management Plan (CEMP);
- Operational Environmental Management Plans (OEMPs); and
- Decommissioning Management Plan (DEMP).

These plans will be subject to approval by RACL and various approval agencies, including Department of the Environment (DotE).

A plan indicating the site layout (current at November 2013) is provided in **Appendix A**. This layout may be subject to modification as a result of outcomes from the approval and detailed design process.

The EMP aims to address the following matters:

(a) Identification of environmental issues and potential impacts.

(b) Environmental commitments - a commitment by senior management to achieve specified and relevant environmental goals.

(c) Control measures for routine operations to minimise likelihood of environmental harm.

(d) Contingency plans and emergency procedures for non-routine situations.

(e) Organisational structure and responsibility.

(f) Effective communication.

(g) Monitoring of mitigation measures and residual impacts.

(h) Conducting ongoing environmental impact assessments.

(i) Staff training.

(j) Record keeping.

(k) Periodic review of environmental performance and continual improvement.

2.0 Management Systems

This section provides an outline of the proposed elements of an Environmental Management System to be adopted for the project.

2.1 Environmental Policy

As a developer of renewable energy in Australia, implementing sustainable measures and ensuring the protection of the environment are fundamental to RACL's long term objectives and philosophy. Investments in renewable energy are both environmentally and commercially sustainable and RACL currently owns three wind farms that are significantly reducing Australia's greenhouse emissions. In addition, RACL continues to improve the environmental ratings of its other power generation assets by continuously revising for economically possible ways of reducing its carbon emissions.

As RACL continues to grow, it strives to promote preservation and restoration of the environment, by managing and minimising the environmental impact of its operations and activities and fully respecting environmental laws and regulations.

RACL encourages employees to take care and demonstrate responsibility towards the environment and to report any incident that may have a hazardous effect. RACL continuously strives to ensure its employees are aware of how they can reduce the consumption of energy and resources and implement strategies focused on waste minimisation and recycling where possible. Ensuring the protection of the environment and implementing sustainable solutions are paramount to the success of RACL, its people and the communities in which it serves.

2.2 Implementation Responsibilities

A draft Site Organisation Chart outlining responsibilities for environmental design and management is presented in **Error! Reference source not found.** below.

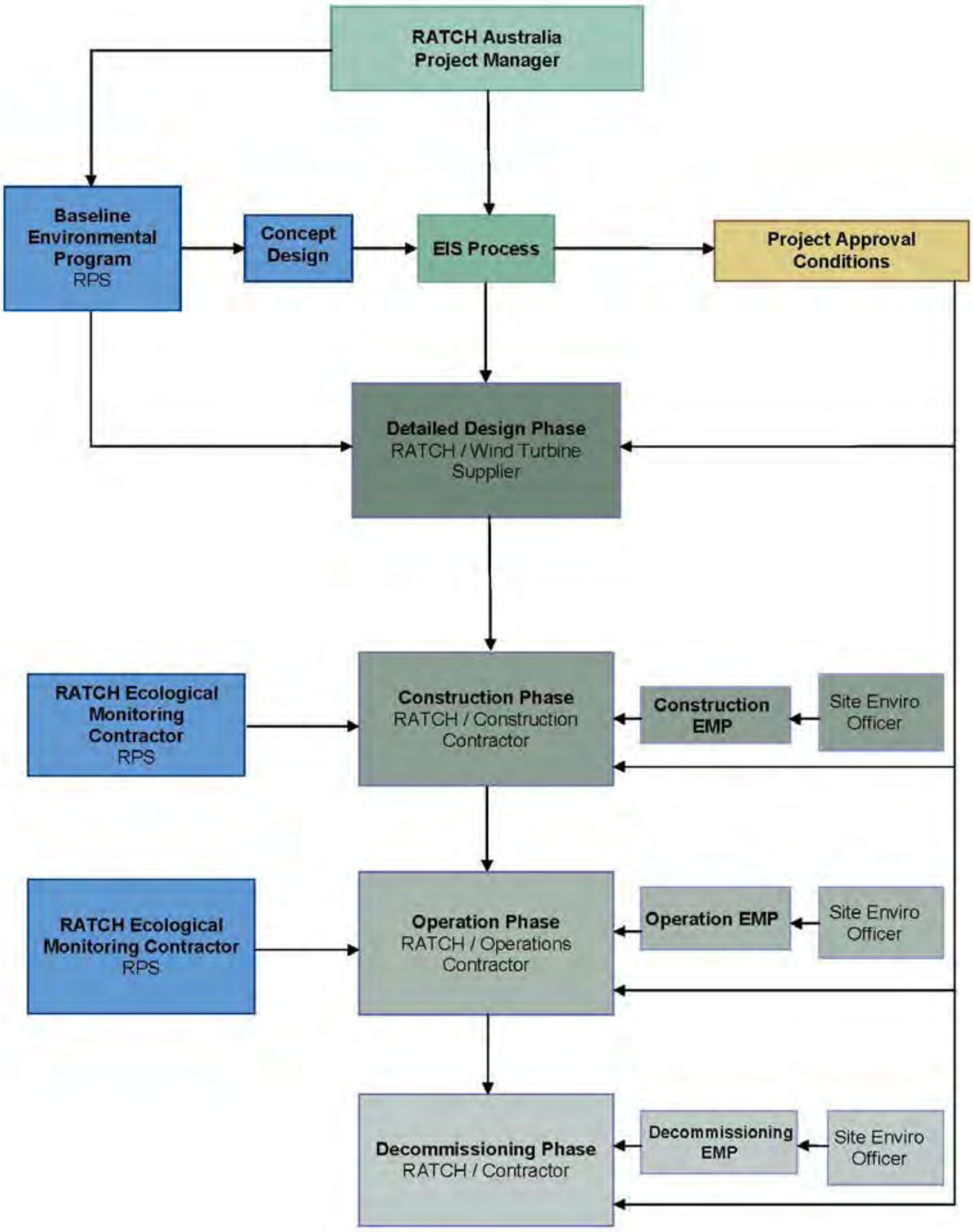


Figure 1 Draft Site Organisation Flowchart

2.2.1 RACL Australia Project Manager

RACL will provide a Project Manager to oversee compliance with EMPs covering construction, operation and decommissioning phases. The Project Manager will also be responsible for integration of outcomes of the EIS / approvals processes into final designs, operational plans and contractual documentation, including facilitating any preconstruction environmental programs, regular review of operational performance reports, facilitation of external environmental compliance audits. In addition the Project Manager will continually review environmental performance against all EIS/EMP commitments, conditions and audit outcomes and drive any necessary operational changes as required to maintain regulatory compliance via the Construction, Operations and Decommissioning Phase Managers. The Project Manager will also be responsible for commissioning any external environmental expertise, particularly in relation to ecological research and monitoring programs and incorporation of outputs into a range of environmental programs identified in the EMPs, in consultation with regulatory agencies as required.

2.2.2 Construction, Operations and Decommissioning Phase Managers

The phase managers will direct work in a manner that complies with;

- all relevant environmental procedures,
- adheres to all legislative requirements and
- ensures that the requirements of this EMP, the EIS, CEMP, OEMP and DEMP are implemented.

The phase managers will have ‘stop task’ and ‘stop work’ authority and will report to the Project Manager. They will also be responsible for initiating and managing external system audits.

2.2.3 Environmental Officers

The Environmental Officers (EO) will be responsible for monitoring and reporting the implementation of EMPs for all project phases. It is likely that Environmental Officers will be appointed by the Construction, Operation and Decommissioning phase entities and will report to the phase managers. Jurisdictional responsibilities between RACL and these entities will be incorporated in contractual documentation.

The Environmental Officers will also be responsible for implementation of environmental programs such as species management plans, Cultural Heritage Management Plan (CHMP), the Complaints Register and for setting up compliance audits and monitoring programs. Construction compliance auditing will be conducted against the requirements of this EMP, CEMP, OEMP, DEMP, Construction Safe Work Method Statements, License and Permit Conditions.

2.2.4 Ecological Monitoring Contractor

RACL will appoint an external ecological contractor to assist with all phases of the project commencing with input into the detailed design process which will be informed by a number of preconstruction ecological surveys identified below. A key function will be the preparation of detailed Significant Species Management Plans which will set out key impact management strategies including further baseline programs, design, construction and operational measures and protocols, monitoring regimes, management targets, corrective actions, timeframes and responsibilities. Elements of these plans are listed below, with details to be provided in the specific plans.

2.3 Training

The success of the EMP depends on all those responsible for implementation and review being thoroughly conversant with its contents, interpretation and performance measurements. RACL and its contractors will be responsible for ensuring that project personnel have sufficient knowledge and awareness to identify potential environmental issues, and that they are trained to take appropriate corrective action.

It is essential all personnel are familiar with the procedures for reporting on issues that may result in environmental degradation. This includes informing key personnel within RACL its contractors and relevant regulatory authorities.

2.4 Induction

All staff, including field staff, will complete a comprehensive Project induction prior to commencing work on the Project. The induction will include safety, access and a comprehensive review of environmental requirements. All Project personnel from supervisory to managerial level will have an additional detailed training session on the use and implementation of the EMPs. It is the responsibility of the phase managers to ensure records of training are maintained.

2.5 Toolbox Meetings

The phase Manager will ensure supervisors hold at least weekly toolbox talks with staff and crews to discuss issues associated with the scheduled work.

This will include highlighting and discussing relevant environmental and safety issues as required. The sessions will include discussion of strategies to be implemented as identified in Job Hazard Analysis (JHA) of current work activities.

2.6 Job Hazard Meetings

A JHA is a simple tool that is used in helping personnel identify, analyse and manage the hazards that exist in the work they undertake. It formalises the process of hazard identification and risk management most people follow when working. The JHA requires personnel to examine the task they are about to undertake and:

- Break the job down into separate, defined steps;
- For each step identify the potential hazards (including potential environmental or cultural heritage hazards) that could occur within that job step; and
- For each potential hazard list the method to be followed to prevent the hazard causing an injury, loss, damage or environmental incident.

Weekly job hazard meetings will be held in conjunction with the Toolbox meetings.

2.7 Reporting and Auditing

During construction, operations and decommissioning phases there will be continuous review of the project area and individuals and work crews will be required to demonstrate the pertinent requirements of the EMPs are being adhered to. Each supervisor will be required to record daily activities including monitoring data, on which relevant EMP requirements will be addressed (daily, weekly, monthly check sheets to be prepared by the construction contractor).

RACL commissioned external audits will include as a minimum, two annual construction audits (the first within 2 months of commencement) and two annual operation phase audits for the first three years, reverting to an annual audit thereafter assuming high levels of compliance; frequency of auditing will be revised following receipt of approval conditions. Where compliance levels are unacceptable to the regulatory authorities auditing and reporting schedules may be reviewed.

The results of other environmental programs directly commissioned by RACL including any additional preconstruction baseline and construction / operation phase ecological impact monitoring will be provided to DEHP and DOTE as requested.

2.7.1 Incident Reporting and Non-conformance

Incident reporting will be implemented to record any safety or environmental non-conformances, incidents or complaints. These shall be recorded on an incident report form and forwarded to the relevant phase Manager for reporting within the RACL system and for a process of continuous improvement to be implemented.

All such incidents shall be investigated in a timely manner and any necessary steps implemented to minimise likelihood of recurrence. If required, the EMP shall be reviewed and updated in accordance with Section 2.9.

2.7.2 Reporting

Section 320 of the EP Act requires any person who becomes aware of an event that may or has caused environmental harm, reports the event / incident to their employer. Details of the nature and circumstances of the event must be provided.

Any such incidents must be immediately reported to the phase manager and recorded on an Incident Report Form. The phase manager will ensure the appropriate external agencies are notified within the appropriate timeframe.

All such incidents shall be investigated in a timely manner and any necessary steps implemented to minimise likelihood of recurrence. If required, the EMP shall be reviewed and updated in accordance with Section 2.9, in consultation with RACL and the relevant regulatory agencies.

The RACL Project Manager will be responsible for the preparation of project phase reporting as identified in approval conditions; this may include compliance reporting and the status of ongoing research and monitoring programs.

2.8 Complaints Procedure

All complaints about the Project will be directed to, and recorded by, the Community Liaison Officer for each phase. Contact details for the Community Liaison Officer will be provided to all affected landowners. A Register will be kept recording details of all complaints received, the action taken in response (where necessary), and any corrective actions or procedural changes implemented to prevent recurrence.

The initiator of the complaint will be advised of the results of all actions taken.

The Community Liaison Officer will review the register daily and advise the Environmental Officer of any relevant complaints. The Environmental Officer will then investigate the complaint and instigate any corrective action required.

The register will be regularly audited by the Construction Manager to ensure adequate and timely response to any verified complaint is occurring.

2.9 Review and Update

The EMPs will be reviewed as required (at least annually) to ensure they address environmental issues and changes in legislation, policies and guidelines including work practices.

As details of design, construction methodology and access needs are refined, so too will the EMP and site and phase specific plans. The 'living' nature of the document means it will progressively improve and will continue to provide appropriate direction for environmental protection. A key review milestone will be following project approvals.

As a number of adaptive management strategies and programs are proposed in the EIS and this EMP, ongoing review of EMP success (or otherwise) in consultation with various regulatory agencies will dictate the frequency of EMP review and modification.

2.10 Legislative and Other Considerations

The legislation and standards listed in Environmental legislation, policies and standards relevant to the Project has been be used to guide preparation of this EMP and will form the basis for ongoing decision-making and complaint resolution in respect of the EMP.

Table 1 Environmental legislation, policies and standards relevant to the Project

Element	Legislative and Other Requirements
Construction—General	*Environmental Protection Act 1994 (Qld)* *Environmental Protection Regulation 2008 (Qld)* *Workplace Health and Safety Act 1995 (Qld)* *Workplace Health and Safety Regulation 1997 (Qld)*
Noise and Vibration	*Environmental Protection (Noise) Policy 2008 (Qld)* *Workplace Health and Safety Act 1995 (Qld)* AS 1055.1 & .2: Acoustics—Description and measurement of environmental noise AS 2436: Guide to noise control on construction, maintenance and demolition NZS 6808:2010 Acoustics – Wind farm noise
Air Quality	*Environmental Protection (Air) Policy 2008 (Qld)* National Health and Medical Research Council Guidelines 1985(Cwth) Draft National Environmental Protection Measures and Impact Statement for Ambient Air Quality 1997(Cwth)
Water Quality	*Environmental Protection (Water) Policy 1997 (Qld)* Australian Water Quality Guidelines for Fresh and Marine Waters, ANZECC 2002 *Water Act 2000 (Qld)*
Erosion and Sedimentation Control	Soil Erosion and Sediment Control, Engineering Guidelines for Queensland Construction Sites—IEAust (Qld) 1996
Contaminated Land	*Environmental Protection Act 1994 (Qld)*
Storage and Handling of Dangerous Goods	*Environmental Protection Act 1994 (Qld)* *Environmental Protection Regulation 2008 (Qld)* *Workplace Health and Safety Act 1995 (Qld)* AS1940 – The Storage and Handling of Flammable and Combustible Liquids
Transport of Dangerous Goods	Australian Code for Transport of Dangerous Goods by Road and Rail
Waste Management	*Environmental Protection (Waste Management) Policy 2000 (Qld)* *Environmental Protection (Waste Management) Regulation 2000 (Qld)*
Flora and Fauna	*Environment Protection and Biodiversity Conservation Act 1999 (Cwth)* *Nature Conservation Act 1992 (Qld)* *Nature Conservation Regulation 1994 (Qld)* *Vegetation Management Act 1999 (Qld)* *Environmental Protection Act (Qld)* *Land Protection (Pest and Stock Route Management) Act 2002 (Qld)*

Element	Legislative and Other Requirements
Cultural Heritage	*Native Title Act 1993 (Cwlth)* *Native Title (Queensland) Act 1993* *Queensland Heritage Act 1992* *Queensland Heritage Regulation 2003* *Aboriginal Cultural Heritage Act 2003 (Qld)*
Land Use	*Integrated Planning Act 1997(Qld)* *Land Protection (Pest and Stock Route Management) Act 2002 (Qld*)

2.11 Related Documentation

The operation will be carried out generally in accordance with the following documents:

- MEWF - Environmental Impact Assessment – RPS Australia 2013 (Volumes 1-3);
- this EMP, CEMP, EOMP, DEMP documents;
- National Wind farm Guidelines
- Consolidated Conditions of Project Approval;
- Weed Management Plan
- Rehabilitation Management Plan
- Fire Management Plan
- Translocation Plans
- Significant Species Management Plans

If there is any inconsistency between the Conditions of Approval and a document listed above, the Conditions of Approval shall prevail to the extent of the inconsistency. If there is any inconsistency between documents listed above (other than the Conditions of Approval) then the most recent document shall prevail to the extent of the inconsistency.

All persons involved with the operational phase of the MEWF shall undertake their respective activities in accordance with the relevant requirements of the OEMP. The OEMP shall also be read in conjunction with the following related RACL documents which exist as separate documents:

- Site Induction Handbook (Service);
- Policies and procedures contained within RACL's Environmental Management System

3.0 Detailed Design (Pre Construction) EMP

The Pre-construction EMP contains a program of works aimed at avoiding, minimising or mitigating impacts through closing information gaps and preparation of a number of detailed management plans which will guide operations through subsequent construction, operation and decommissioning phases.

Species	Potential Impact	Impacting Phase	Proposed Mitigation Strategy	Essential Information Gaps	Management Actions Required	Monitoring, Reporting	Timing	Responsibilities	Relevant Agency
Fauna									
Bare-rumped Sheathtail Bat	Turbine Collision & Barotrauma	Operation	Turbine operation curtailment (increased cut-in speed & targeted turbine shut-down during high risk conditions or detected collision mortality	1. Relationship between environmental factors (weather, insect abundance) and call activity. 2. Utilisation of the turbine rotor sweep area (RSA) (abundance and flight height data)	1. Continue and expand ultrasonic call surveys; sample within Rotor Swept Area (RSA) (higher towers & balloons) 2. Collect weather and insect abundance/height data 3. Identify high-risk conditions/times and seasons 4. Conduct radar utilisation at call survey locations sampling at RSA; quantify abundance and flight heights 5. Conduct numerical risk modelling (for *S. saccolaimus only* or for entire microchiropteran bat community – depending on radar data quality)	Prepare Microchiropteran Bat Management Plan	Pre-construction	External Ecologist / Specialist (inc. Biostatistician)	DotE DERM
Spectacled Flying-fox / Grey-headed Flying Fox	Turbine Collision	Operational Phase	Turbine curtailment during high-risk conditions (active) or excessive mortality events (reactive)	1.Utitlisation of the RSA (abundance and flight height data) 2. Population Viability Analysis (PVA) to determine sustainable collision mortality levels	1. Conduct radar utilisation surveys 2. Support CSIRO researchers to conduct satellite telemetry of more individuals from nearest colonies to site (Mareeba and Tolga Scrub) 3. Conduct numerical collision risk modelling (using radar/telemetry data)	Prepare Flying Fox Management Plan	Pre-construction	External Ecological/Specialist	DotE DERM
Northern Quoll	Habitat Loss	Construction	Avoid clearing high-quality denning and foraging habitats	1. Denning and foraging habitat preferences especially of breeding females 2. Estimates of dispersion for PVA model	Preconstruction 1. Undertake additional telemetry studies on the project site to determine whether proposed turbine ridge habitats are used preferentially, particularly females with young; and offsite, to collect data on dispersion rates to refine the PVA (to assess the significance of potential impacts) 2. Redesign infrastructure layout to avoid high quality foraging or maternal denning habitat and/or inform Quoll Management Plan	Prepare Quoll Management Plan	Pre-construction	External Specialist	DotE DERM
	Habitat Degradation (late dry season wild fires and weed invasion)	Construction and Operation	1. Weed monitoring and control 2. Implementation of Ecological Fire Management (to avoid extensive wild fire in late dry season)	1. Long-term fine-scale fire history of site	1. Fire-scale mapping using Landsat imagery 2. Control of existing weed infestations (especially invasive grasses along Kippen Drive and access tracks)	Prepare Weed Management Plan and Fire Management Plan	Pre-construction	External Specialist	DotE DERM
Sarus Crane	Turbine Collision	Operational Phase	Turbine curtailment during high-risk conditions (active) or excessive mortality events (reactive)	1.Utitlisation of the RSA (abundance and flight height data) 2. Population Viability Analysis (PVA) to determine sustainable collision mortality levels	1. Conduct radar utilisation surveys 2. Support CSIRO researchers to conduct satellite telemetry of more individuals from nearest colonies flocks 3. Conduct numerical collision risk modelling (using radar/telemetry data) - updated	Prepare Bird Adaptive Management Plan	Pre-construction	External Ecological / Specialist	DotE DERM
Flora									
Significant Plants	Clearing of Conservation Significant Plants	Construction	Avoidance and micro-siting of turbines.	Detailed distribution of significant plants Relocation and translocation strategies.	Avoidance of disturbance to key plant habitats (see next point). Detailed plant survey of south-west montane heath habitat - GPS mapping of avoidance patches. Micro positioning of turbines to minimise clearing and disturbance to conservation significant plants and important vegetation types.	Final site-based floristic records. Records of seed collections as per Rehabilitation Plan.	Preconstruction and ongoing throughout construction phase. Seed collection every 3 months after construction	External Botanist	DotE DERM

Species	Potential Impact	Impacting Phase	Proposed Mitigation Strategy	Essential Information Gaps	Management Actions Required	Monitoring, Reporting	Timing	Responsibilities	Relevant Agency
					Presence of Botanical advisor in pre clearance team. Instigate site-based seed and propagule collection for future rehabilitation work.	Conservation Significant Plant Management Plan	for at least 5 years.		
	Clearing of Conservation Significant Plants	Operation / Decommissioning	Translocation and revegetation strategies	Propagation viability of significant plants. Plant successional traits.	Prepare Significant Plant Management Plans including : Research propagation of *Homoranthus porteri*, *Melaleuca uxorum, Plectranthus amoenus and Grevillea glossadenia*. Conduct Revegetation trials. Investigate plant successional traits.	Conservation Significant Plant Management Plan Annual Revegetation Trial report	Preconstruction and ongoing as required First 3 years of operation	External botanist/ Nursery External Specialist	DotE DERM
Water Quality									
Aquatic Flora and Fauna	Reduced downstream water quality	Construction / Decommissioning and Operation	Maintenance of downstream water quality through water monitoring and management in accordance with a detailed Erosion and Sediment Control Plan	Background Water Quality(pH, Electrical Conductivity, Turbidity)	Conduct preconstruction water quality monitoring to inform construction water quality targets Prepare Detailed Erosion And Sediment Control Plan (ESCP)	as per Approval Conditions and CEMP Annual Baseline Water Quality Assessment Report Monthly reporting against approval conditions	preconstruction and event based during construction and first year of operation	Pre-construction - External Specialist Construction- Environmental Officer	DEHP DotE

4.0 Construction EMP

4.1 Flora

Policy	To minimise the effect on vegetation and habitat for flora, and to promote regeneration of native vegetation on the WTG access tracks and turbine sites.
Performance Objectives	▪ Minimise impacts to native vegetation and disturbance to important plant habitats. ▪ Rehabilitation with native plants of available cleared areas ▪ Where practicable, avoid disturbance to significant species (endangered, vulnerable and rare flora species). ▪ Minimise habitat fragmentation and maintain absolute minimum width clearing along ridges. ▪ Prevent weeds and plant pest diseases spreading as a result of construction activities. ▪ Offset of any rare, endangered or vulnerable plants disturbed by construction by translocating species where practicable, and providing additional rehabilitation areas where revegetation trials can be established.
Management Strategies	▪ Conduct activities in accordance with Conservation Significant Plant Management Plan. ▪ Preconstruction survey (early works package) undertaken to identify locations of rare and threatened species and other significant plants (including habitat trees) along the preferred WTG access tracks/turbine sites will be undertaken to allow designers to avoid and minimise clearing of these species and communities during construction. Any seed or plant propagules should be collected, stored and labelled by a botanist or qualified person to accumulate a seed bank for future rehabilitation. ▪ Topsoil is a rare commodity on the site and soil and rock spoil should be stockpiled separately and adjacent to where the material was taken, or the very nearest suitable storage area. Stockpiles of material (particularly soil) will not exceed a height of 1 (one) metre. ▪ Placement of physical barriers around significant vegetation areas in order to restrict access and prevent disturbance. ▪ Transplanting trials of suitable plants to be practiced as a rehabilitation/conservation measure if feasible. Transplanting will occur when ground conditions are best suited to plant growth (i.e. some longer term moisture is available in the soil). ▪ Windrowed vegetation should not be burnt. Respreading of cleared native vegetation over areas available for rehabilitation (i.e. laydown areas, track batters, temporary crane pads) to occur following construction. ▪ Conduct rehabilitation success trials particularly in relation to significant species and trials as per Conservation Significant Plant Management Plan ▪ Preconstruction survey (early works package) to identify location of weeds along the proposed WTG access tracks and turbine sites and existing tracks. ▪ Control environmental weeds by approved methods and in accordance with the Weed Management Plan along the WTG access tracks and turbine sites prior to clearing and grading. This should be undertaken at least 2 weeks prior to construction work commencing in the respective areas. ▪ Declared weeds to be controlled by an approved method prior to clearing and grading. ▪ All soil and rock material is to be stockpiled *in situ*. All imported construction material (road base, sand, rock-fill etc.) is to be free of weed seed and propagules, and be sourced from clean suppliers in the local region. ▪ All vehicles and machinery to be washed down and certified weed free prior to entering site and in accordance with the Weed Management Plan. Vehicles and machinery is to be monitored at the site entry point (washdown bay). ▪ Vehicles, plant and equipment is to be washed down following work in areas affected by weeds. ▪ Vehicles and machinery working in internal weed infested areas are not to continue work in weed-free zones unless certified clean and weed free. Mobile washdown facilities will be established.

Performance Indicators	▪ Minimum impact to ecosystems and plant species of National Environmental Significance and species known to be of interest to conservation. ▪ Minimal disturbance of flora during construction of the WTG access tracks and turbine sites and associated camp sites. ▪ Achievement of Conservation Significant Plant Management Plan targets ▪ No damage to protected species without relevant permit and approval. ▪ No presence of environmental and declared weeds (e.g. grader grass, sicklepod, Lantana, thatch grass etc. - refer to Weed Management Plan). ▪ Survival and persistence of species planted for the offset programme and Translocation Plan.
Monitoring, Reporting and Corrective Action	▪ Photographic records are to be maintained throughout the year (monthly basis). Fixed photo monitoring points are to be established. ▪ Daily Check Sheets to include weed presence – completed and reviewed by manager/supervisor, and supervising botanist when on site ▪ Regular inspections, third party audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented. ▪ Prepare Annual Conservation Significant Plant Management Plan and Rehabilitation Plan reports. ▪ Additional weed control as required with supplementary weed surveys within 14 days following rainfall events. ▪ Offset rehabilitation planting to be monitored for a period of 3 years following rehabilitation to ensure survival, persistence and performance, as well as replacement of mortalities.
Responsible Person	▪ Environmental Officer and supervising botanist ▪ Annual site rehabilitation assessment by supervising botanist
Associated Documentation	▪ Conservation Significant Plant Management Plan ▪ Rehabilitation Plan ▪ Weed Management Plan ▪ Translocation Plan ▪ Offset Programme ▪ EIS technical reports

4.2 Fauna

<table>
<tr><td>Policy</td><td>To minimise the effect on fauna and habitat.</td></tr>
<tr><td>Performance Objectives</td><td>
Minimise impacts to native fauna.
Where practicable, avoid disturbance to endangered, vulnerable and rare fauna species.
Minimise habitat fragmentation and promote habitat regeneration where practicable.
Pest animals and animal pest diseases not spread as a result of construction activities.
</td></tr>
<tr><td>Management Strategies</td><td>
Spotter catcher present prior to and during all clearing activities.
Implementation of Quoll Management Plan Construction Phase Protocols. Key draft elements include:

Saturation trapping and collaring of all quolls prior to commencement of section clearing and daily radio tracking/sniffer dog surveys to confirm absence of quolls in proposed clearing area. Trapping to confirm stage of reproduction cycle as this can vary from year to year.
Daily clearing to commence only once all tracked animals are confirmed clear of the area.
Carry out primary earthworks during February to October period to avoid mortality of dependant juveniles (left in den sites). If earthworks is to occur during November to January period conduct sniffer dog searches in advance of clearing to confirm presence/ absence. If present delay clearing in that area until maternal removal. This is dependent on trapping activities.

Implementation of Bird Management Plan Construction Phase Protocols. Key draft elements to include:

Avoidance of clearing of any roosting trees identified during preconstruction surveys and micro siting of turbine and track location.
Minimizing area of cleared vegetation
Implementation of Micro bat Management Plan Construction Phase protocols. Key draft elements to include:
Avoidance of clearing of any roosting trees identified during preconstruction surveys and micro siting of turbine and track location.

Minimizing area of cleared vegetation
Avoid vehicular use of site at night where possible
Restrict speed limits at night
Weed monitoring and control
Develop and implement ecological burning regime
</td></tr>
<tr><td>Performance Indicators</td><td>
Mortality of endangered species within approved limits; and
Compliance with species management plans
</td></tr>
<tr><td>Monitoring, Reporting and Corrective Action</td><td>
Photographic records are to be maintained throughout the year (monthly basis). Fixed photo monitoring points are to be established.
Daily Spotter Catcher records including quoll tracking records – reviewed by manager / supervisor, and supervising botanist when on site
Clearing scheduling to be determined by Construction Manager in consultation with Spotter Catcher and External Ecological Contractor
Regular inspections, third party audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Prepare Annual Conservation Significant Plant Management Plan and Rehabilitation Plan reports.
Additional weed control as required with supplementary weed surveys within 14 days following rainfall events.
Offset rehabilitation planting to be monitored for a period of 3 years following rehabilitation to ensure survival, persistence and performance, as well as replacement of mortalities.
</td></tr>
<tr><td>Responsible Person</td><td>
Environmental Officer
</td></tr>
</table>

	▪ External Ecological Contractor / Spotter Catcher ▪ Construction Manger to authorize clearance only
Associated Documentation	▪ Species Management Plans ▪ Approval permits

4.3 Erosion and Sediment Control

Policy	To provide effective erosion and sediment practices to mitigate the potential effects of construction on watercourses, land use and the general environment.
Performance Objectives	▪ Minimise soil erosion. ▪ Minimise sedimentation of land. ▪ Minimise modification to drainage patterns. ▪ Prevent as far as practical, sediment transport to adjacent watercourses.
Management Strategies	▪ Conduct all earthworks in accordance with a detailed Erosion and Sediment Control Plan prepared by a suitably experienced professional (e.g. Certified Professional in Erosion and Sediment Control) ▪ Minimise the quantity and duration of soil exposure. ▪ Protect topsoil, root and seed stock. ▪ Protect critical areas during and after construction by reducing the velocity of stormwater flow and redirecting runoff onto undisturbed areas. ▪ Install and maintain temporary erosion and sediment control measures during construction. ▪ Replace topsoil and seed stock on turbine laydown pads and track verges to facilitate revegetation as soon as practicable following construction. ▪ Inspect disturbed areas and maintain erosion and sediment controls as necessary during and after construction until stabilisation is achieved. ▪ Should the cabling trench require dewatering in wet weather, then this is to be pumped out and disposed across grass and not directly discharged to any stormwater drain or creek. ▪ Strict implementation of permanent stormwater diversion drains on all hilly slopes (approximately 20 m intervals, depending on slope). ▪ Strict implementation of silt mesh fencing, and stormwater diversion drains on the banks of all waterways containing flowing water during construction. ▪ Highly erodible soils are identified by visual inspection of the site to identify the extent and location of existing soil erosion. ▪ Where highly erodible soils are identified, and if the area cannot be reasonably avoided, the following controls should be implemented: ▪ Keep the work area to a minimum so that the smallest possible ground area is disturbed. ▪ Place erosion control structures such as diversion drains and silt fences at key locations to capture the suspended sediment. ▪ Divert stormwater away from the exposed soil to reduce overland flow or channel flow on the vulnerable soils. ▪ Stormwater Diversion ▪ In areas which are subject to erosion potential (slopes >5%), stormwater diversion banks / drains (whoa-boys) should be placed diagonally across the tracks to divert stormwater to adjacent undisturbed grassed areas following completion of construction. Spacing of such diversion drains can be approximately 50 m to 70 m apart. Where slopes are >5%, then more frequent spacing is required. ▪ Adequate monitoring and follow-up work following construction to ensure any initiated erosion is arrested early.
Performance Indicators	▪ Achievement of downstream water quality targets (Turbidity, TSS) ▪ No large scale erosion or sedimentation caused to adjacent land uses as a result of construction activities. ▪ No evidence of additional sedimentation in watercourses as a result of erosion from construction activities. ▪ Reinstatement of watercourses to original profile. ▪ Adequate spacing of stormwater diversion drains in areas of erosion potential
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting)

	undertaken in accordance with EMP and recommendations and corrective actions implemented. ▪ Construction audits will include all watercourse crossings. ▪ A post-construction audit which will evaluate revegetation, erosion control, weed control, water course bank stability will be conducted annually for two years following completion of construction.
Responsible Person	▪ Environmental Officer ▪ Construction Superintendant ▪ Construction Manager
Associated Documentation	▪ Detailed Erosion and Sediment Control Plan

4.4 Management of Flammable and Combustible Substances

Policy	To ensure storage and handling of flammable and combustible substances onsite does not cause environmental harm or harm to persons.
Performance Objectives	▪ To minimise potential for land contamination. ▪ To ensure the on-going safety of construction personnel.
Management Strategies	▪ An Emergency Response Plan shall be in place and employees inducted in its application. ▪ Flammable and combustible substances are stored, handled, separated and signed as required by the Flammable and Combustible Liquids Regulations and AS1940. ▪ Transportation of dangerous goods will be in accordance with the Regulations and with AS 1678, AS 2809 and AS 2931. ▪ A qualified person will be appointed as Site Safety Officer. ▪ An on-site set of the relevant MSDS for all flammable and combustible substances and dangerous goods used during construction will be maintained and available. ▪ Waste flammable and combustible substances which cannot be recycled will be transported to a designated disposal site as approved by Local Government. ▪ No refuelling of plant and equipment over or within 100m of watercourses. ▪ Spill kits containing absorbent and containment material (e.g. absorbent matting) will be available where hazardous materials are used and stored and personnel trained in their correct use. ▪ Spills of flammable and combustible substances will be rendered harmless and collected for treatment and / or remediation or disposal at a designated site, including cleaning materials, absorbents and contaminated soils and reinstatement made to the affected area. ▪ Personal protective equipment (PPE) appropriate to the materials in use will be provided. ▪ Relevant Local Government permits will be held and conditions of permits met.
Performance Indicators	▪ No hazardous goods contamination of the environment.. ▪ Ensure appropriate remedial action has been implemented for any spills. ▪ Major incidents reported to relevant authorities and their directions followed. ▪ Spill kits and PPE available and used as appropriate.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Regular inspection of storage facilities and work practices in the handling of flammable and combustible substances or other dangerous substances. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager ▪ Environmental Officer
Associated Documentation	▪ Nil

4.5 Noise and Vibration

Policy	To minimise the impact of construction noise nuisance and vibration to nearby residences.
Performance Objectives	▪ Minimise noise nuisance generated by construction activities. ▪ Minimise any vibration nuisance to nearby residences.
Management Strategy	▪ Provide advance notice of any scheduled atypical noise events to nearby residents. ▪ equipment maintained in accordance with manufacturer's specifications. ▪ Schedule atypical noise events for appropriate times. ▪ Any blasting is to be carried out in accordance with current practice standards with particular reference to AS 2187. ▪ Maintain liaison with nearby residents. ▪ Noisy construction activities in proximity to residences to be limited to 7.00 am to 6.00 pm Monday to Saturday or in accordance with local permits.
Performance Indicators	▪ Number of noise related complaints received from residents during construction. ▪ Evidence of repair and replacement of faulty equipment as soon as possible. ▪ Evidence of condition surveys.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Noise survey in the event of complaint. ▪ Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager
Associated Documentation	▪ Complaints Register ▪ Marshall Day Accoustics Report November 2013

4.6 Air Emissions

Policy	To complete the installation of each WTG line in a manner to maintain ambient air quality of the local area.
Performance Objectives	▪ To maintain acceptable limits of vehicular and machinery operating emissions and to receive zero complaints from local landholders regarding air quality. ▪ To minimise the generation of fugitive dust emissions produced during construction.
Management Strategies	▪ Vehicles and machinery shall be maintained in accordance with manufacturer's specifications. ▪ Watering of construction site and access tracks will be carried out on an as required basis, particularly on dry and windy days and especially near residences. ▪ Avoid smoke generation by a strict no burning policy. ▪ Implement fire control measures during welding operations.
Performance Indicators	▪ Visual observations of dust emissions during windy / dry periods ▪ Receipt of dust nuisance complaints from nearby residents ▪ Excessive visual dust cloud during construction activities.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager ▪ Environmental Officer
Associated Documentation	▪ Nil

4.7 Waste Management

Policy	To minimise waste generation and maximise reuse and recycling of construction waste products.
Performance Objectives	▪ Minimise impacts related to waste management. ▪ No evidence of litter or refuse generated from construction related activities.
Management Strategies	▪ Stockpiling and salvaging reusable and recyclable wastes, such as timber skids, pallets, drums and scrap metals. ▪ Collecting and removing waste oil and solvents from site for recycling, reuse or disposal at approved locations. ▪ Disposing of sewage and sullage from camp site via a packaged mini sewerage treatment plant (greywater may be discharged to land in accordance with local approvals). ▪ Collection of chemical wastes in 200 L drums (or similar sealed container), appropriately labelled, for safe transport to an approved chemical waste depot or collection by a liquid waste treatment service. ▪ All binding material and dunnage from transport vehicles and unloading areas is to be collected and transported off the easement to designated disposal areas. ▪ Collecting and transporting general refuse to a Local Government approved disposal site. ▪ Ensure wastes are not accessible by stock or wildlife. ▪ Refuse containers will be located at each worksite. ▪ Where practical, wastes will be segregated and reused / recycled (e.g. scrap metal). ▪ All personnel shall be instructed in project waste management practices as a component of the environmental induction process. ▪ Spraying of declared plants and disposal to regulated landfill.
Performance Indicators	▪ Clean and waste-efficient construction site ▪ Percentage of waste recycled ▪ Litter left onsite during construction
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular housekeeping checks and a waste audit to be conducted. The camp site area is to be inspected after relocation. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager ▪ Environmental Officer
Associated Documentation	▪ Material Safety Data Sheets

4.8 Fire Management

Policy	To minimise the potential for vegetation to catch fire from construction activities.
Performance Objectives	▪ No fires deliberately lit or allowed to remain alight along the WTG line or other project related worksites. ▪ No build-up of flammable material during construction near hot work areas.
Management Strategies	▪ Open fires will be banned on the project. Fires include open barbeques, billy fires, brush burning and rubbish burning. ▪ Adoption of lightning protection measures for both turbines and substations. ▪ Unnecessary build-up of flammable material near working areas will be prevented, with vegetation and other flammable material being stockpiled well clear of hot work activities. ▪ Water trucks (also used for dust suppression) will be available for use as fire trucks in the event of fire. ▪ All vehicles will be equipped with portable fire extinguishers. ▪ Fire extinguishers and a water cart will be available to the welding crew. All appropriate crew members will be trained in the use of fire fighting equipment. ▪ Emergency Response Plan shall include details on local contacts for fire fighting assistance. ▪ Construction management liaison with local Rural Fire Service personnel during high fire periods.
Performance Indicators	▪ Fire frequency. ▪ Ignition from lightning strikes ▪ Build-up of flammable material near hot work areas. ▪ Emergency Response Plan in place. ▪ Permits and approvals as required.
Monitoring, Reporting and Corrective Action	▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Environmental Officer ▪ Construction Supervisor
Associated Documentation	▪ RACL Fire Management Plan

5.0 Operational EMP

5.1 Access and Landholder Relationships

Policy	To minimise the impact on surrounding landholders.
Performance Objectives	▪ Minimise impacts to adjoining native flora and fauna ▪ Eliminate the likelihood of the spread of weeds off site ▪ Minimise disruption to landholder activities along Kippin Drive ▪ Maintain regular liaison with landholders along the route
Management Strategies	▪ Restrict site entry to designated access track ▪ Maintain regular liaison with landholders ▪ Landholder concerns are addressed promptly ▪ Erosion and sediment control measures will be maintained as required. ▪ Ensure gates are locked where access can be obtained from a road (to ensure unauthorised users are excluded).
Performance Indicators	▪ Complaints from land owners minimised ▪ Erosion and sediment control in place
Monitoring & Reporting	▪ Complaint Register ▪ Easement inspection check sheet ▪ Independent audit every two years
Responsible Person	▪ Site Manager
Associated Documentation	▪

5.2 Flora Management

Policy	To promote vegetation re-establishment, and promote a stable landform.
Performance Objectives	▪ Promote the establishment of ground cover plants and zones of native vegetation (including shrubs and trees) on all areas of disturbance. ▪ Promote natural regeneration of native plant communities on temporarily cleared areas. ▪ In addition to typical regenerating vegetation, planting and transplanting of conservation significant plant species in appropriate areas wherever possible. ▪ Maintenance of revegetation and rehabilitation areas in accordance with the Rehabilitation Plan and Conservation Significant Plant Management Plan. ▪ Ensure that weeds are not spread along WTG access tracks, particularly environmental weeds, declared plants and invasive grasses.
Management Strategies	▪ Promote low regrowth of native plants along access track verges. Pads required for crane access during maintenance may be grassed with native species or a species certified to be sterile and non-weed forming. This may require spreading native grass seed following rain. ▪ Monthly weed survey by supervising botanist (monthly during wet season for first 2 years after construction); control of weeds along the WTG access tracks, turbine pads and contractors yard implemented.
Performance Indicators	▪ Track verges, turbine pads stabilized and revegetated or rehabilitated according to Rehabilitation Plan. ▪ Nil declared, invasive or environmental weeds present. All outbreaks controlled before setting flowers and seeds.
Responsible Person	▪ Site Manager and supervising botanist.
Monitoring & Reporting	▪ Monthly and weekly inspection check sheets ▪ Independent audit every year ▪ Weed records to be maintained according to Weed Management Plan.

Responsible Person	▪ Site Manager and supervising botanist ▪ Ratch Project Manager
Associated Documentation	▪

5.3 Fauna Management

Policy	To minimise the effect on fauna and habitat.
Performance Objectives	▪ Minimise impacts to native fauna. ▪ Where practicable, avoid disturbance to endangered, vulnerable and rare fauna species. ▪ Minimise habitat fragmentation and promote habitat regeneration where practicable. ▪ Pest animals and animal pest diseases not spread as a result of construction activities. ▪ Prevent introduction and spread of declared and invasive weeds
Management Strategies	▪ Adaptive management strategies in accordance with Significant Species management Plans. Key elements of these plans to include: ▪ Trial visual and acoustic automated collision detection systems (TADS/WT-Bird etc.) ▪ Conduct carcass searches (calibrated for scavenger removal and detectability); validate collision risk model. ▪ Conduct call activity surveys at turbines within RSA ▪ Curtail operation of all/some of turbines during high-risk conditions or in response to detected excessive collision mortality ▪ Operate avian and bat radar SCADA system to implement automatic turbine shut-down
Performance Indicators	▪ Mortality of endangered species within approved limits; and ▪ Compliance with species management plans
Monitoring & Reporting	▪ Annual (quarterly for first 2 years) reports in accordance with Significant Species Management Plans and approval conditions, including mortality surveys
Responsible Person	▪ Site Manager ▪ RACL Project Manager
Associated Documentation	▪

5.4 Erosion and Sediment Control

Policy	To ensure erosion and sediment control measures along access tracks and turbine pads are effectively maintained.
Performance Objectives	▪ Minimise soil erosion ▪ Minimise sedimentation of land ▪ Minimise modification to drainage patterns ▪ Prevent as far as practical, sediment transport to adjacent watercourses.
Management Strategies	▪ Inspect all disturbed areas monthly and maintain erosion and sediment controls as necessary. ▪ Place additional erosion control structures such as diversion banks / drains, rock check dams, rock armouring, whoa-boys) at key locations if additional erosion is detected along tracks. ▪ Divert stormwater away from tracks if necessary. ▪ Ensure replacement of any erosion control measures as required. ▪ Monitor downs stream water quality (turbidity) for first 12 months after construction.
Performance Indicators	▪ No large scale erosion or sedimentation caused to adjacent land uses as a result of construction activities. ▪ No evidence of additional sedimentation in watercourses as a result of erosion from operational activities.

	▪ Compliance with water quality targets
Monitoring & Reporting	▪ inspection check sheets ▪ Independent audit every two years
Responsible Person	▪ Site Manager
Associated Documentation	▪

5.5 Management of Flammable and Combustible Substances

Policy	To ensure that storage and handling of flammable and combustible substances onsite Does not cause environmental harm or harm to persons.
Performance Objectives	▪ To minimise potential for land contamination. ▪ To ensure the on-going safety of operational personnel.
Management Strategies	▪ An Emergency Response Plan in place and employees inducted in its application. ▪ Flammable and combustible substances are stored, handled, separated and signed as required by the Flammable and Combustible Liquids Regulations and AS 1940. ▪ Relevant MSDS for all flammable and combustible substances and dangerous goods maintained. ▪ Waste flammable and combustible substances which cannot be recycled will be transported to a designated disposal site as approved by Local Government. ▪ Spill kits containing absorbent and containment material (e.g. absorbent matting) will be available where hazardous materials are used and stored and personnel trained in their correct use. ▪ Spills of flammable and combustible substances will be rendered harmless and collected for treatment and / or remediation or disposal at a designated site, including cleaning materials, absorbents and contaminated soils and affected area reinstated. ▪ Personal protective equipment (PPE) appropriate to the materials in use, will be provided. ▪ Relevant Local Government permits will be held and conditions of permits met.
Performance Indicators	▪ No hazardous goods contamination of the environment. ▪ Ensure appropriate remedial action has been implemented for any spills. ▪ Spill kits and PPE available for use.
Monitoring & Reporting	▪ HSE check list and annual audit
Responsible Person	▪ Site Manager
Associated Documentation	▪

5.6 Noise

Policy	To minimise the impact of noise nuisance from wind farm maintenance activities to nearby residences.
Performance Objectives	▪ Minimise noise nuisance generated by operation and maintenance activities.
Management Strategy	▪ Provide advance notice of any scheduled maintenance activities to nearby residents. ▪ Schedule noisy maintenance activities to appropriate times. ▪ Maintain liaison with nearby residents. ▪ Advise nearby residents in advance if any planned venting or other noisy activities are to be undertaken. ▪ Conduct Noise impact monitoring of operation within three months of commencement and review mitigation measures as necessary
Performance Indicators	▪ Number of noise related complaints received from residents.
Monitoring & Reporting	▪ Complaint Register ▪ Independent audit every year (years 1-3) then every two years
Responsible Person	▪ Site Manger ▪ RACL Project Manager
Associated Documentation	▪

5.7 Waste Management

Policy	To minimise waste generation and maximise reuse and recycling of waste products.
Performance Objectives	▪ Minimise impacts related to waste management. ▪ No evidence of litter or refuse generated from maintenance activities.
Management Strategies	▪ Collecting and removing waste oil and solvents for recycling, reuse or disposal at approved locations. ▪ Where practical, wastes will be segregated and reused / recycled (e.g. scrap metal). ▪ All maintenance personnel shall be instructed in waste management practices as a component of their induction process.
Performance Indicators	▪ Percentage of waste recycled ▪ Litter left onsite after maintenance activities
Monitoring & Reporting	▪ Easement inspection check sheet
Responsible Person	▪ Site Manager
Associated Documentation	▪

6.0 Decommissioning EMP

6.1 Access

Policy	Existing cleared areas and access tracks shall be used to access the WTG's so as to minimise the impact on vegetation and existing land use and minimise potential for weed invasion. Safely manage the transportation of wind turbine components in accordance with the Traffic Management Plan.
Performance Objectives	▪ Minimise impacts to native flora and fauna. ▪ Minimise impacts to soil and water. ▪ Avoid adverse impacts on cultural and historic heritage sites. ▪ Reduce the likelihood of the spread of weeds and fauna pests. ▪ As far as reasonably practicable, prevent movement of pest animals across declared barrier fences. ▪ Safely manage the transportation of WTG elements. ▪ Minimise any new access tracks and the number of access tracks. ▪ Minimise disruption to landholder activities and third parties. ▪ Manage road and track usage, and achieve satisfactory road and site rehabilitation. ▪ Minimise damage to existing road networks. ▪ Stakeholder consultation plan implemented.
Management Strategies	▪ Existing roads and tracks will be used where practicable. ▪ New access tracks and any diversions will generally be avoided, but if necessary, will be selected to minimise impacts on sensitive vegetation, erosion-prone soils and watercourse crossings; avoid any significant cultural heritage sites in accordance with the CHMP and minimise noise to nearby residents. New access tracks and diversions will only be used by agreement with the landholder. ▪ Consultation shall occur between Decommissioning Manager and senior police management at Mareeba and Atherton to ensure any potential cumulative impacts are mitigated. ▪ Disturbance (including access) to No-go areas shall be avoided. These shall be marked with flagging tape, paraweb fencing or equivalent. ▪ Wash down of plant and equipment (including vehicles) following work in any declared plant area. ▪ Erosion and sediment control measures will be used as and where required. ▪ Speed and weight restrictions will be applied to project vehicles as appropriate. ▪ Any damage to existing roads and tracks shall be repaired regularly. ▪ Safely manage the transport of WTG components in accordance with the TMP to be developed in conjunction with local governments, QPS and DTMR. ▪ Undertake a road condition survey of roads used by the Project.
Performance Indicators	▪ Access readily manageable and able to be rehabilitated using standard techniques. ▪ Complaints from land owners, authorities and public are minimised. ▪ Erosion and sediment control in place. ▪ Condition of existing roads and tracks are maintained. ▪ WTG components managed in line with transport management plan. ▪ Road condition not deteriorated as a result of project activities or made good following deterioration caused by project activities.
Monitoring, reporting and corrective actions	▪ Photographic records ▪ Complaint Register – complaints recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.

Responsible Person	▪ Environmental Officer / Community Liaison Officer
Associated Documentation	▪ Biosecurity (including weeds) Management Strategy ▪ Decommissioning Safety Management Plan ▪ Road condition assessment ▪ Maps of access tracks

6.2 Flora and Fauna Management

Policy	To minimise additional impacts and effects on vegetation and habitat for flora and fauna during the decommissioning of the wind farm, including infrastructure such as turbine pads, compounds and yards and laydown areas and the access tracks.
Performance Objectives	▪ Prevent impacts to native vegetation and rehabilitation and conservation areas. ▪ Prevent weeds from entering the site. Continue application of Weed Management Plan and washdown facilities. ▪ No spread of weeds, and plant pest diseases within the site as a result of decommissioning activities. The site will be left free of serious weeds (environmental and declared, as well as introduced pasture grasses). ▪ Where practicable, avoid disturbance to endangered, vulnerable, rare and poorly known flora species that have regenerated adjacent to or in original construction zones. Avoid all impacts to these types of plants and habitats outside of the original construction zone. ▪ No net loss of habitat connectivity or additional habitat fragmentation to occur. ▪ Offset programme for rare, endangered or vulnerable plants has been successful and the objectives have been met as outlined in respective Management Plans.
Management Strategies	▪ A post-decommissioning survey undertaken to identify rare and threatened species within the decommissioning zone. ▪ Flag individual significant plant species (including habitat trees) which are located in the decommissioning zone so they may be avoided where practicable during operational work. ▪ Placement of physical barriers around significant vegetation areas in order to restrict access and avoid further disturbance. ▪ Harvesting seeds for replacement use in rehabilitation zones, where natural regeneration was not successful. ▪ Ensure adequate measures are in place to safeguard and assist the movement of fauna from the decommissioning zone. ▪ All weeds established within the site are to be recorded in a decommissioning weed survey. ▪ Control environmental and declared weeds within and adjacent to the decommissioning zone. This should be performed in accordance with the methods and control measures detailed in the Weed Management Plan; ▪ Management strategies for the continued health and population growth of conservation significant flora and fauna are implemented and have a success rate that meets criteria detailed in respective species' management plans.
Performance Indicators	▪ Vegetation, ecosystems, habitats and conservation significant species of flora and fauna are not suffering from adverse impacts, ▪ Matters of National Environmental Significance are maintained in their current condition with negligible declines in population dynamics and the numbers of species present on the site. ▪ Minimal disturbance to flora and fauna has occurred as a result of decommissioning the wind farm. ▪ Restoration (successful rehabilitation) has resulted from progressive rehabilitation and environmental management of the wind farm site. Vegetation communities have recovered with a major proportion of the flora comprising native species. ▪ No failure or irreversible decline of rehabilitation measures. ▪ The dominant ground cover adjacent to tracks and turbine pads comprises native species and not introduced pasture grasses or legumes. ▪ No damage to protected species or designated conservation zones without relevant approval and supervision. ▪ Ensure relevant permits are effective before removing any protected species. ▪ Declared plants and environmental weeds ine are adequately controlled, and no fauna pests are introduced into the site ▪ Plant species planted for the offset programme are self-sustaining and do not require

	human assistance to survive. Rehabilitated plant communities should be persistent in the landscape able to function without intervention.
Monitoring, Reporting and Corrective Action	▪ Photographic records to be maintained. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented. ▪ Offset planting to be monitored for a period of 3 years following rehabilitation to ensure survival and replacement of mortalities.
Responsible Person	▪ Environmental Officer and respective environmental advisors.
Associated Documentation	▪ Weed Management Plan ▪ Conservation Significant Plant Species Management Plan ▪ Threatened Plant Species Translocation Plan ▪ Environmental Offsets Plan Conservation Significant Plant Management Plan ▪ Rehabilitation Plan ▪ Offset Programme ▪ EIS technical reports

6.3 Erosion and Sediment Control

Policy	To provide effective erosion and sediment practices to mitigate the potential effects of construction on watercourses, land use and the general environment.
Performance Objectives	▪ Minimise soil erosion. ▪ Minimise sedimentation of land. ▪ Minimise modification to drainage patterns. ▪ Prevent as far as practical, sediment transport to adjacent watercourses.
Management Strategies	▪ Conduct activities in accordance with a detailed Erosion and Sediment Control Plan (ESCP). ▪ Minimise the quantity and duration of soil exposure. ▪ Protect topsoil, root and seed stock. ▪ Protect critical areas during and after construction by reducing the velocity of stormwater flow and redirecting runoff onto undisturbed areas. ▪ Install and maintain temporary erosion and sediment control measures during construction. ▪ Re-contour modified landforms to their original condition as soon as practicable including any erosion controls established prior to construction. ▪ Replace topsoil and seed stock to facilitate revegetation as soon as practicable following construction. ▪ Inspect disturbed areas and maintain erosion and sediment controls as necessary during and after construction until stabilisation is achieved. ▪ Strict implementation of permanent stormwater diversion drains on all hilly slopes (approximately 20 m intervals, depending on slope). ▪ Strict implementation of silt mesh fencing and stormwater diversion drains on the banks of all waterways containing flowing water during construction. ▪ Highly erodible soils are identified by visual inspection of the site to identify the extent and location of existing soil erosion. ▪ Where highly erodible soils are identified, and if the area cannot be reasonably avoided, the following controls should be implemented: ▪ Keep the work area to a minimum so that the smallest possible ground area is disturbed. ▪ Place erosion control structures such as diversion drains and silt fences at key locations to capture the suspended sediment. ▪ Divert stormwater away from the exposed soil to reduce overland flow or channel flow on the vulnerable soils.

	▪ For wet crossings, the following sediment controls should be implemented: ▪ Place erosion control structures such as rock check dams and sand bags in the channel to slow velocity and capture suspended sediment. ▪ Divert stormwater away from disturbed channels or swales to minimise the flow of water and erosion potential. ▪ Minimise disturbance to the existing channel. This may involve constructing a temporary access across small swales and channels. ▪ If flow modification is necessary during construction, reinstate the channel on completion of works. ▪ Reinstate all existing erosion control structures on completion of works. ▪ Stormwater Diversion ▪ In areas which are subject to erosion potential (slopes >5%), stormwater diversion banks / drains (whoa-boys) should be placed diagonally across access tracks to divert stormwater to adjacent undisturbed grassed areas following completion of construction. Spacing of such diversion drains can be approximately 50 m to 70 m apart. Where slopes are >5%, then more frequent spacing is required. ▪ Adequate monitoring and follow-up work following construction to ensure any initiated erosion is arrested early.
Performance Indicators	▪ No large scale erosion or sedimentation caused to adjacent land uses as a result of construction activities. ▪ No evidence of additional sedimentation in watercourses as a result of erosion from construction activities. ▪ Reinstatement of watercourses to original profile. ▪ Adequate spacing of stormwater diversion drains in areas of erosion potential.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented. ▪ Construction audits will include all watercourse crossings. ▪ A post-construction audit which will evaluate revegetation, erosion control, weed control, water course bank stability will be conducted annually for two years following completion of construction.
Responsible Person	▪ Environmental Officer and Community Liaison Officer
Associated Documentation	▪ Erosion and Sediment Control Plan

6.4 Management of Flammable and Combustible Substances

Policy	To ensure storage and handling of flammable and combustible substances onsite does not cause environmental harm or harm to persons.
Performance Objectives	▪ To minimise potential for land contamination. ▪ To ensure the on-going safety of construction personnel.
Management Strategies	▪ An Emergency Response Plan shall be in place and employees inducted in its application. ▪ Flammable and combustible substances are stored, handled, separated and signed as required by the Flammable and Combustible Liquids Regulations and AS1940. ▪ Transportation of dangerous goods will be in accordance with the Regulations and with AS 1678, AS 2809 and AS 2931. ▪ A qualified person will be appointed as Site Safety Officer. ▪ An on-site set of the relevant MSDS for all flammable and combustible substances and dangerous goods used during construction will be maintained and available. ▪ Waste flammable and combustible substances which cannot be recycled will be transported to a designated disposal site as approved by Local Government. ▪ No refuelling of plant and equipment over or within 100m of watercourses. ▪ Spill kits containing absorbent and containment material (e.g. absorbent matting) will be available where hazardous materials are used and stored and personnel trained in their correct use. ▪ Spills of flammable and combustible substances will be rendered harmless and collected for treatment and / or remediation or disposal at a designated site, including cleaning materials, absorbents and contaminated soils and reinstatement made to the affected area. ▪ Personal protective equipment (PPE) appropriate to the materials in use will be provided. ▪ Relevant Local Government permits will be held and conditions of permits met.
Performance Indicators	▪ No hazardous goods contamination of the environment. ▪ Cut off flowpath to drains / watercourses e.g. sand bags, earthen bund, in the event of a spill. ▪ Ensure appropriate remedial action has been implemented for any spills. ▪ Major incidents reported to relevant authorities and their directions followed. ▪ Spill kits and PPE available and used as appropriate.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Regular inspection of storage facilities and work practices in the handling of flammable and combustible substances or other dangerous substances. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager
Associated Documentation	▪ Flammable and Combustible Liquids Regulations and AS1940

6.5 Noise and Vibration

Policy	To minimise the impact of construction noise nuisance and vibration to nearby residences.
Performance Objectives	▪ Minimise noise nuisance generated by construction activities. ▪ Minimise any vibration nuisance to nearby residences.
Management Strategy	▪ Provide advance notice of any scheduled atypical noise events to nearby residents. ▪ Ensure camp sites are located a sufficient distance form residences to limit any noise nuisance. ▪ Equipment maintained in accordance with manufacturer's specifications. ▪ Schedule atypical noise events for appropriate times. ▪ Any blasting is to be carried out in accordance with current practice standards with particular reference to AS 2187. ▪ Maintain liaison with nearby residents. ▪ Noisy construction activities in proximity to homesteads to be limited to 7.00 am to 6.00 pm Monday to Saturday or as stipulated in approval permits.
Performance Indicators	▪ Number of noise related complaints received from residents during construction. ▪ Evidence of repair and replacement of faulty equipment as soon as possible. ▪ Evidence of condition surveys.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Noise survey in the event of complaint. ▪ Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager
Associated Documentation	▪ Complaints Register

6.6 Air Emissions

Policy	To complete the installation of each WTG and access track in a manner to maintain ambient air quality of the local area.
Performance Objectives	▪ To maintain acceptable limits of vehicular and machinery operating emissions and to receive zero complaints from local landholders regarding air quality. ▪ To minimise the generation of fugitive dust emissions produced during construction.
Management Strategies	▪ Vehicles and machinery shall be maintained in accordance with manufacturer's specifications. ▪ Watering of construction site and access tracks will be carried out on an as required basis, particularly on dry and windy days and especially near residential homesteads. ▪ Avoid smoke generation by a strict no burning policy. ▪ Implement fire control measures during welding operations.
Performance Indicators	▪ Visual observations of dust emissions during windy / dry periods ▪ Receipt of dust nuisance complaints from nearby residents ▪ Excessive visual dust cloud during construction activities.
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager

Associated Documentation	▪ Nil

6.7 Waste Management

Policy	To minimise waste generation and maximise reuse and recycling of construction waste products.
Performance Objectives	▪ Minimise impacts related to waste management. ▪ No evidence of litter or refuse generated from construction related activities.
Management Strategies	▪ Stockpiling and salvaging reusable and recyclable wastes, such as timber skids, pallets, drums and scrap metals. ▪ Collecting and removing waste oil and solvents from site for recycling, reuse or disposal at approved locations. ▪ Disposing of sewage and sullage from camp sites via a packaged mini sewerage treatment plant (greywater may be discharged to land). ▪ Collection of chemical wastes in 200 L drums (or similar sealed container), appropriately labelled, for safe transport to an approved chemical waste depot or collection by a liquid waste treatment service. ▪ All binding material and dunnage from transport vehicles and unloading areas is to be collected and transported off the easement to designated disposal areas. ▪ Collecting and transporting general refuse to a Local Government approved disposal site. ▪ Ensure wastes are not accessible by stock or wildlife. ▪ Refuse containers will be located at each worksite. ▪ Where practical, wastes will be segregated and reused / recycled (e.g. scrap metal). ▪ All personnel shall be instructed in project waste management practices as a component of the environmental induction process. ▪ Spraying of declared plants and disposal to regulated landfill.
Performance Indicators	▪ Clean and waste-efficient construction site ▪ Percentage of waste recycled ▪ Nil litter left onsite during construction
Monitoring, Reporting and Corrective Action	▪ Photographic Records ▪ Complaints Register – recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular housekeeping checks and a waste audit to be conducted. The camp site area is to be inspected after relocation. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Construction Manager
Associated Documentation	▪ Nil

6.8 Fire Management

Policy	To minimise the potential for vegetation to catch fire from construction activities.
Performance Objectives	▪ No fires deliberately lit or allowed to remain alight at WTG sites or access tracks or other project related worksites. ▪ No build-up of flammable material during construction near hot work areas.
Management Strategies	▪ Open fires will be banned on the project. Fires include open barbeques, billy fires, brush burning and rubbish burning. ▪ Unnecessary build-up of flammable material near working areas will be prevented, with vegetation and other flammable material being stockpiled well clear of hot work activities. ▪ Water trucks (also used for dust suppression) will be available for use as fire trucks in the event of fire. ▪ All vehicles will be equipped with portable fire extinguishers. ▪ Fire extinguishers and a water cart will be available to the welding crew. All appropriate crew members will be trained in the use of fire fighting equipment. ▪ Emergency Response Plan shall include details on local contacts for fire fighting assistance. ▪ Construction management liaison with local Rural Fire Service personnel during high fire periods.
Performance Indicators	▪ Nil Construction related fires ▪ Build-up of flammable material near hot work areas. ▪ Emergency Response Plan in place. ▪ Permits and approvals as required.
Monitoring, Reporting and Corrective Action	▪ Complaints Register – recorded and closed out. ▪ Daily Check Sheets – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented.
Responsible Person	▪ Environmental Officer and Community Liaison Officer
Associated Documentation	▪ Emergency Response Plan

6.9 Clean up and Rehabilitation

Policy	To restore the land to a status that is comparable to the condition of the pre-construction environmental characteristics.
Performance Objectives	▪ Minimise soil erosion ▪ WTG line stable ▪ Minimise modification of drainage patterns ▪ Minimise weed invasion ▪ Minimise visual impact ▪ Minimise adverse impacts on other land uses
Management Strategies	▪ Stockpiled topsoil and seed stock will be respread on prepared surfaces in an even layer to assist natural regeneration. Minor surface roughness will be encouraged when spreading topsoil to trap water and seed. ▪ Visual markers used to identify clearing boundaries and sensitive features, will be removed. ▪ Hollow-bearing logs and coarse woody debris are to be repositioned on decommissioned sites to provide habitat for fauna. ▪ Where ground conditions allow, compaction relief will be undertaken where required by scarifying soils along the contours. ▪ Former turbine pads will be re-profiled according to the nearest and most appropriate landform (i.e. additional slopes will not be created).

	▪ Erosion and sediment control measures will be installed where necessary. Existing soil erosion measures will be reinstated to a condition at least equal to the pre-existing state. ▪ All waste materials and equipment will be removed from the site following decommissioning. ▪ Soil material is to be returned to the same general area from which it was extracted to minimise the risk of the spread of weeds, pests and diseases. ▪ Where disturbed areas are to be re-planted or re-seeded, only local provenance native species sourced from a local seed bank will be used. If direct-seeding is recommended for particular situations as detailed in the Rehabilitation Plan, the seed mixtures will be formulated for the conditions of the area. ▪ Where applied, seed will be evenly spread over the entire disturbed area. ▪ Direct-seeding will take place as soon as practicable during clean up and when ground conditions are most conducive to seed germination. ▪ Fertilisers and soil supplements will be used only if prescribed in the Rehabilitation Plan or approved through specific expert advice. ▪ Two monitoring sites for each Regional Ecosystem to be rehabilitated are required to be established as a benchmark from which to measure performance of rehabilitation.
Performance Indicators	▪ No new weed species introduced ▪ Weed Management implemented ▪ Groundcover re-established ▪ No change in drainage pattern leading to soil erosion ▪ Stable landforms
Monitoring, Reporting and Corrective Action	▪ Photographic records from monitoring sites. ▪ Check Sheets (recorded at monitoring sites) – completed and reviewed by manager / supervisor. ▪ Regular inspections, audits and reviews (non-compliance and incident reporting) undertaken in accordance with EMP and recommendations and corrective actions implemented. ▪ Post Construction Audits ▪ Regular Easement Inspections
Responsible Person	▪ Environmental Officer and Construction Manager
Associated Documentation	▪ Rehabilitation Plan

Appendix 34

Mount Emerald Wind Farm EPBC Offsets Assessment Guide

Prepared by CO2 Australia Limited

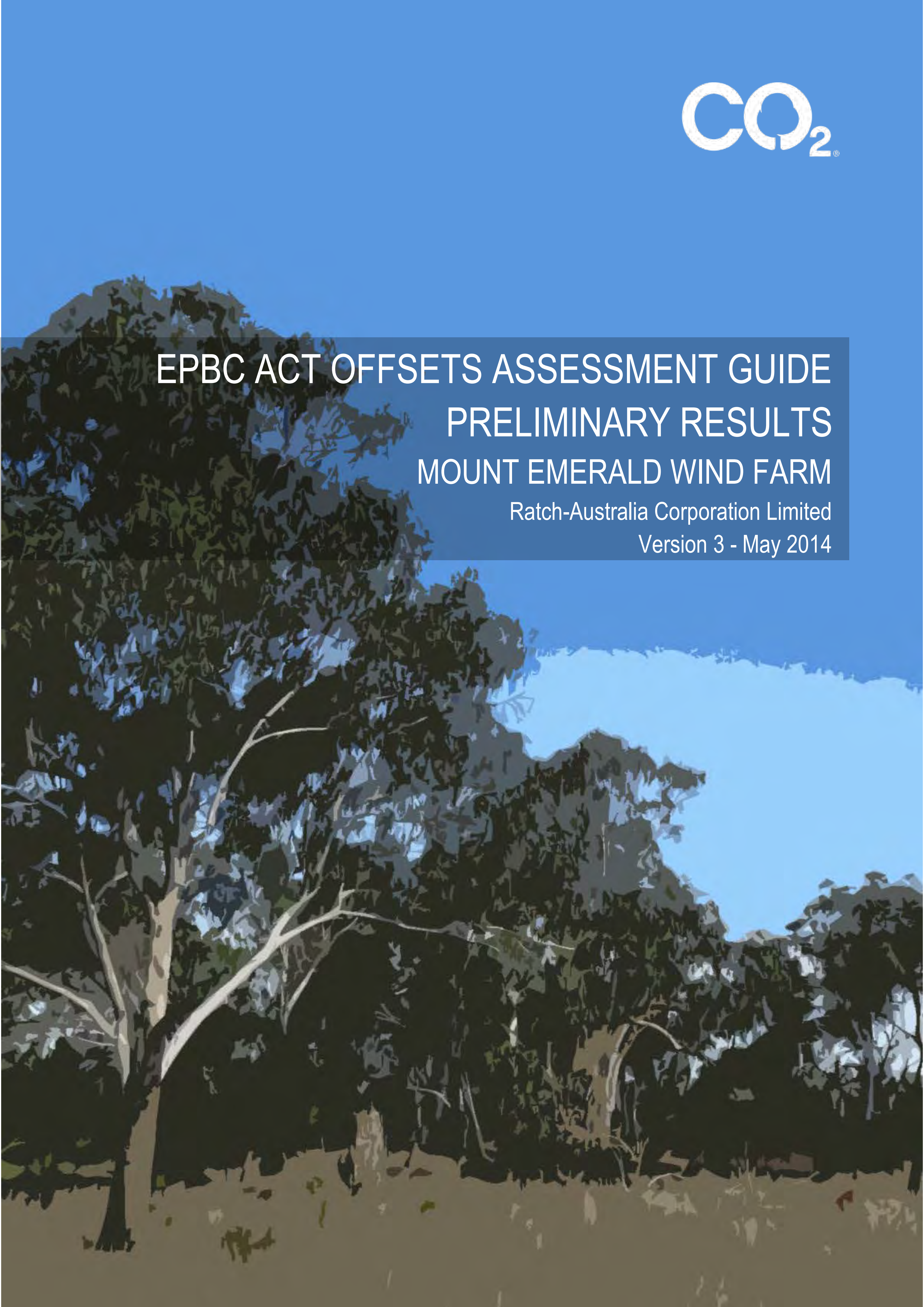
EPBC ACT OFFSETS ASSESSMENT GUIDE

PRELIMINARY RESULTS

MOUNT EMERALD WIND FARM

Ratch-Australia Corporation Limited

Version 3 - May 2014



REPORT TITLE: EPBC Act Offsets Assessment Guide Preliminary Results

PREPARED FOR: Ratch-Australia Corporation Limited

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DATE: 5 May 2014

VERSION: 3.0

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ABBREVIATIONS AND ACRONYMS

DoTE	Australian Government Department of the Environment
DERM	Queensland Department of Environment and Resource Management (now the Department of Environment and Heritage Protection and the Department of Natural Resources and Mines)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
EPBC Act offsets policy	EPBC Act Environmental Offsets Policy (October 2012)
ha	hectares
MNES	matters of national environmental significance
MW	megawatts
OAMP	offset area management plan
RAC	RATCH-Australia Corporation Limited
the project	Mount Emerald Wind Farm project
VM Act	*Vegetation Management Act 1999* (Qld)

EXECUTIVE SUMMARY

RATCH-Australia Corporation Limited (RAC) is proposing to develop the Mount Emerald Wind Farm (the project). The project (Lot 7 SP235244) is located approximately 50 kilometres south-west of Cairns in north Queensland within the Tablelands Regional Council local government area. The project will include 70 wind turbines and associated access tracks and electrical infrastructure feeding into the main electricity grid.

The project is currently being assessed by the Australian Government in accordance with the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Cwlth). While the project has been designed to avoid and mitigate impacts on the environment, unavoidable significant residual impacts on matters of national environmental significance remain, namely five threatened species:

- northern quoll (*Dasyurus hallucatus*)
- spectacled flying-fox (*Pteropus conspicillatus*)
- bare-rumped sheathtail bat (*Saccolamimus saccolaimus nudicluniatus*)
- *Grevillea glossenia*
- *Homoranthus porteri.*

To compensate for these unavoidable impacts, RAC has committed to providing an offset in accordance with the EPBC Act Environmental Offsets Policy. A potential offset for the project has been identified on six contiguous lots located adjacent to the project area. The offset area is mapped with the same vegetation communities and is contiguous with vegetation in the project area. It is expected that due to its close proximity to the project area it also contains similar flora and fauna habitat values. The proposed offset includes the:

- protection of up to 583 ha of native remnant vegetation through the application of a statutory covenant under the *Land Title Act 1994*
- adaptive management of up to 583 ha of native remnant vegetation including weed control, pest animal control and fire management
- translocation of *Grevillea glossadenia* and *Homoranthus porteri* individuals directly impacted by the project
- ongoing management of the translocated species
- implementation of a monitoring program to determine the success of management actions and inform adaptive management.

The suitability of the offset area in acquitting the project's offset requirements has been assessed using the EPBC Act Offsets Assessment Guide (the offsets assessment guide). The offsets assessment guide has been developed to give effect to the requirements of the EPBC Act Environmental Offsets Policy and utilises a balance sheet approach to estimate impacts and offsets for threatened species and ecological communities.

By applying conservative assumptions to populate the offsets assessment guide for the five threatened species listed above, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset on the identified offset property (**Table ES1**). While this assessment is preliminary in nature, the values generated from the offsets assessment guide indicate that the proposed offset is suitable to acquit the offset requirements of the project and that the percentage of impact offset is over 100% for all values.

The final configuration of the offset area will be determined following ecological surveys, the results of which will inform the final offsets assessment guide scores. The offset area provides for the long term protection of habitat for the five threatened species and through the implementation of adaptive management practices the quality of the habitat will be improved and maintained over time.

Table ES1: Offsets assessment guide results

OFFSETS ASSESSMENT GUIDE PARAMETER	MNES				
	northern quoll	spectacled flying-fox	bare-rumped sheathtail bat	*Grevillea glossadenia*	*Homoranthus porteri*
Size of impact area:	57.7 ha	57.7 ha	57.7 ha	10.2 ha	5.1 ha
Quality of impact area:	8	3	7	7	7
Start quality of offset area:	8	3	7	7	7
Future quality with offset:	9	4	8	8	8
Future quality without offset:	6	3	6	6	7
Confidence in results:	50%	70%	70%	70%	50%
Risk of loss with offset:	2%	2%	2%	2%	2%
Risk of loss without offset:	5%	5%	5%	5%	5%
Confidence in results:	70%	70%	70%	70%	70%
Time over which loss is averted:	20 years	20 years	20 years	20 years	20 years
Time until ecological benefit:	5 years	Immediate	Immediate	5 years	5 years
Minimum offset area:	315[1] ha	213 ha	300 ha	50 ha	57 ha
Minimum % of impact offset:	100%	100%	100%	100%	100%
Maximum offset area:	347[1] ha	360 ha	391 ha	167 ha	117 ha
Maximum % of impact offset:	112%	155 %	133%	346%	207%

[1] Includes denning habitat only; however, 236 ha of potential foraging habitat is also available within the proposed offset area.

1. INTRODUCTION

1.1. BACKGROUND

RATCH-Australia Corporation Limited (RAC) proposes to develop the Mount Emerald Wind Farm (the project). The project (Lot 7 SP235244) is located in the Tablelands Regional Council local government area, approximately 50 km south-west of Cairns in North Queensland (**Figure 1**). The project will include 70 wind turbines and associated access tracks and electrical infrastructure feeding into the main electricity grid (Chalumbin-Woree transmission line). Each tower will be approximately 80 – 90 m high with approximately 50 m blades, utilising 3 MW machines.

The project is currently being assessed by the Australian Government in accordance with the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). While the project has been designed to avoid and mitigate impacts on environmental values, unavoidable impacts on matters of national environmental significance (MNES) remain. To compensate for these unavoidable impacts, RAC is committed to delivering offsets in accordance with the EPBC Act Environmental Offsets Policy October 2012 (the EPBC Act offsets policy). RAC has prepared an Offset Plan (CO2 Australia, 2013), which outlines the project's offset requirements under the EPBC Act offsets policy and identifies a potential direct, land-based offset area located adjacent to the project area. The proposed offset includes the:

- protection of up to 583 ha of native remnant vegetation through the application of a statutory covenant under the *Land Title Act 1994*
- adaptive management of up to 583 ha of native remnant vegetation including weed control, pest animal management and fire management
- translocation of *Grevillea glossadenia* and *Homoranthus porteri* individuals directly impacted by the project
- ongoing management of the translocated species
- implementation of a monitoring program to determine the success of management actions and inform adaptive management.

1.2. REPORT PURPOSE

The suitability of the offset area is subject to an assessment against the EPBC Act Offsets Assessment Guide (the offsets assessment guide). The offsets assessment guide has been developed to give effect to the requirements of the EPBC Act offsets policy and utilises a balance sheet approach to assess the appropriateness of offsets to compensate for impacts on threatened species and ecological communities. A preliminary assessment of the area against the offsets assessment guide has been undertaken prior to ground-truthing of the offset site. This report presents the results of the preliminary assessment and includes:

- an overview of the proposed offset area
- methods of assessment
- scores reflecting quality and risk in relation to both the impact and proposed offset areas
- justification and supporting documentation for the scores used in this guide
- the results of the offsets assessment guide for each impacted MNES.

Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

Figure 1:
Overview Map

DATA SOURCE:

The following datasets are © State of Qld 2013:
- Cadastral Data (2011)

Offset area

DATE	AUTHOR	REQUESTED BY
24-02-2014	RF	LW

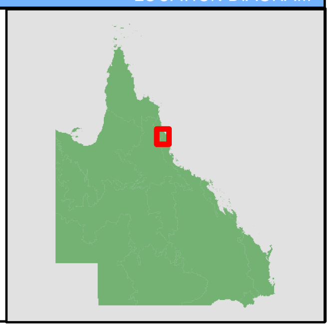
N

0 5 10 15

Kilometres

1:500,000

(A4) GCS GDA 1994



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2. PROPOSED OFFSET AREA

RAC proposes to acquit the project's offset requirements by securing an offset area on six contiguous lots (based on the Digital Cadastral Database, current as of 11 August 2013) located adjacent to the project area (**Figure 2**; 7SP198648, 40SP258906, 21SP210202, 22SP210202, 23SP258905, 42SP258905). The potential offset area is approximately 583.49 ha in size and is located in the Tablelands Regional Council local government area. The land tenure is freehold and the property is zoned as general rural. The offset area fringes the southern boundary of the project area and provides connectivity to the Herberton Range State Forest, Baldy Mountain Forest Reserve and the Herberton Range National Park via the Herberton range (Queensland Government, 2013).

The offset area is characterised by high elevation ridges and valleys composed of remnant vegetation communities. The Queensland Government's regional ecosystem mapping has been assessed to identify the vegetation communities present within the offset area and the types of habitat for MNES that may be present. The majority of the remnant vegetation communities are listed as 'least concern' under the *Vegetation Management Act 1999* (VM Act; Qld); however approximately 159 ha of 'of concern' montane heath community (RE 7.12.57) is mapped within the offset area (**Figure 3**). A review of the EPBC Act Protected Matters Search Tool database indicates that the northern quoll, spectacled flying-fox, *Grevillea glossadenia* and *Homoranthus porteri* and/or their habitat are likely to occur in the offset area. The Atlas of Living Australia has known records within the offset area of the *Grevillea glossadenia* and *Homoranthus porteri*. In addition, a northern quoll was detected in an infrared camera trap near the northern boundary of the offset area during flora and fauna surveys (RPS, 2013).

The offset area is mapped with the same vegetation communities and is contiguous with vegetation in the project area. It is expected that due to its close proximity to the project area it also contains similar flora and fauna habitat values. To assist in the preparation of this preliminary assessment, the results of the survey efforts undertaken in the project area have been used to assess the habitat value of the offset area for the impacted MNES (**Table 1**). The specific method used to calculate the area of potential habitat present in the offset area for each impacted MNES is detailed in **Sections 2.1** to **2.5**.

2.1. NORTHERN QUOLL OFFSET AVAILABILITY

The maximum impact of the project on habitat for the northern quoll is 57.7 ha. The impacted area is considered to contain a mix of denning and foraging habitat (RPS, 2013). However, for the purpose of undertaking a conservative approach to offset assessment it has been assumed that all of the impacted habitat is denning habitat. Denning habitat on the project site consists of suitable fallen and standing (live or dead) hollow eucalypts and rocky outcrops along ridge tops and ridgelines.

As the offset area is yet to be ground-truthed a desktop GIS assessment was undertaken to determine the extent of northern quoll habitat within the offset area. Analysis of satellite imagery was used to divide the potential northern quoll habitat area into denning and foraging habitat types. Rocky areas along ridge tops and ridge lines were considered as denning habitat, while the steep slopes, gullies and low flats were considered as suitable foraging habitat. Based on this analysis the proposed offset area is estimated to contain 347 ha of denning habitat and 236 ha of foraging habitat for the northern quoll (**Figure 4**).

2.2. SPECTACLED FLYING-FOX OFFSET AVAILABILITY

The maximum impact of the project on habitat for the spectacled flying fox is 57.7 ha and includes foraging habitat only (RPS, 2013). Foraging habitat for the spectacled flying-fox in the project area consists of eucalyptus woodlands. The availability of spectacled flying-fox habitat within the offset area was calculated based on a desktop assessment and the presence of regional ecosystems 9.12.4c, 9.12.2, 9.12.7a, 7.12.34, all of which contain eucalyptus forests and are considered suitable foraging habitat for the species. Regional ecosystem 7.12.7c (Simple to complex microphyll to notophyll vine forest) and regional ecosystem 7.12.57 (Shrubland and low woodland mosaic with *Syncarpia glomulifera, Corymbia abergiana, Eucalyptus portuensis, Allocasuarina littoralis* and *Xanthorrhoea johnsonii* on uplands and highlands on granite) were also included in the offset area calculation as they are considered suitable spectacled flying-fox foraging habitat. Based on an analysis of these regional ecosystems there is estimated to be 360 ha of potential foraging habitat for the spectacled flying-fox within the offset area (**Figure 5**).

2.3. BARE-RUMPED SHEATHTAIL BAT OFFSET AVAILABILITY

The project will impact on a maximum of 57.7 ha of potential roosting habitat for the bare-rumped sheathtailed bat (RPS, 2013), which consists of eucalypt woodlands with microhabitat features such as hollow bearing trees. The availability of bare-rumped sheathtail bat roosting habitat within the offset area was calculated based on the presence of the following regional ecosystems:

- 9.12.2, 9.12.30a, 7.12.34 – eucalypt forests
- 9.12.4c, 9.12.7a – open woodlands
- 9.12.20 – low woodlands containing eucalypts.

Based on an analysis of these regional ecosystems there is estimated to be 391 ha of potential roosting habitat for the bare-rumped sheathtail bat within the offset area (**Figure 6**).

2.4. GREVILLEA GLOSSADENIA OFFSET AVAILABILITY

The project will impact on 10.2 ha of potential habitat for *Grevillea glossadenia* (RPS, 2014, pers. comm., 1 May). The availability of habitat in the offset area was calculated based on the presence of the following regional ecosystems:

- 7.12.57
- 7.12.65k
- 7.12.30

Based on an analysis of these regional ecosystems there is estimated to be 167 ha of habitat for Grevillea *glossadenia* within the offset area (**Figure 7**).

2.5. HOMORANTHUS PORTERI OFFSET AVAILABILITY

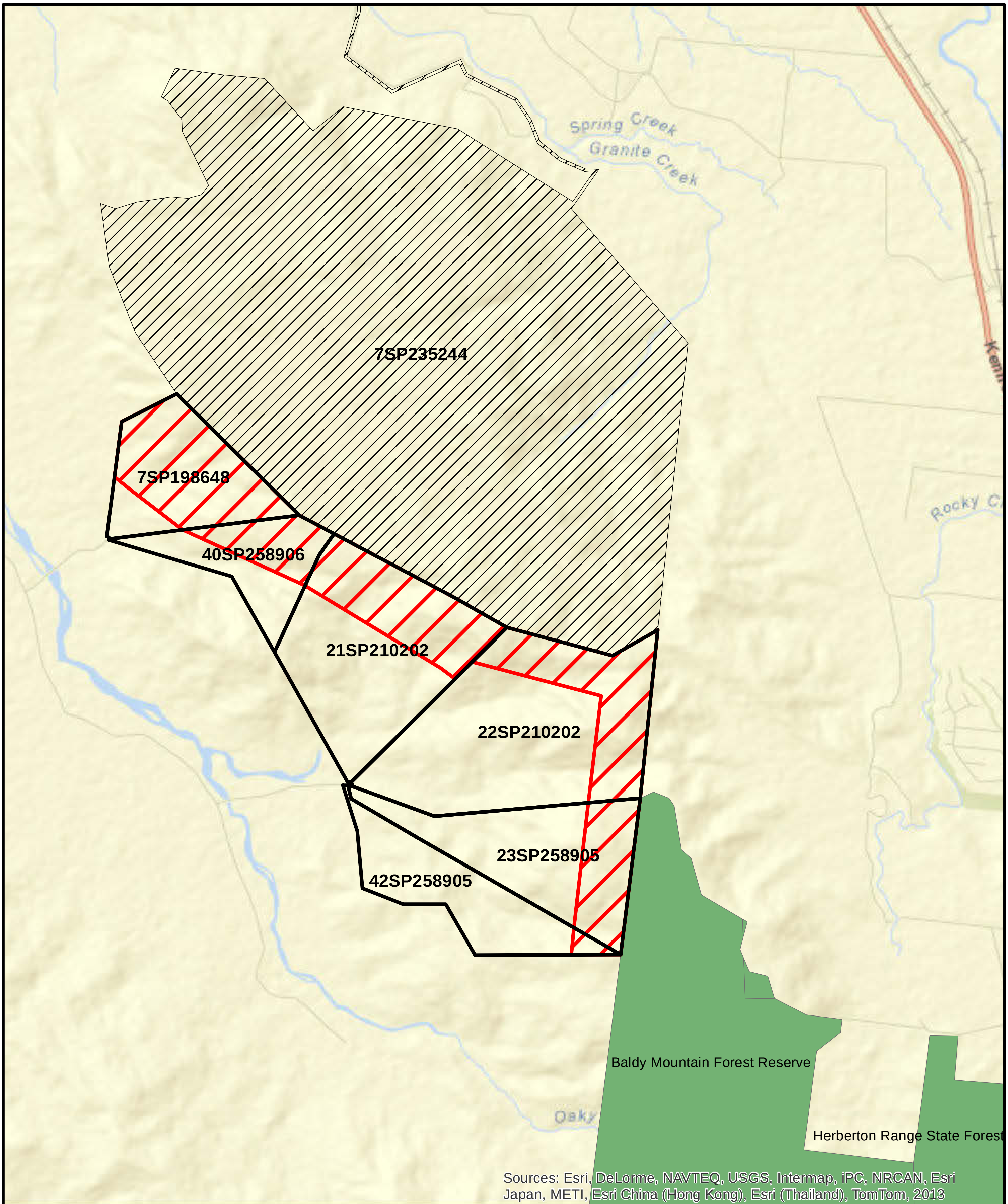
The project will impact on 5.1 ha of potential habitat for *Homoranthus porteri* (RPS, 2014, pers. comm., 1 May). *Homoranthus porteri* is generally found at altitudes above 900 m ASL. The availability of habitat in the offset area was therefore calculated based on the presence of the following regional ecosystems above 900 m ASL:

- 7.12.57
- 7.12.65k
- 7.12.30

Based on an analysis of these regional ecosystems there is estimated to be 117 ha of habitat for *Homoranthus porteri* within the offset area (**Figure 7**).

Table 1: Results of flora and fauna surveys of the project area

SPECIES	SURVEY EFFORT IN THE PROJECT AREA	RECORDS IN PROJECT AREA	HABITAT IN PROJECT AREA	RECORDS IN THE OFFSET AREA
northern quoll	• infrared camera traps at 131 sites (set for 7 consecutive nights at each site) • detection dog survey over five days • Elliott and wire cage trapping at 13 sites (up to 50 traps at each site) • radio tracking of 26 captured individuals (including 5 females) • opportunistic observations (scats and tracks)	• images of the northern quoll were captured at 88 of the 131 infrared camera trap sites • numerous scats belonging to the northern quoll were also identified throughout the project area	• ridgetops and escarpments • steep gullies and creeklines • logs and rock piles (denning habitat)	• one northern quoll detected on infrared camera trap in offset area during field surveys (northern boundary of offset area) • several other northern quolls were recorded on infrared camera traps immediately to the north of the offset area • several quolls that were radio tracked were recorded moving in the offset area (along the northern boundary) • a denning site of a radio tracked female was recorded in the north of the offset area
bare-rumped sheathtail bat	• ANABAT • one harp net was deployed over four consecutive nights • opportunistic observations	• five calls potentially belonging to the bare-rumped sheathtail bat were recorded during the surveys	• hollow bearing trees particularly along the lower reaches of Granite Creek	• no known records in offset area
spectacled flying-fox	• night vision googles at 21 survey sites (one nights observation at each survey site) • thermal imaging at three survey sites (one night at each site) • opportunistic sightings	• three individuals were observed during field surveys, two were flying overhead and one was foraging in *Melaleuca viridiflora* trees	• foraging trees that are in flower (e.g. *Melaleuca viridiflora* during the time of the surveys)	• no known records in offset area
Grevillea glossidenia	• vegetation mapping and identification of potential habitat • targeted searches	• over 500 individuals recorded during surveys	• ridges and rock pavements • heath and sparse low woodland vegetation	• records in the offset area from the Atlas of Living Australia
Homoranthus porteri	• vegetation mapping and identification of potential habitat • targeted searches	• over 400 individuals recorded during surveys	• ridgelines and rock pavements • heath and sparse low woodland vegetation above 900 m ASL	• records in the offset area from the Atlas of Living Australia



Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

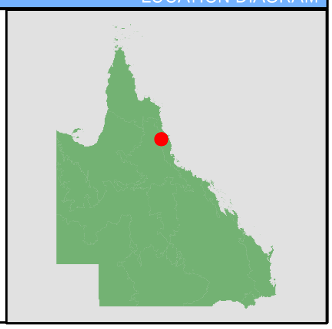


Figure 2:
Mt Emerald Wind Farm
Offset Area

- Mount Emerald Wind Farm
- Offset area
- Offset lots
- Protected areas

0 0.5 1 1.5
Kilometres

1:55,000

(A4) GCS GDA 1994

N

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)

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LOCATION DIAGRAM

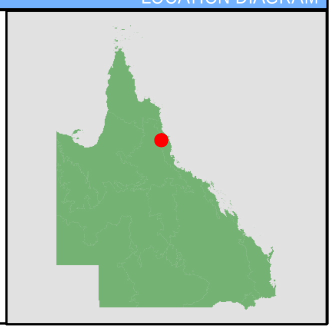

Figure 3:
Regional ecosystems
within the offset

Mount Emerald Wind Farm
Offset area
Offset lots
Protected areas
Photo monitoring points

VMA Status

Containing Endangered regional ecosystems
Containing Of Concern regional ecosystems
Is a Least Concern regional ecosystem

0 0.25 0.5 0.75 1
Kilometres
1:35,000
(A4) GCS GDA 1994

N

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
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- Vegetation Management Act Regional Ecosystems V6.1 (2011)

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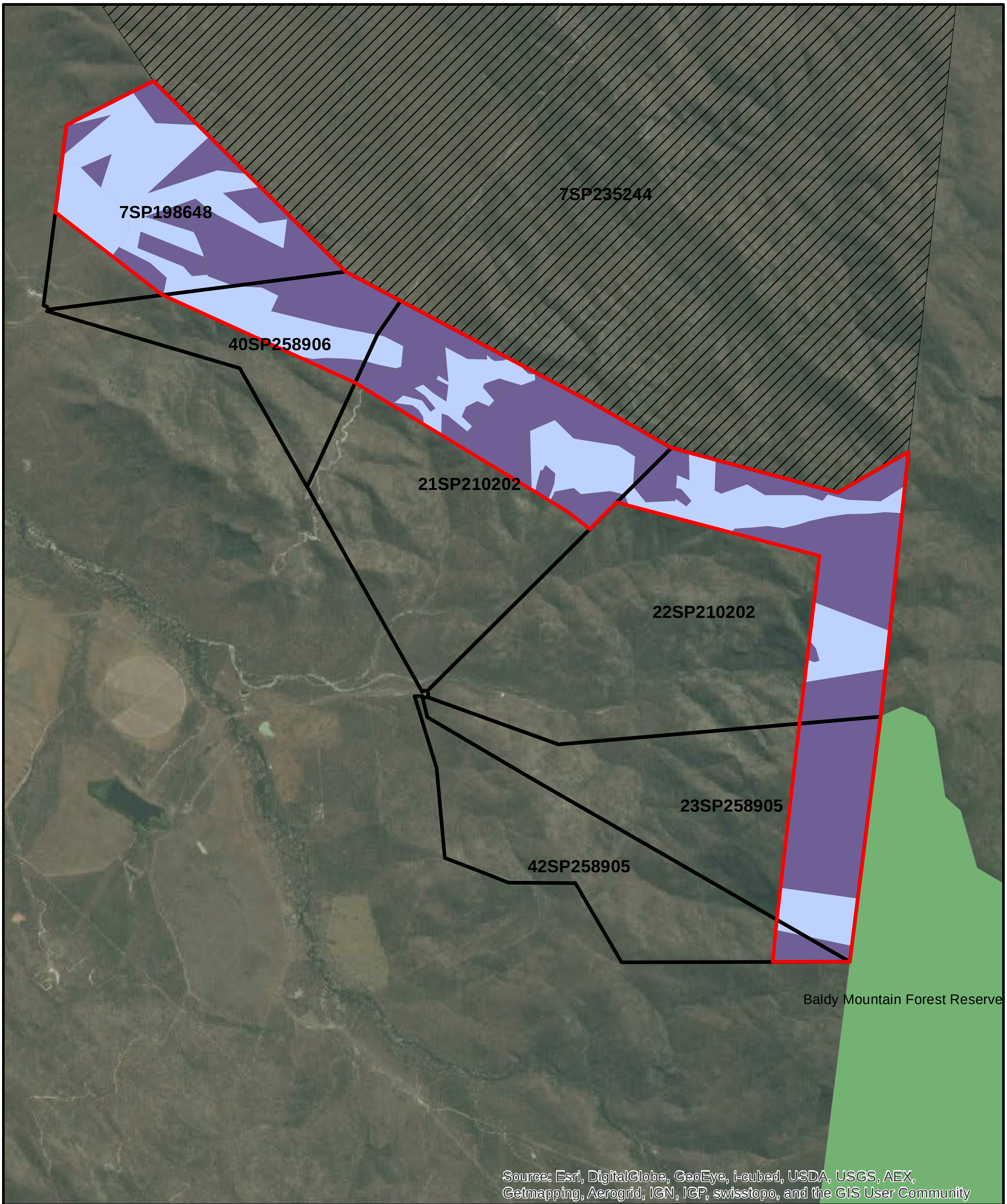

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LOCATION DIAGRAM

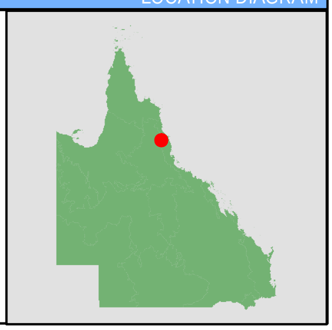

Figure 4:
Northern Quoll habitat
within the offset

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

Mount Emerald Wind Farm
Offset area
Offset lots
Protected areas

Northern quoll habitat (approx 580 ha)

Denning habitat (approx 345 ha)
Foraging and dispersal habitat (approx 235 ha)

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04-04-2014	RF	LW

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0 0.25 0.5 0.75 1
Kilometres
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(A4) GCS GDA 1994

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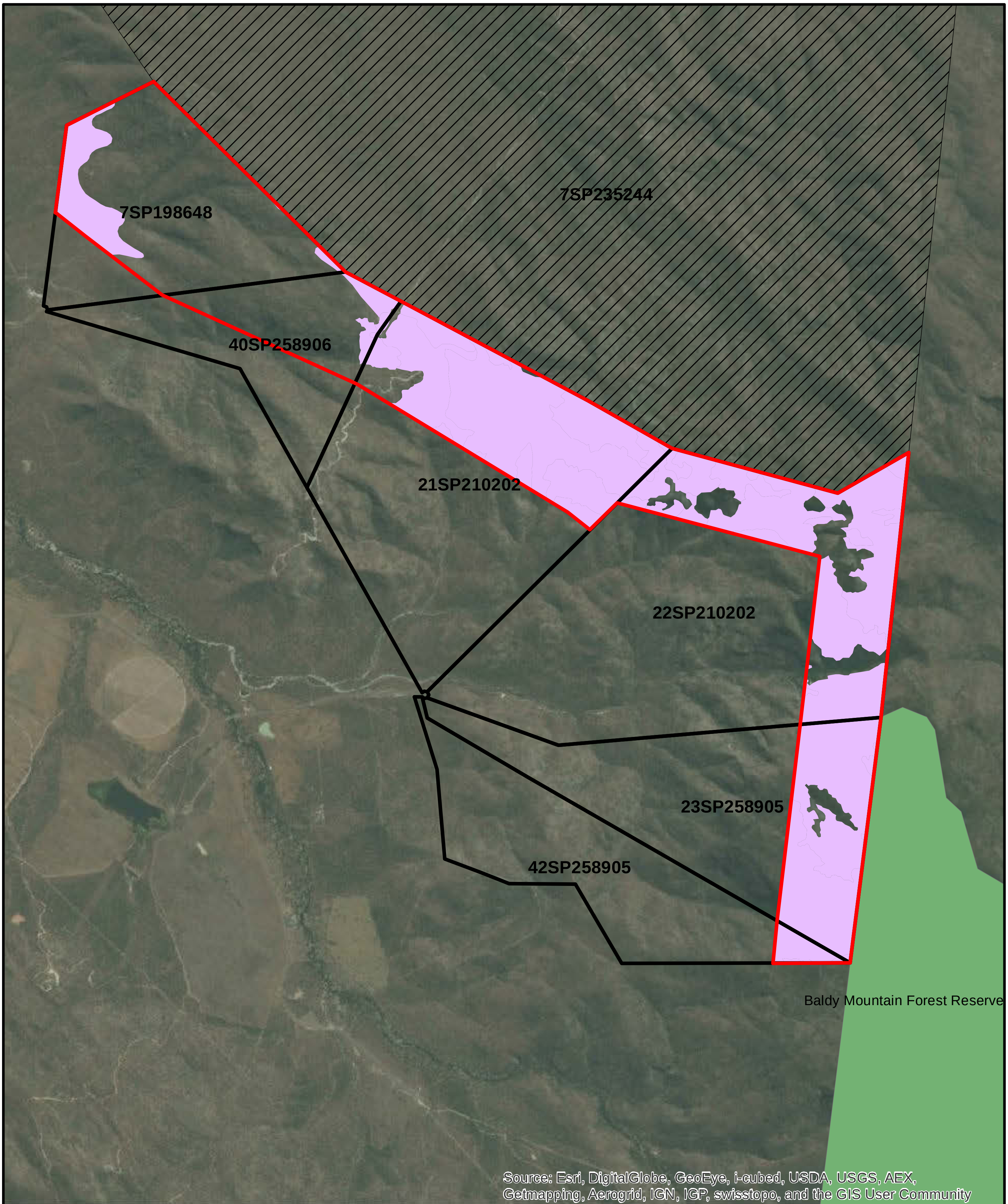

Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

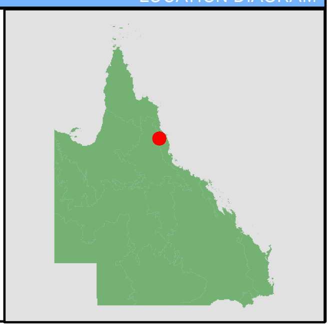

Figure 5:
Spectacled flying-fox
habitat within the offset

- Mount Emerald Wind Farm
- Offset area
- Offset lots
- Protected areas
- Spectacled flying-fox habitat (approx 360 ha)

0 0.25 0.5 0.75 1
Kilometres
1:35,000
(A4) GCS GDA 1994

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DATA SOURCE:

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- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

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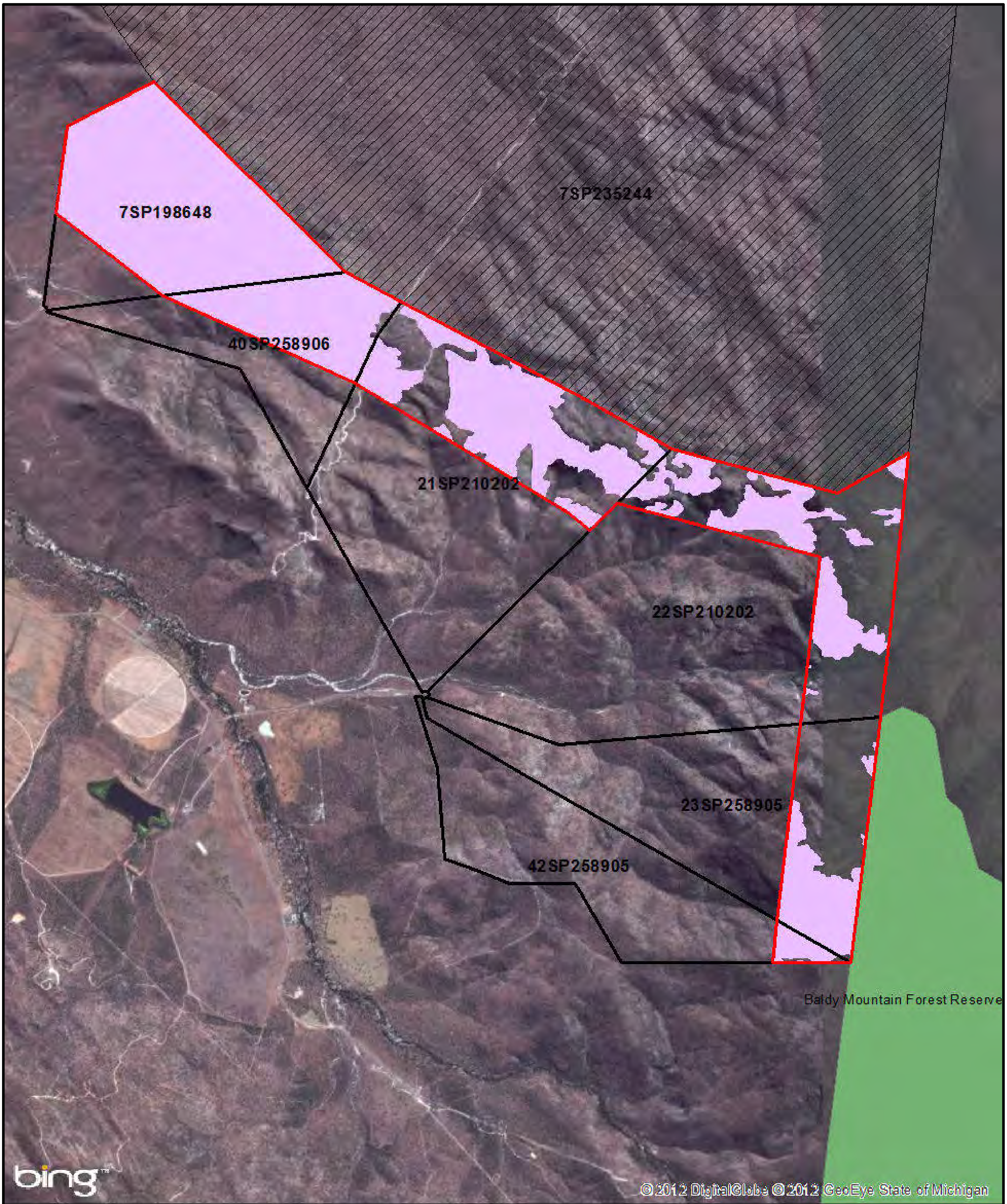

Ratch/Australia Corporation - Mt Emerald Wind Farm

LOCATION DIAGRAM

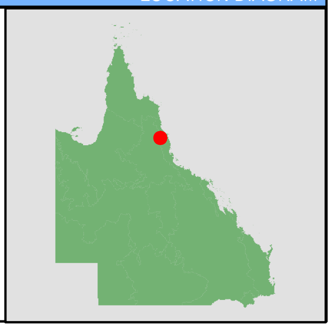

Figure 6:
Potential bare-rumped sheathtail bat habitat within the offset area

- Bare-rumped sheathtail bat habitat (approx 390 ha)
- Project area
- Offset area
- Offset lots
- Protected areas

0 0.25 0.5 0.75 1
Kilometres

1:35,000

(A4) GCS GDA 1994

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- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

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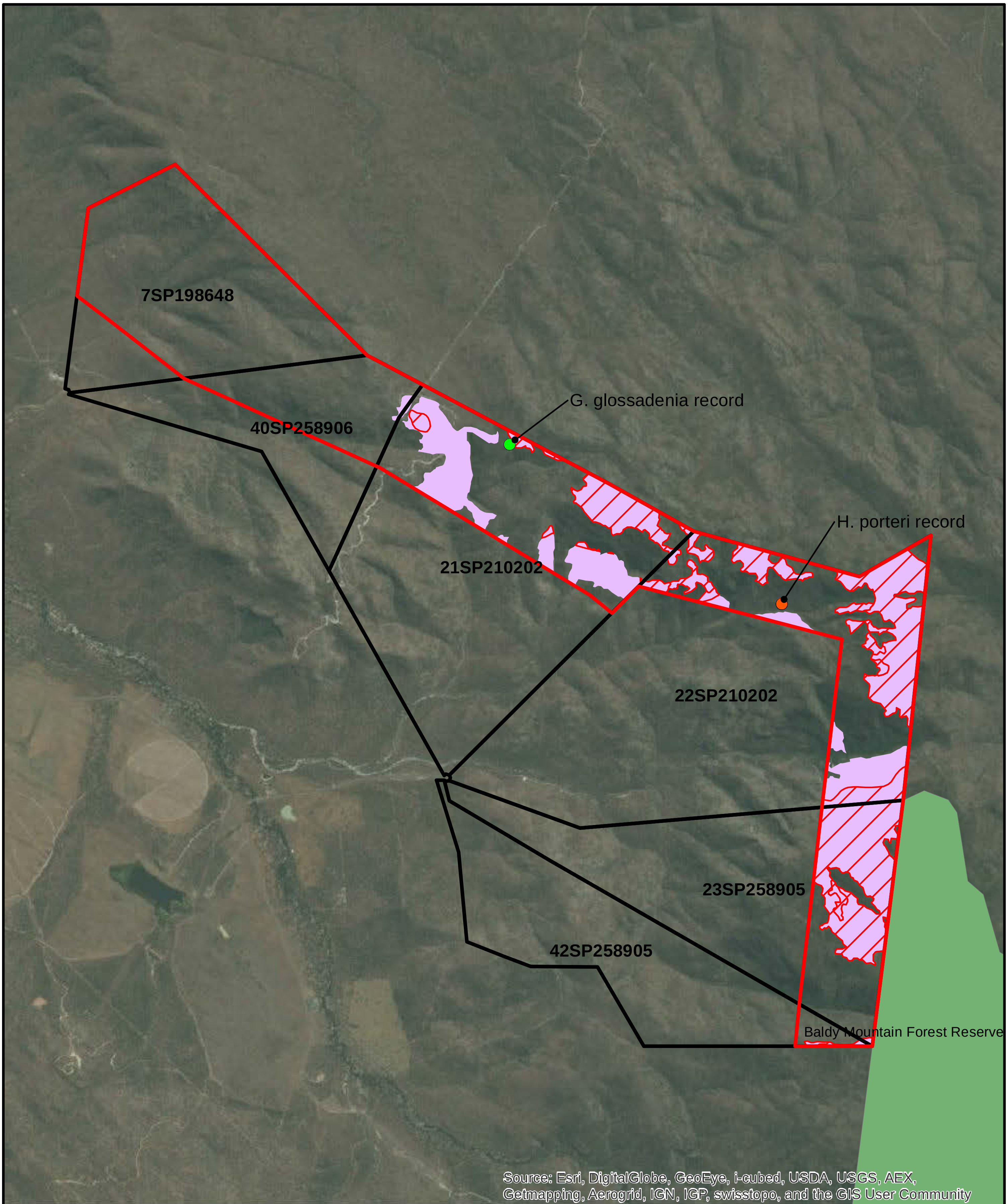

Ratch/Australia Corporation - Mount Emerald Wind Farm

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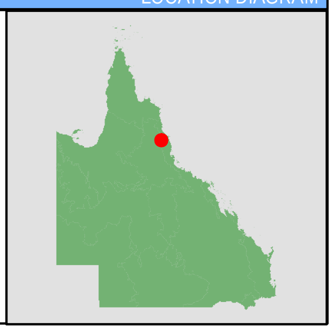

Figure 7:
Flora habitat
within the offset

- Offset area
- Offset lots
- Protected areas
- H. porteri habitat (approx 115 ha)
- G. glossadenia habitat (approx 165 ha)
- G. glossadenia record
- H. porteri record

0 0.25 0.5 0.75 1
Kilometres
1:35,000 (A4) GCS GDA 1994

N

DATA SOURCE:
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- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V8 (2013)
- Habitat areas assessed by CO2 Australia (desktop analysis only)
- Species records from Atlas of Living Australia Records (May 2014)

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3. METHODS

The offsets assessment guide utilises a balance sheet approach to measure and compare values between the impact area and the offset area. The guide is used as a tool by Australian Government assessment officers to determine the suitability of the proposed offset. The offsets assessment guide requires the following values:

- the size of the impact area
- current quality of impact area
- start quality of the offset area
- future quality of the offset area with offsets
- future quality of the offset area without offsets
- risk of ecological loss of MNES-specific value with an offset
- risk of ecological loss of MNES-specific value without an offset
- the time over which ecological loss is averted
- the time until ecological benefit
- the confidence in results of the future quality of the offset area and the risk of loss with and without offsets.

Impact areas for each of the MNES were provided by RPS (RPS, 2013; RPS, 2014, pers. comm., 1 May). The quality of the impact and offset area (current, start and future) was determined by identifying the key ecological attributes of each MNES and comparing it to the values presented in **Table 2**. Key ecological attributes were summarised using the Species Profile and Threats database, recovery plans and relevant published literature. Habitat quality was ranked from one (poor) to 10 (high). Qualitative scores incorporate attributes that would affect habitat quality including, disturbance (e.g. introduced species, fire, current land use), connectivity, previous species records and the presence of microhabitat features necessary to each MNES assessed. The draft EIS prepared by RPS was reviewed for information about the current habitat quality of the impact area and offset area (where applicable).

Table 2. Habitat quality scores for the project site and the offset area

DESCRIPTION	QUALITATIVE SCORE	QUANTITATIVE SCORE
This area provides no habitat value for species.	Nil	0
The species or community is unlikely to occur or may occur in low densities as habitat features are lacking. Broad scale habitat may be present but micro habitat is lacking. The area may be exposed to disturbance effects limiting the sustainable presence or affecting the ecological quality of the species habitat or community.	Low	1-2
The species has the potential to occur based on the presence of some habitat features however the successful establishment of a population in the area is limited by disturbance. Essential habitat may be lacking for a stage within the species life cycle (if applicable).	Low-Moderate	3-4
This area supports, or is likely to support, the species/community due to the presence of macro and microhabitat features however, the site is exposed to disturbance effects that may hinder the success of the population or has poor connectivity.	Moderate	5-6
The species is known or likely to occur in this area based on the presence of suitable macro habitat as well as most micro features the species requires. This area is exposed to little disturbance.	Moderate-High	7-8
This area achieves the primary habitat values for the species including species-specific essential conditions and resources for all life cycle stages (if applicable). Habitat type is >50 ha and/or is ecologically connected with other suitable habitat. This area is exposed to little or negligible levels of disturbance.	High	9-10

4. NORTHERN QUOLL

4.1. SUMMARY OF RESULTS

The northern quoll (*Dasyurus hallucatus*) is listed as an endangered species under the EPBC Act. The project will impact on a maximum of 57.7 ha of habitat for the northern quoll, which consists of a mix of denning and foraging habitat (RPS, 2013). However, for the purpose of undertaking a conservative approach to offset assessment it has been assumed that the impacted habitat is denning habitat only. Denning habitat on the project site consists of suitable fallen and standing (live or dead) hollow eucalypts and rocky outcrops along ridge tops and ridgelines. As the offset area is yet to be ground-truthed a desktop GIS assessment was undertaken to determine the extent of northern quoll habitat within the offset area. Analysis of satellite imagery was used to divide the potential northern quoll habitat area into denning and foraging habitat types. Rocky areas on ridge lines were considered as denning habitat, while the steep slopes, gullies and low flats were considered as suitable foraging habitat. Based on this analysis the proposed offset area is estimated to contain 347 ha of denning habitat and 236 ha of foraging habitat for the northern quoll (**Figure 4**).

Using only the available denning habitat and by applying the offsets assessment guide, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset area on the identified offset property (**Table 3**). The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 3: Summary of values and results for the northern quoll offset assessment

Quality of impact area:	8	Risk of loss without offset:	5%
Quality of offset area:	8	Risk of loss with offset:	2%
Future quality without offset:	6	Confidence in result:	70%
Future quality with offset:	9	Time over which loss is averted (years):	20
Confidence in result:	50%	Time until ecological benefit (years):	5
Minimum offset area (ha):	315[2] ha	Maximum offset area (ha):	347[2] ha
% of impact offset	100%	% of impact offset	112%

4.2. CURRENT QUALITY OF IMPACT AREA

The northern quoll is distributed across northern Australia and occupies a variety of habitats including rocky areas, eucalypt forest and woodlands, rainforest, shrublands and sandy lowlands and beaches. Their habitat generally encompasses some type of rocky area, which they use for denning purposes, surrounded by vegetated habitats which they use for foraging and dispersal.

The northern quoll was found to be widely distributed across the project area and present in relatively high numbers (RPS, 2013). Northern quolls from different age groups were recorded during fauna surveys and the project area was

[2] Includes denning habitat only; however, 236 ha of potential foraging habitat is also available within the proposed offset area.

found to have high quality denning (i.e. exposed outcrops on rocky ridge tops and ridgelines) and foraging and dispersal (i.e. dense understory vegetation) habitat for the species.

Consequently, the project will result in the removal of approximately 57.7 ha of foraging and denning habitat for the northern quoll. The current quality of the habitat for the northern quoll in the project area is rated moderate to high (8).

4.3. START QUALITY OF OFFSET AREA

The offset area is mapped with the same vegetation communities, is contiguous with vegetation in the project area and provides connectivity to Baldy Mountain Forest Reserve. It is expected that due to its close proximity to the project area it also contains similar fauna habitat values and is similar in condition to the project area. A northern quoll was detected by an infrared camera trap near the northern boundary of the offset area (RPS, 2013) and it is expected that northern quoll utilise the offset area for denning and foraging purposes. The EPBC Act protected matters search tool database also indicates that northern quoll and/or their habitat area likely to occur in the offset area. A desktop assessment of regional ecosystem mapping indicates that the proposed offset area is likely to contain 347 ha of denning habitat and 236 ha of foraging habitat for the northern quoll. Based on an assessment of these factors, the current quality of habitat for the northern quoll in the offset area is rated as moderate to high (8).

4.4. FUTURE QUALITY OF OFFSET AREA WITHOUT OFFSET MANAGEMENT

Major threats to the northern quoll and its habitat include cane toad invasion, removal and fragmentation of habitat, inappropriate fire regimes, weeds and introduced predators (DoTE, 2014a). As cane toads are known to occur in the vicinity of the offset area (RPS, 2013) there is the potential for a decline of the population due to lethal toxic ingestion. Additionally, without the management afforded by offset protection, vegetation may be cleared and/or the area further developed. Weed encroachment may also reduce the establishment of native species and increase the fuel load with the potential to result in high intensity bush fires which would destroy microhabitat features for the species. The lack of feral predator control (specifically feral cats and dogs) may also lead to a steady decline in the northern quoll. Based on the factors described above, the future quality of the offset area without offset management is rated as moderate (6).

4.5. FUTURE QUALITY OF OFFSET AREA WITH OFFSET MANAGEMENT

The quality of habitat for the northern quoll will be improved through the establishment of the offset area. An Offset Area Management Plan (OAMP) will be developed which will detail land management actions to be implemented to improve habitat for the northern quoll. The management plan objectives will be developed in accordance with the draft National Recovery Plan for the Northern Quoll (Hill &Ward, 2010) and will aim to minimize the rate of decline of Northern Quoll in Australia. Management actions will include, but are not limited to:

- pest animal control
- weed control
- fire management.

Monitoring activities, including condition, presence or absence of species and monitoring of cane toad densities will also be undertaken as part of the implementation of the offset plan. Through the implementation of an adaptive management plan the future quality of habitat for the northern quoll in the offset area with offset management is rated as moderate to high (9).

4.6. CONFIDENCE IN RESULTS – FUTURE QUALITY

The management objectives detailed within the OAMP will target the threat abatement and recovery actions identified in the species recovery plan. The objectives of the OAMP will be based on published conservation recommendations and best practice management. However, while most of the threats on the northern quoll and its habitat can be controlled there is significant difficulty in managing cane toads in areas where they already exist. Based on an assessment of these factors the level of certainty about the success of the offset area in improving the quality of habitat for the northern quoll is rated as 50%.

4.7. RISK OF LOSS WITHOUT OFFSET

Far North Queensland is one of the fastest growing regions in Queensland and over the past 15 years has experienced continuous growth in resident population, visitation, economic activity and urban development. This trend is forecast to continue for at least the next 20 years with the population of the region set to increase by 100,000 people by 2029 (Queensland Government, 2011). This growth will result in increased urban, agricultural, infrastructure and transport development across the region.

The proposed offset area is located on six contiguous lots which are currently owned by four different landholders. The primary land use of the lots is described as vacant large house site and subdivided land. While the remnant vegetation in the offset area is protected by the VM Act, the *Sustainable Planning Act 2009* (Qld) and associated policies and codes, an application can made to the state government to clear remnant vegetation. It is possible that an application could be approved to clear remnant vegetation within the offset area for a number of activities including, but not limited to:

- residential activities
- service infrastructure (e.g. transmission lines)
- access roads.

However, given the location and topography of the proposed offset area, the risk that the habitat will be completely lost over the foreseeable future has been determined to be 5%. This accounts for the low risk that the vegetation in the offset area could be lost through future development activities.

4.8. RISK OF LOSS WITH OFFSET

The offset area will be secured in perpetuity through a legally binding mechanism, such as a statutory covenant, registered under the *Land Title Act 1994* (Qld). The legally binding mechanism will be registered on the land title and will be binding on all current and future owners of the land. Land use within the offset area will be restricted in accordance with the legally binding mechanism and the OAMP. Therefore, the implementation of the legally binding mechanism will reduce the risk of loss of the offset area to 2%.

4.9. CONFIDENCE IN RESULTS – RISK OF LOSS

The confidence in results in terms of the risk of loss is determined to be 70%. The legally binding mechanism will be registered on the land title and will remain in effect in perpetuity. The legally binding mechanism can only be removed by the relevant Queensland Government Minister with regard to a public interest.

4.10. TIME OVER WHICH LOSS IS AVERTED

The offset area is proposed to be managed for a period of 20 years.

4.11. TIME UNTIL ECOLOGICAL BENEFIT

By selecting offsets in areas where current habitat for the species already exists, the time lag in between the establishment of the offset area and the ecological benefit is reduced. The proposed offset area already provides suitable denning and foraging habitat for the northern quoll. The National Recovery Plan for the Northern Quoll (Hill and

Ward, 2010) aims to minimise the rate of decline of the species. Of the nine main objectives of the draft Plan, three objectives may practically apply on the offset area:

- reduce the impact of pastoral land management practices on northern quolls
- reduce the risk of northern quoll populations being impacted by disease
- halt declines in areas not yet or recently colonised by cane toads.

The delivery and management of targeted actions aimed at mediating threatening processes (e.g. feral predator control, cane toad management) is expected to have a measurable effect within five years.

5. SPECTACLED FLYING-FOX

5.1. SUMMARY OF RESULTS

The spectacled flying-fox (*Pteropus conspicillatus*) is listed as a vulnerable species under the EPBC Act. The project will impact on a maximum of 57.7 ha of foraging habitat for the spectacled flying-fox. The availability of spectacled flying-fox habitat within the offset area was calculated based on a desktop assessment and the presence of regional ecosystems 9.12.4c, 9.12.2, 9.12.7a, 7.12.34, all of which contain eucalyptus forests and are considered suitable foraging habitat for the species. Regional ecosystems 7.12.7c and 7.12.57 were also included in the offset area calculation as they are also considered to be suitable spectacled flying-fox foraging habitat. Based on an analysis of these regional ecosystems there is estimated to be 360 ha of potential foraging habitat for the spectacled flying-fox within the offset area (**Figure 5**).

By applying conservative assumptions to populate the offsets assessment guide, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset area on the identified offset property (**Table 4**). The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 4: Summary of values and results for the spectacled flying-fox offset assessment

Quality of impact area:	3	Risk of loss without offset:	5%
Quality of offset area:	3	Risk of loss with offset:	2%
Future quality without offset:	3	Confidence in result:	70%
Future quality with offset:	4	Time over which loss is averted (years):	20 years
Confidence in result:	70%	Time until ecological benefit (years):	Immediate
Minimum offset area (ha):	213 ha	Maximum offset area (ha):	360 ha
% of impact offset	100%	% of impact offset	155%

5.2. CURRENT QUALITY OF IMPACT AREA

The spectacled flying-fox inhabits tropical rainforest areas of north-eastern Queensland, with the largest population known from the Wet Tropics World Heritage Area between Townsville and Cooktown. The species feeds on fruit and blossom primarily in the canopy of a wide range of vegetation communities including tropical rainforests, eucalypt open forest and woodland, melaleuca swamps, mangroves, vegetation in urban environments and commercial fruit crops.

They may forage up to 50 to 100 km each night; however, their roosts are always found within 6 km of tropical rainforest (DoTE, 2014b).

The spectacled flying-fox was recorded during fauna surveys of the project area. No suitable roosting habitat for the spectacled flying-fox (i.e. rainforest) is present in the project area; however, it may sporadically forage in the project area during flowering and fruiting of Myrtaceous trees, including eucalypts (RPS, 2013). Consequently, the project will have a direct impact on 57.7 ha of potential foraging habitat for the spectacled flying-fox. This habitat is not considered to be critical to the survival of the species as foraging habitat for the spectacled flying-fox is widely available in the area surrounding the project (RPS, 2013). As such, the current quality of the project area for the spectacled flying-fox is rated as low-moderate (3).

5.3. START QUALITY OF OFFSET AREA

The offset area is mapped with the same vegetation communities, is contiguous with vegetation in the project area and provides connectivity to the Baldy Mountain Forest Reserve. It is expected that due to its close proximity to the project area it also contains similar fauna habitat values and is similar in condition to the project area. A review of the EPBC Act Protected Matters Search Tool database indicates that the spectacled flying-fox and/or its habitat are likely to occur in the offset area. Based on a desktop assessment of regional ecosystem mapping, the proposed offset area contains 360 ha of potential foraging habitat (i.e. Myrtaceous trees) for the spectacled flying-fox. No suitable roosting habitat (i.e. rainforest) for the spectacled flying-fox occurs on the offset area. Based on the proximity of the impact area to the offset area and the factors outlined above, the current quality of habitat for the spectacled flying-fox in the offset area is rated as low to moderate (3).

5.4. FUTURE QUALITY OF OFFSET AREA WITHOUT OFFSET MANAGEMENT

There is not anticipated to be a decline in quality of spectacled flying-fox habitat without offset management, primarily as the habitat is currently considered to be of low quality, as is the quality of habitat in the impact area. Therefore, the future quality of the offset area without offset management is rated as low to moderate (3).

5.5. FUTURE QUALITY OF OFFSET AREA WITH OFFSET MANAGEMENT

The quality of habitat for the spectacled flying-fox will be improved through active management. An OAMP will be developed, in accordance with the National Recovery Plan for the species (DERM, 2010), which will detail management actions to be implemented to improve habitat in the offset area for the spectacled flying-fox. Therefore, the future quality of habitat for the spectacled flying-fox in the offset area with offset management is rated as moderate (4).

5.6. CONFIDENCE IN RESULTS – FUTURE QUALITY

The level of certainty about the success of the offset area in improving the quality of habitat for the spectacled flying-fox is rated as 70%. The management objectives detailed within the OAMP will target the threat abatement and recovery actions identified in the species recovery plan. The objectives of the OAMP will be based on published conservation recommendations and best practice management.

5.7. RISK OF LOSS WITHOUT OFFSET MANAGEMENT

Far North Queensland is one of the fastest growing regions in Queensland and over the past 15 years has experienced continuous growth in resident population, visitation, economic activity and urban development. This trend is forecast to continue for at least the next 20 years with the population of the region set to increase by 100,000 people by 2029

(Queensland Government, 2011). This growth will result in increased urban, agricultural, infrastructure and transport development across the region.

The proposed offset area is located on six contiguous lots which are currently owned by four different landholders. The primary land use of the lots is described as vacant large house site and subdivided land. While the remnant vegetation in the offset area is protected by the VM Act, the *Sustainable Planning Act 2009* (Qld) and associated policies and codes, an application can made to the state government to clear remnant vegetation. It is possible that an application could be approved to clear remnant vegetation within the offset area for a number of activities including, but not limited to:

- residential activities
- service infrastructure (e.g. transmission lines)
- access roads.

However, given the location and topography of the proposed offset area, the risk that the habitat will be completely lost over the foreseeable future has been determined to be 5%. This accounts for the low risk that the vegetation in the offset area could be lost through future development activities.

5.8. RISK OF LOSS WITH OFFSET

The offset area will be secured in perpetuity through a legally binding mechanism, such as a statutory covenant, registered under the *Land Title Act 1994* (Qld). The legally binding mechanism will be registered on the land title and will be binding on all current and future owners of the land. Land use within the offset area will be restricted in accordance with the legally binding mechanism and the OAMP. Therefore, the implementation of the legally binding mechanism will reduce the risk of loss of the offset area to 2%.

5.9. CONFIDENCE IN RESULTS – RISK OF LOSS

The confidence in results in terms of the risk of loss is determined to be 70%. The legally binding mechanism will be registered on the land title and will remain in effect in perpetuity. The legally binding mechanism can only be removed by the relevant Queensland Government Minister with regard to a public interest.

5.10. TIME OVER WHICH LOSS IS AVERTED

The offset area is proposed to be actively managed for a period of 20 years.

5.11. TIME UNTIL ECOLOGICAL BENEFIT

By selecting offsets in areas where current habitat for the species already exists, the time lag in between the acquisition of the offset area and the ecological benefit is reduced. The proposed offset area is likely to provide suitable foraging habitat for the spectacled flying-fox. Therefore, the ecological benefit of the offset for the spectacled flying-fox will be immediate. Furthermore, the establishment of the offset area is consistent with second recovery objective in the National Recovery Plan for the spectacled flying-fox which specifies that native foraging habitat critical to the survival of the species be identified and protected (DERM, 2010).

6. BARE-RUMPED SHEATHTAIL BAT

6.1. SUMMARY OF RESULTS

The bare-rumped sheathtail bat (*Saccolamimus saccolaimus nudicluniatus*) is listed as a critically endangered species under the EPBC Act. The project will impact on a maximum of 57.7 ha of potential roosting habitat for the bare-rumped sheathtailed bat. The availability of bare-rumped sheathtail bat roosting habitat within the offset area was calculated based on the presence of the following regional ecosystems:

- 9.12.2, 9.12.30a, 7.12.34 – eucalypt forests
- 9.12.4c, 9.12.7a – open woodlands
- 9.12.20 – low woodlands containing eucalypts.

Based on an analysis of these regional ecosystems there is estimated to be 391ha of potential roosting habitat for the bare-rumped sheathtail bat within the offset area (**Figure 6**). By applying conservative assumptions to populate the offsets assessment guide, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset area on the identified offset property (**Table 5**). The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 5: Summary of values and results for the bare-rumped sheathtail bat offset assessment

Quality of impact area:	7	Risk of loss without offset:	5%
Quality of offset area:	7	Risk of loss with offset:	2%
Future quality without offset:	6	Confidence in result:	70%
Future quality with offset:	8	Time over which loss is averted (years):	20 years
Confidence in result:	70%	Time until ecological benefit (years):	Immediate
Minimum offset area (ha):	300 ha	Maximum offset area (ha):	391ha
% of impact offset	100%	% of impact offset	133.25%

6.2. CURRENT QUALITY OF IMPACT AREA

The bare-rumped sheathtail bat inhabits tropical woodland and tall open forests in coastal lowlands of north-eastern Queensland and the Northern Territory. The species has a fast, direct flight and forages for aerial insects over woodland/forest canopy (Churchill, 1998). It has been recorded roosting in deep hollows in the trunks of a number of Eucalyptus species, including *E. miniata*, *E. tetradonta* and *E. platyphylla* (Churchill, 1998).

The project area will impact on approximately 57.7 ha of potential roosting habitat for the bare-rumped sheathtail bat (RPS, 2013). A number of suitable roost trees (*E. platyphylla*) were observed along the lower reaches of Granite Creek and calls potentially belonging to the bare-rumped sheathtail bat were recorded during fauna surveys of the project area (RPS, 2013). Therefore, the current quality of habitat for the bare-rumped sheathtail bat in the project area is rated as moderate to high (7).

6.3. START QUALITY OF OFFSET AREA

The offset area is mapped with the same vegetation communities, is contiguous with vegetation in the project area and provides connectivity to the Baldy Mountain Forest Reserve. It is expected that due to its close proximity to the project area it also contains similar fauna habitat values and is similar in condition to the project area. Based on a desktop assessment of regional ecosystem mapping, the proposed offset area is estimated to contain 391 ha of potential roosting habitat for the bare-rumped sheathtail bat. The current quality of habitat for the bare-rumped sheathtail bat in the offset area is rated as moderate to high (7).

6.4. FUTURE QUALITY OF OFFSET AREA WITHOUT OFFSET MANAGEMENT

Without active management there may be a decline in the quality of habitat for the bare-rumped sheathtail bat within the offset area. Threats to the species that may impact on quality of habitat include vegetation clearance, changes in vegetation structure through altered fire regimes and invasion of exotic weeds (DoTE, 2014c). Potential weed encroachment can reduce the establishment of native species and increase the fuel load with the potential to result in high intensity bush fires which would destroy microhabitat features. Therefore, the future quality of habitat for the bare-rumped sheathtail bat in the offset area without offset management is rated as moderate (6).

6.5. FUTURE QUALITY OF OFFSET AREA WITH OFFSET MANAGEMENT

The quality of habitat for the bare-rumped sheathtail bat would be improved through the establishment of the offset area. An OAMP will be developed which will detail land management actions to be implemented to improve habitat in the offset area for the bare-rumped sheathtail bat. These management actions will include, but are not limited to, weed control and fire management. Therefore, the future quality of habitat for the bare-rumped sheathtail bat in the offset area with offset management is rated as moderate to high (8).

6.6. CONFIDENCE IN RESULTS – FUTURE QUALITY

The level of certainty about the success of the offset area in improving the quality of habitat for the bare-rumped sheathtail bat is rated as 70%. The management objectives detailed within the OAMP will target the threat abatement and recovery actions identified in the species recovery plan. The objectives of the OAMP will be based on published conservation recommendations and best practice management.

6.7. RISK OF LOSS WITHOUT OFFSET

Far North Queensland is one of the fastest growing regions in Queensland and over the past 15 years has experienced continuous growth in resident population, visitation, economic activity and urban development. This trend is forecast to continue for at least the next 20 years with the population of the region set to increase by 100,000 people by 2029 (Queensland Government, 2011). This growth will result in increased urban, agricultural, infrastructure and transport development across the region.

The proposed offset area is located on six contiguous lots which are currently owned by four different landholders. The primary land use of the lots is described as vacant large house site and subdivided land. While the remnant vegetation in the offset area is protected by the VM Act, the *Sustainable Planning Act 2009* (Qld) and associated policies and codes, an application can made to the state government to clear remnant vegetation. It is possible that an application could be approved to clear remnant vegetation within the offset area for a number of activities including, but not limited to:

- residential activities
- service infrastructure (e.g. transmission lines)

- access roads.

However, given the location and topography of the proposed offset area, the risk that the habitat will be completely lost over the foreseeable future has been determined to be 5%. This accounts for the low risk that the vegetation in the offset area could be lost through future development activities.

6.8. RISK OF LOSS WITH OFFSET

The offset area will be secured in perpetuity through a legally binding mechanism, such as a statutory covenant, registered under the *Land Title Act 1994* (Qld). The legally binding mechanism will be registered on the land title and will be binding on all current and future owners of the land. Land use within the offset area will be restricted in accordance with the legally binding mechanism and the OAMP. Therefore, the implementation of the legally binding mechanism will reduce the risk of loss of the offset area to 2%.

6.9. CONFIDENCE IN RESULTS – RISK OF LOSS

The confidence in results in terms of the risk of loss is determined to be 70%. The legally binding mechanism will be registered on the land title and will remain in effect in perpetuity. The legally binding mechanism can only be removed by the relevant Queensland Government Minister with regard to a public interest.

6.10. TIME OVER WHICH LOSS IS AVERTED

The offset area is proposed to be actively managed for a period of 20 years.

6.11. TIME UNTIL ECOLOGICAL BENEFIT

By selecting offsets in areas where current habitat for the species already exists, the time lag in between the establishment of the offset area and the ecological benefit is reduced. The proposed offset area already provides suitable foraging and roosting habitat for the bare-rumped sheathtail bat. Therefore, the ecological benefit of the offset for the bare-rumped sheathtail bat will be immediate. Furthermore, the establishment of the offset area is consistent with the second recovery objective in the National recovery plan for the bare-rumped sheathtail bat which specifies the protection of roosting sites for the species outside of reserved lands (Schulz & Thomson, 2007).

7. GREVILLEA GLOSSADENIA

7.1. SUMMARY OF RESULTS

Grevillea glossadenia is listed as vulnerable under the EPBC Act. The project will impact on 10.2 ha of habitat for the *species* (RPS, 2014, pers. comm., 1 May) and will result in the removal of approximately 300-350 individuals (RPS, 2013). Based on a desktop assessment there is approximately 167 ha of habitat available for *Grevillea glossadenia* within the proposed offset area (**Figure 7**). By applying conservative assumptions to populate the offsets assessment guide, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset area on the identified offset property (**Table 6**). The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 6: Summary of values and results for *Grevillea glossadenia* offset assessment

Quality of impact area:	7	Risk of loss without offset:	5%
Quality of offset area:	7	Risk of loss with offset:	2%
Future quality without offset:	6	Confidence in result:	70%
Future quality with offset:	8	Time over which loss is averted (years):	20 years
Confidence in result:	70%	Time until ecological benefit (years):	5 years
Minimum offset area (ha):	50 ha	Maximum offset area (ha):	167 ha
% of impact offset	100%	% of impact offset	346%

7.2. CURRENT QUALITY OF IMPACT AREA

Grevillea glossadenia occurs in north-east Queensland and grows in eucalypt woodland or low open forest, in shallow skeletal granitic soils. The species prefers an exposed, fully-lit, free-draining habitat and is frequently encountered as a regenerating species in disturbed areas (e.g. along road verges).

Grevillea glossadenia has been recorded in a number of locations in the project area, primarily along ridges and on the edges of existing tracks. The species is associated with REs 7.12.57, 7.12.65k and 7.12.30and over 500 individuals have been recorded in the project area. Approximately 300-350 individuals and 10.2 ha of habitat for the species will be directly impacted by the project.

The current quality of habitat for the *Grevillea glossadenia* in the project area is rated as moderate to high (7).

7.3. START QUALITY OF OFFSET AREA

The offset area is mapped with the same vegetation communities, is contiguous with vegetation in the project area and provides connectivity to Baldy Mountain Forest Reserve. It is expected that due to its close proximity to the project area it also contains similar habitat values and is similar in condition to the project area. Based on a desktop assessment of regional ecosystem mapping, the proposed offset area contains 167 ha of potential habitat for Grevillea *glossadenia*. A known record of the species is also located within the offset area (**Figure 7**). Therefore, the current quality of habitat for the *Grevillea glossadenia* in the offset area is rated as moderate to high (7).

7.4. FUTURE QUALITY OF OFFSET AREA WITHOUT OFFSET MANAGEMENT

Without active management there may be a decline in the quality of habitat for *Grevillea glossadenia* within the offset area. Threats to the species that may impact on quality of habitat include invasion of exotic weed species and extinction associated with stochastic events (DoTE, 2014d). The encroachment of exotic weeds, including *Agave sisalana* which is known to occur in and around the project area, can prevent the growth of *Grevillea glossadenia*. Therefore, the future quality of the offset area without offset management for *Grevillea glossadenia* is rated as moderate (6).

7.5. FUTURE QUALITY OF OFFSET AREA WITH OFFSET MANAGEMENT

The quality of habitat for *Grevillea glossadenia* will be improved through the establishment of the offset area. An OAMP will be developed for the offset area which will detail management actions to be implemented to improve habitat for the species. These management actions will include weed control measures to prevent the introduction and/or spread of weeds in the offset area.

In addition to these measures, the individuals that will be directly impacted by the project will be translocated to establish a self-sustaining *Grevillea glossadenia* population in the offset area. A site specific Plant Translocation Plan will be developed based on the criteria and guidelines in Vallee et. al. (2004).

Therefore, the future quality of habitat for *Grevillea glossadenia* in the offset area with offset management is rated as moderate to high (8).

7.6. CONFIDENCE IN RESULTS – FUTURE QUALITY

The level of certainty about the success of the offset area in improving the quality of habitat for *Grevillea glossadenia* is rated as 70%. The management actions to be detailed within the OAMP will be based on published conservation recommendations and best practice management and will target improving existing habitat in the offset area for the species, threat abatement and will ensure the survival of the translocated population.

7.7. RISK OF LOSS WITHOUT OFFSET

Far North Queensland is one of the fastest growing regions in Queensland and over the past 15 years has experienced continuous growth in resident population, visitation, economic activity and urban development. This trend is forecast to continue for at least the next 20 years with the population of the region set to increase by 100,000 people by 2029 (Queensland Government, 2011). This growth will result in increased urban, agricultural, infrastructure and transport development across the region.

The proposed offset area is located on six contiguous lots which are currently owned by four different landholders. The primary land use of the lots is described as vacant large house site and subdivided land. While the remnant vegetation in the offset area is protected by the VM Act, the *Sustainable Planning Act 2009* (Qld) and associated policies and codes, an application can made to the state government to clear remnant vegetation. It is possible that an application could be approved to clear remnant vegetation within the offset area for a number of activities including, but not limited to:

- residential activities
- service infrastructure (e.g. transmission lines)
- access roads.

However, given the location and topography of the proposed offset area, the risk that the habitat will be completely lost over the foreseeable future has been determined to be 5%. This accounts for the low risk that the vegetation in the offset area could be lost through future development activities.

7.8. RISK OF LOSS WITH OFFSET

The offset area will be secured in perpetuity through a legally binding mechanism, such as a statutory covenant, registered under the *Land Title Act 1994* (Qld). The legally binding mechanism will be registered on the land title and will be binding on all current and future owners of the land. Land use within the offset area will be restricted in accordance with the legally binding mechanism and the OAMP. Therefore, the implementation of the legally binding mechanism will reduce the risk of loss of the offset area to 2%.

7.9. CONFIDENCE IN RESULTS – RISK OF LOSS

The confidence in results in terms of the risk of loss is determined to be 70%. The legally binding mechanism will be registered on the land title and will remain in effect in perpetuity. The legally binding mechanism can only be removed by the relevant Queensland Government Minister with regard to a public interest.

7.10. TIME OVER WHICH LOSS IS AVERTED

The offset area is proposed to be actively managed for a period of 20 years.

7.11. TIME UNTIL ECOLOGICAL BENEFIT

By selecting offsets in areas where current habitat for the species already exists, the time lag in between the establishment of the offset area and the ecological benefit is reduced. The proposed offset area already provides approximately 167 ha of suitable habitat for *Grevillea glossadenia*. Additionally, the individuals to be impacted by the project will be translocated and established in the offset area. Once translocated, these individuals will require further management in order to become a self-sustaining population in the offset area. Therefore, the time until the offset provides an ecological benefit for *Grevillea glossadenia* is expected to be approximately five years.

8. HOMORANTHUS PORTERI

8.1. SUMMARY OF RESULTS

Homoranthus porteri is listed as vulnerable under the EPBC Act. The project will impact on 5.1 ha of habitat for *Homoranthus porteri* (RPS, 2014, pers. comm., 1 May) and will result in the removal of approximately 300-350 individuals (RPS, 2013). Based on a desktop assessment there is approximately 117 ha of habitat available for *Homoranthus porteri* within the proposed offset area. By applying conservative assumptions to populate the offsets assessment guide, CO2 Australia has determined that there is sufficient potential for RAC to configure a compliant offset area on the identified offset property (**Table 7**). The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 7: Summary of values and results for *Homoranthus porteri* offset assessment

Quality of impact area:	7	Risk of loss without offset:	5%
Quality of offset area:	7	Risk of loss with offset:	2%
Future quality without offset:	7	Confidence in result:	70%
Future quality with offset:	8	Time over which loss is averted (years):	20 years
Confidence in result:	50%	Time until ecological benefit (years):	5 years
Minimum offset area (ha):	57 ha	Maximum offset area (ha):	117 ha
% of impact offset	100%	% of impact offset	207.03%

8.2. CURRENT QUALITY OF IMPACT AREA

Homoranthus porteri is restricted to north-east Queensland from near Mareeba southwards to near Ravenshoe (DoTE, 2014e). It occurs in shallow soils on rock outcrops, scree slopes, on the edge of rocky escarpments and rocky hillsides often in very exposed positions.

Homoranthus porteri has been recorded in a number of locations along ridges lines in the project area. Approximately 400 individuals have been recorded in the project area, of which 300 to 350 will be directly impacted by the project. The project will also result in the removal of approximately 5.1 ha of potential habitat for the species.

The current quality of habitat for the *Homoranthus porteri* in the project area is rated as moderate to high (7).

8.3. START QUALITY OF OFFSET AREA

The offset area is mapped with the same vegetation communities, is contiguous with vegetation in the project area and provides connectivity to Baldy Mountain Forest Reserve. It is therefore expected that the offset area will contain the same habitat value for *Homoranthus porteri* as the project area and is similar in condition to the project area. Based on a desktop assessment of regional ecosystem mapping, the proposed offset contains 117 ha of potential habitat for *Homoranthus porteri*. A known record of the species is also located within the offset area (**Figure 7**).

The current quality of habitat for the *Homoranthus porteri* in the offset area is rated as moderate to high (7).

8.4. FUTURE QUALITY OF OFFSET AREA WITHOUT OFFSET MANAGEMENT

As further research is needed to identify the threats to *Homoranthus porteri* the quality of the offset area without offset management has been determined to be the same as the start quality, moderate (7). Once further information about the species becomes available and field work is undertaken within the offset area, the future quality of the offset area without offset management may be revised. It is possible due to the restricted distribution of *Homoranthus porteri*, important populations of the species may be prone to disturbance from threatening processes such as vegetation clearance, weed invasion and fire.

8.5. FUTURE QUALITY OF OFFSET AREA WITH OFFSET MANAGEMENT

The quality of habitat for *Homoranthus porteri* will be improved through the establishment of the offset area. An OAMP will be developed for the offset area which will detail management actions to be implemented to improve habitat for the species. Further research will be undertaken to determine the threats to the species and appropriate threat abatement actions will be incorporated into the OAMP. In addition, the individual plants that will be directly impacted by the project will be translocated to establish a self-sustaining *Homoranthus porteri* population in the offset area. A site specific Plant Translocation Plan will be developed based on the criteria and guidelines in Vallee, et. al. (2004). Therefore, based on these actions, it is anticipated that the future quality of habitat for *Homoranthus porteri* in the offset area with offset management will be rated as high (8).

8.6. CONFIDENCE IN RESULTS – FUTURE QUALITY

The level of certainty about the success of the offset area in improving the quality of habitat for *Homoranthus porteri* is rated as 50%. While the management objectives and practices detailed within the OAMP will target protecting and improving existing habitat for the species in the offset area and will ensure the survival of the translocated population, there is some uncertainty regarding the threats to *Homoranthus porteri*. This uncertainty has been accounted for in this score. It is recognised that further research will be required to be undertaken to determine the threats to the species and develop appropriate management activities for this species within the offset area.

8.7. RISK OF LOSS WITHOUT OFFSET

Far North Queensland is one of the fastest growing regions in Queensland and over the past 15 years has experienced continuous growth in resident population, visitation, economic activity and urban development. This trend is forecast to continue for at least the next 20 years with the population of the region set to increase by 100,000 people by 2029 (Queensland Government, 2011). This growth will result in increased urban, agricultural, infrastructure and transport development across the region.

The proposed offset area is located on six contiguous lots which are currently owned by four different landholders. The primary land use of the lots is described as vacant large house site and subdivided land. While the remnant vegetation in the offset area is protected by the VM Act, the *Sustainable Planning Act 2009* (Qld) and associated policies and codes, an application can made to the state government to clear remnant vegetation. It is possible that an application could be approved to clear remnant vegetation within the offset area for a number of activities including, but not limited to:

- residential activities
- service infrastructure (e.g. transmission lines)
- access roads.

However, given the location and topography of the proposed offset area, the risk that the habitat will be completely lost over the foreseeable future has been determined to be 5%. This accounts for the low risk that the vegetation in the offset area could be lost through future development activities.

8.8. RISK OF LOSS WITH OFFSET

The offset area will be secured in perpetuity through a legally binding mechanism, such as a statutory covenant, registered under the *Land Title Act 1994* (Qld). The legally binding mechanism will be registered on the land title and will be binding on all current and future owners of the land. Land use within the offset area will be restricted in accordance with the legally binding mechanism and the OAMP. Therefore, the implementation of the legally binding mechanism will reduce the risk of loss of the offset area to 2%.

8.9. CONFIDENCE IN RESULTS – RISK OF LOSS

The confidence in results in terms of the risk of loss is determined to be 70%. The legally binding mechanism will be registered on the land title and will remain in effect in perpetuity. The legally binding mechanism can only be removed by the relevant Queensland Government Minister with regard to a public interest.

8.10. TIME OVER WHICH LOSS IS AVERTED

The offset area is proposed to be actively managed for a period of 20 years.

8.11. TIME UNTIL ECOLOGICAL BENEFIT

By selecting offsets in areas where current habitat already exists, the time lag in between the establishment of the offset area and the ecological benefit for the species is reduced. The proposed offset area already provides approximately 117 ha of suitable habitat for *Homoranthus porteri*. Additionally, the individuals to be impacted by the project will be translocated and established in the offset area. Once translocated, these individuals will require further management in order to become a self-sustaining population in the offset area. Therefore, the time until the offset provides an ecological benefit for *Homoranthus porteri* is expected to be approximately five years.

9. SUMMARY OF RESULTS

Based on the results of the offset assessment, there is sufficient potential for RAC to configure an offset area that is compliant with the requirements of the Australian Government's EPBC Act Offsets Policy on the proposed offset property (**Table 8**). While this assessment is preliminary in nature, the values generated from the offsets assessment guide indicate that the proposed offset is suitable to acquit the offset requirements of the project and the percentage of impact offset is over 100% for all values.

The offset area provides for the long term protection of habitat for the five threatened species and through the implementation of adaptive management practices the quality of the habitat will be improved and maintained over time. The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 8. Offsets assessment guide results

OFFSETS ASSESSMENT GUIDE PARAMETER	MNES				
	northern quoll	spectacled flying-fox	bare-rumped sheathtail bat	*Grevillea glossadenia*	*Homoranthus porteri*
Size of impact area:	57.7 ha	57.7 ha	57.7 ha	10.2 ha	5.1 ha
Quality of impact area:	8	3	7	7	7
Start quality of offset area:	8	3	7	7	7
Future quality with offset:	9	4	8	8	8
Future quality without offset:	6	3	6	6	7
Confidence in results:	50%	70%	70%	70%	50%
Risk of loss with offset:	2%	2%	2%	2%	2%
Risk of loss without offset:	5%	5%	5%	5%	5%
Confidence in results:	70%	70%	70%	70%	70%
Time over which loss is averted:	20 years	20 years	20 years	20 years	20 years
Time until ecological benefit:	5 years	Immediate	Immediate	5 years	5 years
Minimum offset area:	315[3] ha	213 ha	300 ha	50 ha	57 ha
Minimum % of impact offset:	100%	100%	100%	100%	100%
Maximum offset area:	347[3] ha	360 ha	391 ha	167 ha	117 ha
Maximum % of impact offset:	112%	155%	133%	346%	207%

[3] Includes denning habitat only; however, 236 ha of potential foraging habitat is also available within the proposed offset area.

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Appendix 35

Mount Emerald Wind Farm Draft Offset Area Management Plan

Prepared by CO2 Australia Limited

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Part of the CO2 Group

Mount Emerald Wind Farm Offset Plan

RATCH-Australia Corporation Limited

Version 4 - May 2014

Part of the CO2 Group

REPORT TITLE: Mount Emerald Wind Farm Offset Plan

PREPARED FOR: RATCH-Australia Corporation Limited

PREPRARED BY: Kate McBean and Meghan Farr

APPROVED BY: Rebecca Enright, Senior Manager Environmental Services

DATE: 5 May 2014

VERSION 4.0

ecofund
Part of the CO2 Group

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ABBREVIATIONS AND ACRONYMS

DoTE	Australian Government Department of the Environment
EIS	environmental impact statement
EIS guidelines	Final Guidelines for an Environmental Impact Statement for the Mount Emerald Wind Farm April 2012 (Department of Sustainability, Environment, Water, Populations and Communities, 2012)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
offsets assessment guide	EPBC Act Offsets Assessment Guide
EPBC Act offsets policy	EPBC Act Environmental Offsets Policy October 2012
MNES	matters of national environmental significance
OAMP	offset area management plan
PMST	Protected Matters Search Tool database (EPBC Act)
the project	Mount Emerald Wind Farm project
SPRAT	Species Profile and Threats database
TEC	threatened ecological community
VM Act	*Vegetation Management Act 1999* (Qld)

1. INTRODUCTION

RATCH-Australia Corporation Limited (RAC) propose to develop the Mount Emerald Wind Farm project (the project) located north-west of Atherton in north Queensland (**Figure 1**). The project area (Lot 7 SP235244) is approximately 2,422 ha in size and will include 70 wind turbines and associated access tracks and electrical infrastructure feeding into the main electricity grid (Chalumbin-Woree transmission line).

The project has been designed to avoid and mitigate impacts on environmental values; however, residual, unavoidable impacts on matters of national environmental significance (MNES) remain. To compensate for these unavoidable impacts, RAC is committed to delivering offsets in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth; EPBC Act) Environmental Offsets Policy October 2012 (the EPBC Act offsets policy).

This report has been prepared to address Section 5.13 of the Final Guidelines for an Environmental Impact Statement (EIS) for the Mount Emerald Wind Farm April 2012 (EIS guidelines), and to inform the Australian Government Department of the Environment (DoTE) and the public about the proposed approach to offset delivery. The purpose of this report is to:

- provide an overview of the EPBC Act offset framework
- summarise how the project has been designed and located to avoid and mitigate impacts on protected environmental values
- identify the residual significant impacts of the project and associated offset requirements
- outline RAC's proposed approach to offset delivery including details of a direct offset option for further assessment
- provide details of potential compensatory measures
- outline RAC's proposed approach to offset implementation including the preparation and implementation of a detailed offset proposal.

Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

Figure 1:
Overview Map

DATA SOURCE:

The following datasets are © State of Qld 2013:
- Cadastral Data (2011)

Offset area

DATE	AUTHOR	REQUESTED BY
24-02-2014	RF	LW

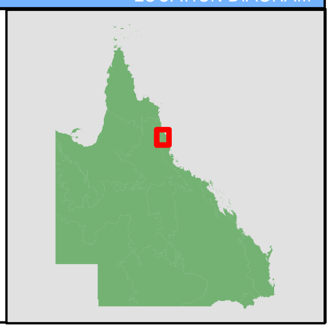
N

0 5 10 15

Kilometres

1:500,000

(A4) GCS GDA 1994



2. PROJECT BACKGROUND

The proposed project was referred under the EPBC Act on 21 December 2011. On 24 January 2012, the Australian Government determined that the project was a controlled action under the provisions of the EPBC Act due to the project's potential impacts on MNES. The controlling provisions for the project are:

- world heritage properties (sections 12 and 15A)
- national heritage places (sections 15B and 15C)
- listed threatened species and ecological communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A).

On the same date, the Australian Government also determined that the proposed project be assessed by EIS in accordance the EIS guidelines. A draft EIS has been prepared by RAC and was submitted to the Australian Government in November 2013.

RAC is also seeking local and Queensland Government approval for the project and in March 2012 submitted an application for a development permit for a material change of use for the purpose of a 'wind farm' as defined under the Mareeba Shire Planning Scheme Temporary Local Planning Instrument 01/11. RAC has recently been granted an extension for the submission of environmental and technical reports to fulfil local and Queensland Government requirements until April 2014. It is possible that impacts to particular state significant biodiversity values that cannot be reasonably avoided or mitigated (i.e. residual impacts) will require environmental offsets as a condition of Queensland Government approval. Assessment of the offset requirements of the project under Queensland legislation will be undertaken separate to the assessment of Australian Government requirements, as presented in this report.

2.1. PROJECT DESCRIPTION

The project is located on a plateau stretching west of the Kennedy Highway between the towns of Walkamin and Tolga on the Atherton Tablelands, approximately 50 km south-west of Cairns. It is located within Tablelands Regional Council local government area and straddles the Wet Tropics bioregion and the Einasleigh Uplands bioregion. The project area is approximately 2,422 ha in size and will include 70 wind turbines and associated access tracks and electrical infrastructure feeding into the main electricity grid (Chalumbin-Woree transmission line). Each tower will be approximately 80 to 90 m high with approximately 50 m blades, utilising 3 MW machines.

2.2. FIELD SURVEYS

Flora and vegetation assessments were undertaken on and surrounding the project area by RPS Group between May 2010 and December 2013 and are documented in the Mount Emerald Flora Report (RPS, 2013). Vegetation survey sites were established across the project area to determine the ecology of the vegetation and its flora, with a particular focus on determining the project's impacts on MNES. All vascular plant species were recorded and an inventory of species was compiled. Voucher specimens were collected for species that could not be identified in the field and lodged with the Queensland Herbarium for formal identification.

Due to the unique characteristics of the project area (including elevation, exposure and landform), poorly represented vegetation communities are present. The project area is almost entirely covered in remnant, dry sclerophyll woodland vegetation on rhyolite geology and is dominated by a series of roughly parallel high rocky ridges, up to 1000 m altitude, dissected by ephemeral creek lines. Remnant vegetation present in the project area is classified under Queensland's *Vegetation Management Act 1999* (VM Act) as least concern and of concern. As a result of field surveys it has been determined that two vulnerable flora species likely to be significantly impacted by the construction and operation of the project are listed as MNES – *Grevillea glossadenia* and *Homoranthus porteri*.

Preliminary surveys undertaken in mid- 2010 also assessed the presence/absence of MNES fauna species within the project area. Subsequent targeted fauna surveys were conducted between August 2012 to September 2013. Fauna survey methodologies were developed and implemented in accordance with the:

- Wildlife Survey Guidelines, NSW Department of Agriculture and NSW National Parks and Wildlife Service (recognised and recommended wildlife survey guidelines for Queensland use) including:
- ANZCCART Guidelines for the Euthanasia of Animals Used for Scientific Purposes; and
- Hygiene protocol for the control of disease in frogs (NSW National Parks and Wildlife Service).

The results of these surveys indicate that three terrestrial fauna species listed as MNES are likely to be significantly impacted by the construction and operation of the project – the endangered northern quoll (*Dasyurus hallucatus*), the critically endangered bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*) and the vulnerable spectacled flying-fox (*Pteropus conspicillatus*).

2.3. AVOIDANCE AND MITIGATION MEASURES

The EPBC Act offsets policy requires that proponents avoid and mitigate impacts on MNES to the greatest practicable extent to ensure only unavoidable residual impacts remain. RAC could not identify any suitable alternative project locations as feasibility assessments determined that the proposed Mount Emerald site is the preferred location for the development of a wind farm in Queensland. However, RAC has identified avoidance and mitigation measures that can be implemented on site during preconstruction, construction, operation and decommissioning of the project.

Preconstruction surveys will be undertaken to identify locations of rare and threatened flora species along the preferred WTG access tracks and turbine sites. These surveys will allow designers to avoid and minimise clearing of these species and communities during construction.

Where practicable, during construction and operation of the project, RAC will avoid disturbance to significant flora and fauna species. The Bird Management Plan Construction Phase protocols will be implemented to avoid clearing of any roosting trees identified during preconstruction surveys and micro siting of turbine and track location and minimise the area of cleared vegetation. The Micro Bat Management Plan Construction Phase protocols will be implemented to avoid clearing of any roosting trees identified during preconstruction surveys and micro siting of turbine and track location.

During the project's decommissioning phase, RAC will avoid disturbance to endangered, vulnerable, rare and poorly known flora species that have regenerated adjacent to or in original construction zones. Individual significant species, which are located in the decommissioning zone, will be flagged (including habitat trees) so they may be avoided. In addition, physical barriers will be placed around significant vegetation areas in order to restrict access and avoid further disturbance.

RAC proposes to adopt a number of mitigation measures to minimise the magnitude of project impacts on specific MNES. These include:

- for turbine collision and barotrauma impacts on the bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*):
    - turbine operation curtailment (increased cut-in speed and targeted turbine shut-down during high risk conditions or detected collision mortality)
    - continue and expand ultrasonic call surveys; sample within Rotor Swept Area (RSA) (higher towers and balloons)
    - collect weather and insect abundance/height data
    - identify high-risk conditions/times and seasons
    - conduct radar utilisation at call survey locations sampling at RSA; quantify abundance and flight heights

    - conduct numerical risk modelling
    - prepare a Microchiropteran Bat Management Plan
- for turbine collision impacts on the spectacled flying-fox (*Pteropus conspicillatus*):
    - turbine curtailment during high risk conditions (active) or excessive mortality events (reactive)
    - conduct radar utilisation surveys
    - support CSIRO researchers to conduct satellite telemetry of more individuals from nearest colonies to site (Mareeba and Tolga Scrub)
    - conduct numerical collision risk modelling (using radar/telemetry data)
- for habitat loss impacts on the northern quoll (*Dasyurus hallucatus*):
    - avoid clearing high-quality denning and foraging habitats
    - undertake additional telemetry studies on the project site to determine whether proposed turbine ridge habitats are used preferentially, particularly females with young; and offsite, to collect data on dispersion rates to refine the population viability analysis (to assess the significance of potential impacts)
    - redesign infrastructure layout to avoid identified high quality foraging or maternal denning habitat
    - prepare a Quoll Management Plan
- for clearing impacts on significant plant species:
    - micro-positioning of turbines to minimise clearing and disturbance to conservation significant plants and important vegetation types
    - presence of botanical advisor in pre clearance team
    - instigate site-based seed and propagule collection for future rehabilitation work
    - prepare a Significant Plan Management Plan
    - research propagation of *Homoranthus porteri*, *Melaleuca uxorum*, *Plectranthus amoenus* and *Grevillea glossadenia*.

3. OFFSET FRAMEWORK

This section provides a summary of the current legislative and policy framework for environmental offsets as applicable to the project. Under the EPBC Act the significant residual impacts of the project on MNES may be required to be offset in accordance with the EPBC Act offsets policy.

3.1. EPBC ACT OFFSETS POLICY

The purpose of the EPBC Act offsets policy is to outline the Australian Government's position on the use of environmental offsets to compensate for significant adverse impacts on MNES. Under the EPBC Act offsets policy, offsets must deliver an overall conservation gain that compensates for the significant residual impacts associated with the project. A suitable offset under the policy must:

- deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action
- be built around direct offsets but may include other compensatory measures
- be in proportion to the level of statutory protection that applies to the protected matter
- be of a size and scale proportionate to the residual impacts on the protected matter
- effectively account for and manage the risks of the offset not succeeding
- be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs
- be efficient, effective, timely, transparent, scientifically robust and reasonable
- have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

Under the EPBC Act offsets policy there are three primary options available for offset delivery: direct offsets, other compensatory measures and advanced offsets.

3.1.1. Direct Offsets

Direct offsets are an essential component of a suitable offsets proposal and must generally account for at least 90% of the offset requirement for any given impact. Direct offsets are actions that ensure a measurable conservation gain for the impacted matter whereby the action maintains or increases its viability or reduces threatening processes. A conservation gain may be achieved by:

- improving existing habitat for the protected matter
- creating new habitat for the protected matter
- reducing threats to the protected matter
- increasing the values of a heritage place, and/or
- averting the loss of a protected matter or its habitat that is under threat.

3.1.2. Compensatory Measures

Other compensatory measures may be used to satisfy up to 10% of offset requirements under the EPBC Act offsets policy. Other compensatory measures do not directly offset the impacts to protected matters but should lead to an increased benefit to the impacted matter. Other compensatory measures are usually delivered through a suitable research or education program that must:

- endeavour to improve the viability of the impacted protected matter

- be targeted toward key research/education activities identified the relevant Commonwealth approved recovery plan, threat abatement plan, conservation advice, ecological character description, management plan or listing document
- be undertaken in a transparent scientifically robust and timely manner
- be undertaken by a suitably qualified individual or organisation in a manner approved by the department
- consider best practice research approaches.

3.1.3.Advanced Offsets

An advanced offset is an offset that is secured to deliver a conservation gain for a protected matter prior to the impact occurring. Advanced offsets must satisfy all of the requirements of the EPBC Act offsets policy. They are advantageous in that they can reduce the project's overall offset requirements as the offsets assessment guide places a higher value on offsets that deliver a conservation gain in a shorter time period. Advanced offsets can be used to better managing the risks associated with the time delay in realising a conversation gain.

3.2. OFFSETS ASSESSMENT GUIDE

The EPBC Act Offsets Assessment Guide (the offsets assessment guide), which accompanies the EPBC Act offsets policy, has been developed to clarify and provide further guidance on the requirements of the policy. The offsets assessment guide utilises a balance sheet approach to compare impacts to the suitability of proposed offset areas. The offsets assessment guide is a tool used by DoTE assessment officers to determine if the proposed offset area adequately acquits the offset requirements for impacts to MNES.

To inform the final offset size requirement and the overall suitability of the proposed offset area, an offsets assessment guide has been completed for each of the listed threatened species on which the project is expected to have a significant residual impact. The guide relies on the input of sound scientific data (ideally obtained through field surveys), including information about the quality of the offset area. A summary of these results are presented in **Section 5**.

4. RESIDUAL IMPACTS AND OFFSET REQUIREMENTS

The residual project impacts (i.e. those impacts that cannot be reasonably avoided or mitigated) are related to the clearing of vegetation, the associated loss of habitat for EPBC Act listed flora and fauna identified within the project area and species mortality due to turbine collisions. RAC has advised that project development requires the removal of approximately 57.7 ha of remnant vegetation for the construction of the turbine pads, contractors lay down pad, access tracks and substation.

RAC has determined that there are likely to residual impacts on three EPBC Act listed fauna species and two flora species as a result of project development. The northern quoll, listed as an endangered species under the EPBC Act, was found to be widely distributed across the project area and present in relatively high numbers (RPS, 2012). Project actions are expected to directly reduce the area of occupancy (i.e. habitat loss) of northern quolls as well as fragment remaining habitat and potentially facilitate weed encroachment in disturbed areas, alter the fire regime and affect predator-prey dynamics by opening intact vegetation communities. The maximum impact of the project on habitat for the northern quoll is 57.7 ha. The impacted area is considered to contain a mix of denning and foraging habitat (RPS 2013). However, for the purpose of undertaking a conservative approach to offset assessment it has been assumed that the all of the impacted habitat is denning habitat.

The spectacled flying-fox is expected to be impacted by the removal of foraging habitat within the project area, and the bare-rumped sheathtail bat is expected to be impacted by the removal of roosting habitat. As the bat species are likely to utilise the foraging and roosting resources across the project area, the residual project impact on foraging and roosting habitat is equivalent to the area of vegetation clearing, 57.7 ha.

Approximately 300-400 *Grevillea glossadenia* individuals and 10.2 ha of potential habitat for *Grevillea glossadenia* (RPS, 2014, pers. comm., 1 May) is expected to be impacted by the project. Approximately 300-350 *Homoranthus porteri* individuals and 5.1 ha of potential habitat for *Homoranthus porteri* (RPS, 2014, pers. comm., 1 May) is expected to be removed as a result of vegetation clearing.

Based on an assessment of the project’s residual impacts, the offset requirements have been identified and are presented in **Table 1**. The offset requirements outlined below are not cumulative as some environmental values occur within the same area. The offset requirements are presented in terms of the minimum area required to be secured and the final size of the offset area and its suitability will be determined through the field assessments and the application of the offsets assessment guide.

Table 1: Summary of the project's offset requirements under the EPBC Act Environmental Offsets Policy

ENVIRONMENTAL VALUE	EPBC ACT STATUS[1]	SPECIES DISTRIBUTION WITHIN PROJECT AREA	TYPE OF HABITAT IMPACTED	IMPACT AREA (ha)
THREATENED FAUNA				
northern quoll (*Dasyurus hallucatus*)	E	A number of individuals of both sexes and different ages were detected across the subject site, predominantly in rocky areas in both ridges and valleys. Quolls were detected through cage trapping, camera traps and scat identification. It was concluded that Northern quolls are abundant and widespread across the site (RPS 2012).	Denning and foraging	57.7
spectacled flying-fox (*Pteropus conspicillatus*)	V	No suitable roosting habitat (rainforest) is present on the subject site; however, the species may forage on site during mass flowering of Myrtaceous trees, and/or fly over site at rotor height between suitable nearby foraging areas.	Foraging	57.7
bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*)	CE	The subject site contains suitable habitat for this species, particularly in the lower reaches of Granite Creek where *E. platyphylla* is present. Calls potentially belong to this species have been recorded in the vicinity of turbine #30 and turbine #38 (RPS 2012).	Roosting	57.7
THREATENED FLORA				
Grevillea glossadenia	V	Widespread in rocky habitat of the Wet Tropics bioregion section of site. Relatively common along ridges above 900 m, but rarely found under woodland cover.	Suitable and known	10.20
Homoranthus porteri	V	More or less confined to south west ridges of the Wet Tropics bioregion section, with two isolated populations in Einasleigh Uplands bioregion.	Suitable and known	5.10

[1] CE- critically endangered; E- endangered; V- vulnerable

Table 2 provides details of species- specific information that will be used to inform the suitability of offsets and the delivery of the project's offset requirements for impacts on MNES. It is important to note that the threat abatement and recovery actions provided are not exhaustive.

Table 2: Species- specific information on MNES

ENVIRONMENTAL VALUE	RELEVANT RECOVERY OR CONSERVATION PLAN AVAILABLE	RECOMMENDED THREAT ABATEMENT AND RECOVERY ACTIONS
THREATENED FAUNA		
northern quoll (*Dasyurus hallucatus*)	National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*) (Hill and Ward, 2010)	The National Recovery Plan for the Northern Quoll aims to minimise the rate of decline of northern quoll in Australia and ensure the viability of remaining populations. Cane toads have been identified as a major threat to northern quoll and recovery actions identified in the recovery plan focus of mitigating this threat. Threat abatement and recovery actions should aim to achieve the following objectives: • Protect northern quoll populations on offshore islands from invasion and establishment of cane toads, cats and other potential invasive species. • Foster the recovery of northern quoll sub-populations in areas where the species has survived alongside cane toads. • Minimise species declines in areas recently colonised by cane toads. • Maintain secure populations and source animals for future reintroductions/introductions, if they become appropriate. • Reduce the risk of northern quoll populations being impacted by disease. • Reduce the impact of pastoral land management practices on northern quolls. Specific actions include: • continue research into the susceptibility of quolls to cane toad poisoning • investigate factors causing declines in northern quoll populations not yet affected by cane toads • continue studies of whether there is a genetic basis for differences in susceptibility of northern quolls to cane toad toxins • develop and, where required, implement a strategy for rapid-response control of cane toad or feral cat outbreaks on offshore islands occupied by northern quolls (DoTE, 2013d).

ENVIRONMENTAL VALUE	RELEVANT RECOVERY OR CONSERVATION PLAN AVAILABLE	RECOMMENDED THREAT ABATEMENT AND RECOVERY ACTIONS
spectacled flying-fox (*Pteropus conspicillatus*)	National Recovery Plan for the Spectacled Flying Fox *Pteropus conspicillatus* (Queensland Department of Environment and Resource Management, 2010).	The overall objectives of the recovery plan are to secure the long term protection of the spectacled flying-fox through a reduction in threats to the species. Threat abatement and recovery actions should aim to achieve the following objectives: • research practicable and cost effective flying fox deterrent systems for commercial fruit growers • identify and protect native foraging habitat critical to the survival of the spectacled flying fox • accurately assess the short and long term population size and population trends of the spectacled flying-fox • improve the public perception of the spectacled flying-fox and the standard of information available to guide recovery • increase knowledge of spectacled flying-fox roosting requirements and protect important camps • improve understanding of incidence of tick paralysis and actions to minimise paralysis mortality in flying foxes • implement strategies to reduce incidence of electrocution and entanglement of spectacled flying-fox roosting • investigate the causes of birth abnormalities such as cleft palate syndrome (Queensland Department of Environment and Resource Management, 2010).
bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*)	National Recovery Plan for the Bare-rumped Sheathtail Bat *Saccolaimus saccolaimus nudicluniatus* 2007-2011 (Schulz and Thomson, 2007)	Threat abatement and recovery actions to mitigate the loss of bare-rumped sheathtail bat habitat and increase the long term viability of the species include: • develop more effective detection techniques (including obtaining echolocation reference calls) and undertake systematic surveys to enable a more comprehensive assessment of distribution, population size, status and habitat preferences • increase protection of known roosts both on and outside reserved lands • better determine roosting requirements and document foraging requirements of the species, including potential seasonal and distributional differences and the identification of threatening processes • establish monitoring sites to investigate population trends in the species • clarify the taxonomic status of the species (DoTE, 2013a).
THREATENED FLORA		
Grevillea glossadenia	Recovery plan not required	Threat abatement and recovery actions to mitigate the loss of *Grevillea glossadenia* habitat and increase the long term viability of the species include: • protection from disturbances associated with mining activities and other developments • control of weed species which may prevent the growth of Grevillea glossadenia particularly sisal (Agave sisalana) and panic grass (Panicum maximum) • increase conservation awareness within the community for Grevillea glossadenia • enable recovery of additional sites through seed collection and storage and translocation (DoTE, 2013b)

ENVIRONMENTAL VALUE	RELEVANT RECOVERY OR CONSERVATION PLAN AVAILABLE	RECOMMENDED THREAT ABATEMENT AND RECOVERY ACTIONS
Homoranthus porteri	Recovery plan not required	Threat abatement and recovery actions to mitigate the loss of *Homoranthus porteri* habitat and increase the long term viability of the species include: • protection from habitat loss, disturbance and modification • provide known occurrences of species to local and State Rural Fire Services for inclusion in mitigation measures in bush fire management plans • control of invasive weed species that threaten Homoranthus porteri growth and long term viability • increase conservation awareness within the community for Homoranthus porteri • enable recovery of additional sites through seed collection and storage and translocation (DoTE, 2013c)

5. PROJECT OFFSETS

The EPBC Act offsets policy states that where a project results in residual impacts to MNES, suitable offsets must be proposed. RAC has undertaken a preliminary assessment to identify suitable areas to meet the offset requirements of the project. The selection of these areas has taken into account:

- the requirements of the EPBC Act offsets policy
- proximity to the existing project area
- the characteristics of the offset area (vegetation, topography, ecosystems) and their similarity to the characteristics of the project area
- connectivity to existing reserves (e.g. national parks, state forests)

Based on this assessment, RAC has identified a potential offset area, comprising six lots, to fulfil the offset requirements of the project. The results of a desktop assessment of the potential offset area are provided in **Section 5.1.** The suitability of the offset area has yet to be ground-truthed to determine the actual extent of environmental values on the ground. Should the offset area prove to be unviable following field surveys an alternative direct offset option will be identified. However, a preliminary assessment of the offset area against the EPBC Act Offsets Assessment Guide (the offsets assessment guide) has been undertaken. This assessment indicates that there is sufficient potential to configure a compliant offset on the identified property.

In the event that direct offsets do not fulfil the entire project's offset requirements, other compensatory measures will be explored in order to meet any shortfall. Examples of compensatory measures relevant to the impacted MNES are outlined in **Section 5.4**.

5.1. OFFSET AREA FOR FURTHER ASSESSMENT

RAC proposes to acquit the project's offset requirements by securing an offset area on six contiguous lots (based on the Digital Cadastral Database, current as of 11 August 2013) that adjoin the project area (**Figure 2**; the offset area). The offset area is approximately 583.48 ha in size, is located in the Tablelands Regional Council local government area and is zoned as rural (general rural). The lot tenure within the offset area is freehold and the primary land use is vacant. The offset area fringes the southern boundary of the project area and is connected to the Herberton Range State Forest, Baldy Mountain Forest Reserve and the Herberton Range National Park via the Herberton range (Queensland Government, 2013). Due to the close proximity of the offset area and the project area, they share similar environmental features such as topography, geology, climate, vegetation communities and fauna diversity.

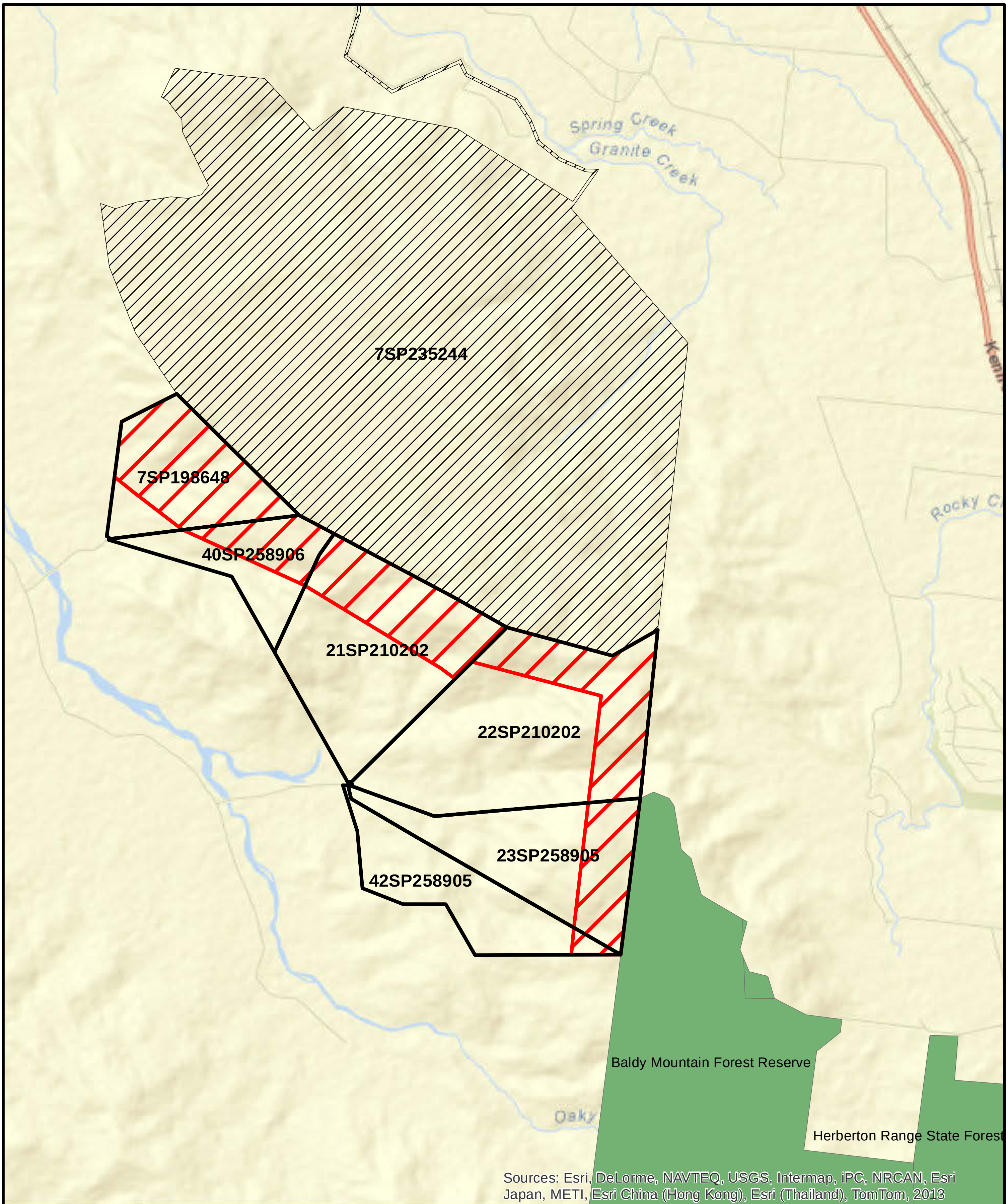
5.1.1. Environmental Values of the Offset Area

The offset area is characterised by high elevation ridges and valleys composed of remnant vegetation communities. The Queensland Government's regional ecosystem mapping has been assessed to identify the vegetation communities present within the offset area and the types of habitat for MNES that may be present. The majority of the remnant vegetation communities are listed as least concern under the VM Act, however approximately 159 ha of concern montane heath community (RE 7.12.57) is mapped within the offset area (**Table 3**; **Figure 3**). An assessment of the EPBC Act Protected Matters Search Tool database (the PMST) indicates that the northern quoll, spectacled flying-fox, *Grevillea glossadenia* and *Homoranthus porteri* and/or their habitat are likely to occur in the offset area. The Atlas of Living Australia has records within the offset area of *Grevillea glossadenia* and *Homoranthus porteri*.

Table 3. Vegetation communities within the offset area

RE	VM ACT STATUS[2]	DESCRIPTION	AREA (ha)
7.12.26	LC	*Syncarpia glomulifera* +/- *Corymbia intermedia* +/- *Allocasuarina* spp. closed forest to woodland, or *Lophostemon suaveolens*, *Allocasuarina littoralis*, *C. intermedia* shrubland, (or vine forest with these species as emergents), on exposed ridgelines or steep rocky slopes, on granite and rhyolite	22.79
7.12.34	LC	*Eucalyptus portuensis* and/or *E. drepanophylla*, +/- *Corymbia intermedia* +/- *C. citriodora*, +/- *E. granitica*, open woodland to open forest on dry uplands on granite	166.05
7.12.57	OC	Shrubland and low woodland mosaic with Syncarpia glomulifera, Corymbia abergiana, Eucalyptus portuensis, Allocasuarina littoralis, and Xanthorrhoea johnsonii, on moist and dry uplands and highlands on granite and rhyolite	158.53
7.12.65	LC	Rock pavements or areas of skeletal soil, on granite and rhyolite, mostly of dry western or southern areas, often with shrublands to closed forests of *Acacia* spp. and/or *Lophostemon suaveolens* and/or *Allocasuarina littoralis* and/or *Eucalyptus lockyeri* subsp. *Exuta*	8.68
7.12.7	LC	Simple to complex microphyll to notophyll vine forest, often with *Agathis robusta* or *A. microstachya*, on granites and rhyolites of moist foothills and uplands	1.14
9.12.30	LC	*Corymbia leichhardtii* +/- *Callitris intratropica* +/- *Eucalyptus shirleyi* low woodland to low open woodland on rhyolite hills	95.88
9.12.20	LC	Eucalyptus pachycalyx and E. cloeziana woodland on acid volcanics	76.70
9.12.4	LC	*Eucalyptus shirleyi* or *E. melanophloia* with *Corymbia peltata* and/or *C. leichhardtii* low open woodland to low woodland on acid volcanic rocks	26.78
9.12.2	LC	Open forest commonly including *Eucalyptus portuensis*, *E. crebra* (sens. lat.), *Corymbia clarksoniana*, *C. citriodora* on steep hills and ranges on acid and intermediate volcanics close to Wet Tropics boundary	3.26
9.12.7	LC	*Eucalyptus cullenii* +/- *Corymbia* spp. +/- *Eucalyptus* spp. woodland on acid and intermediate volcanic rocks	22.72
non-remnant	-	-	0.95
TOTAL			**583.48**

[2] LC- least concern; OC- of concern



Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

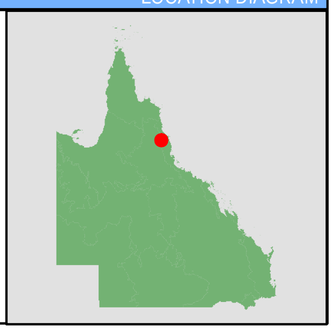


Figure 2:
Mt Emerald Wind Farm
Offset Area

- Mount Emerald Wind Farm
- Offset area
- Offset lots
- Protected areas

0 0.5 1 1.5
Kilometres

1:55,000

(A4) GCS GDA 1994

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)

DATE	AUTHOR	REQUESTED BY
24-02-2014	RF	LW

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Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

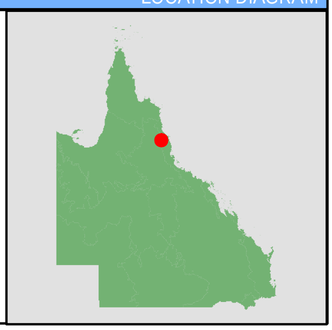

Figure 3:
Regional ecosystems
within the offset

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V6.1 (2011)

Mount Emerald Wind Farm
Offset area
Offset lots
Protected areas
Photo monitoring points

VMA Status

Containing Endangered regional ecosystems
Containing Of Concern regional ecosystems
Is a Least Concern regional ecosystem

DATE	AUTHOR	REQUESTED BY
24-02-2014	RF	LW

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0 0.25 0.5 0.75 1
Kilometres
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(A4) GCS GDA 1994

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5.1.2. Offset Potential of the Offset Area

A preliminary desktop assessment of the environmental values within the offset area demonstrates that the offset area has the potential to acquit the project's offset requirements as outlined in **Table 4**. A detailed discussion on the suitability of the offset area to fulfil the offset requirement for each impacted MNES is provided below.

Table 4: Potential offset availability within the offset area

MNES	EPBC STATUS[3]	IMPACT (ha or count)	ESTIMATED OFFSET POTENTIAL IN OFFSET AREA (ha)	TYPE OF HABITAT IN OFFSET AREA
northern quoll (*Dasyurus hallucatus*)	E	57.7	583	Denning and foraging
spectacled flying-fox (*Pteropus conspicillatus*)	V	57.7	360	Foraging
bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*)	CE	57.7	391	Roosting
Grevillea glossadenia	V	10.20	167	Suitable and known
Homoranthus porteri	V	5.10	117	Suitable and known

Northern quoll

The proposed offset area has the potential to deliver a conservation gain that maintains, and is likely to enhance, the viability of the regional northern quoll population. As the offset area is yet to be ground-truthed a desktop GIS assessment was undertaken to determine the extent of northern quoll habitat within the offset area. Analysis of satellite imagery was used to divide the potential northern quoll habitat area into denning and foraging habitat types. Rocky areas on ridge lines were considered as denning habitat, while the steep slopes, gullies and low flats were considered as suitable foraging habitat. Based on this analysis the proposed offset area is estimated to contain 347.32 ha of denning habitat and 236.17 ha of foraging habitat for the northern quoll (**Figure 4**).

The actual extent and quality of the habitat within the offset area will require field verification; however, as the offset area neighbours the project area, the habitat quality within the offset area is expected to be similar to the baseline conditions of the project area as identified in the draft Flora Report (RPS, 2013). The baseline conditions within the project area were characterised by high levels of natural landscape integrity, remnant and relatively intact vegetation communities. As the offset area is likely to provide habitat for the northern quoll, it is expected that the proposed offset area can effectively compensate for specific impacted attributes of the project on the species (i.e. habitat loss, habitat degradation and potential displacement) by securing a neighbouring area that meets, if not exceeds, the quality of the habitat at the project area.

Securing a neighbouring area as an offset also manages the risk of the offset not succeeding. The analogous vegetation communities and environmental values of the two areas increase the effectiveness of the offset. In addition, the connectivity of vegetation between the offset area and the Baldy Mountain Forest Reserve, Herberton Range State Forest and the Herberton Range National Park via the Herberton range reduces the risk of the offset not being effective as the continuity of remnant vegetation facilitates flora and fauna dispersal and ecological resilience.

The proposed offset area is not currently reserved by law or planning regulations or agreed to under other schemes or programs; therefore, securing and managing the proposed offset area will deliver a new conservation gain for the

[3] E- endangered; CE- critically endangered; M- migratory; V- vulnerable

impacted protected matter. To determine that the proposed offsets are in proportion to the level of statutory protection that apply to the northern quoll, the offsets assessment guide has been completed as part of offset implementation (CO2 Australia 2014). A summary of the results of this assessment are presented in Section 5.2.

Offsets will be implemented in accordance with MNES flora and fauna national recovery plans and/or the threat abatement and recovery recommendations in the DoTE Species Profile and Threats Database thereby ensuring that the offsets are effective, timely, reasonable and scientifically robust.

Securing the direct offset area is expected to wholly acquit the project's offset requirements, however, the implementation of compensatory measures may provide the opportunity to enhance the viability of the northern quoll population and lead to a long term conservation outcome. The northern quoll's population is declining across its distribution; however, the species was found to be widely distributed across the project area and present in relatively high numbers (RPS, 2012). Studying this population in accordance with the actions and objectives detailed in the National Recovery Plan for the Northern Quoll (Hill and Ward, 2010) may provide valuable data that contributes to minimising the rate of decline and ensuring that viable populations (such as this one) remain in each of the major regions of distribution into the future.

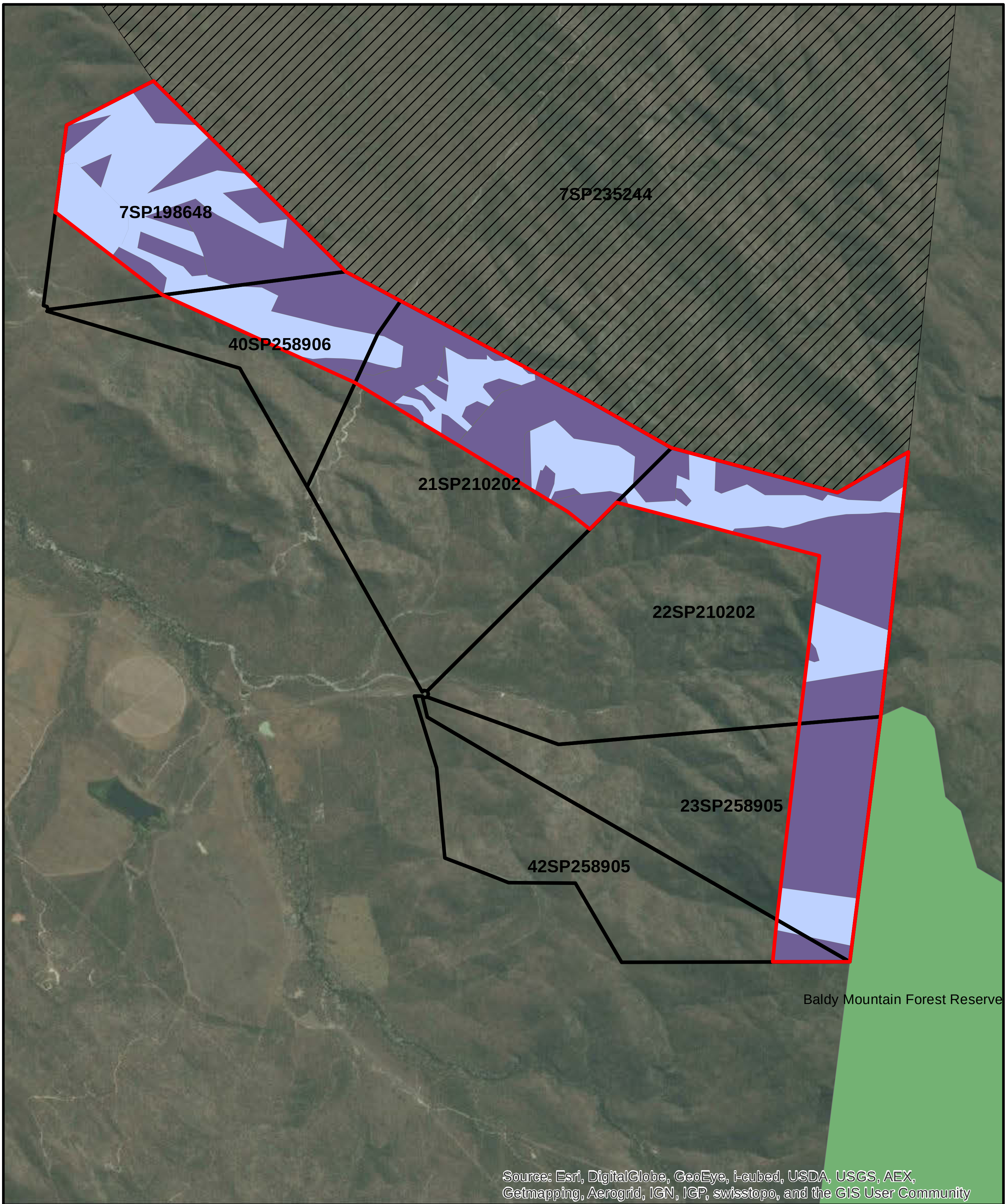

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Figure 4:
Northern Quoll habitat
within the offset

DATA SOURCE:

Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

Mount Emerald Wind Farm
Offset area
Offset lots
Protected areas

Northern quoll habitat (approx 580 ha)

Denning habitat (approx 345 ha)
Foraging and dispersal habitat (approx 235 ha)

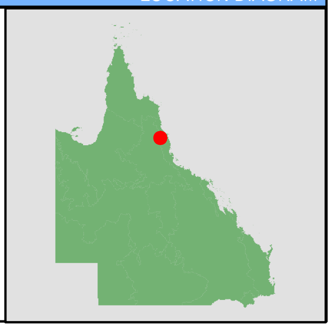
DATE	AUTHOR	REQUESTED BY
04-04-2014	RF	LW

N

CO2

0 0.25 0.5 0.75 1
Kilometres
1:35,000
(A4) GCS GDA 1994

LOCATION DIAGRAM



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Spectacled flying- fox

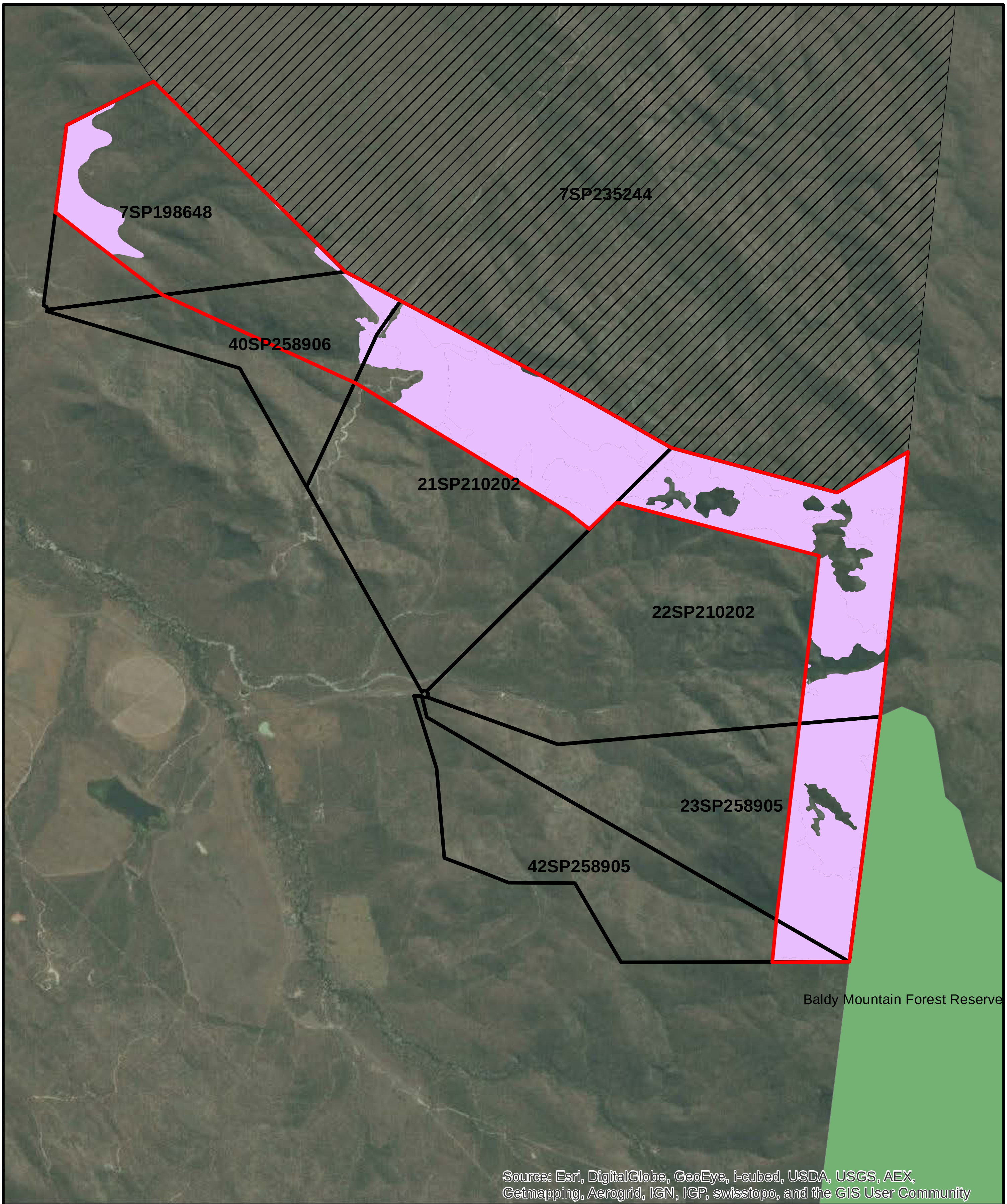
The proposed offset is expected to deliver a conservation gain by compensating for the specific attributes impacted by project actions. Project actions are expected to impact on spectacled flying-fox foraging habitat as well introduce the risk of direct mortality from turbine strike (RPS, 2012).

The availability of spectacled flying-fox habitat within the offset area was calculated based on a desktop assessment and the presence of regional ecosystems 9.12.4c, 9.12.2, 9.12.7a, 7.12.34, all of which contain eucalyptus forests and are considered suitable foraging habitat for the species. Regional ecosystem 7.12.7c (Simple to complex microphyll to notophyll vine forest) and regional ecosystem 7.12.57 (Shrubland and low woodland mosaic with *Syncarpia glomulifera, Corymbia abergiana, Eucalyptus portuensis, Allocasuarina littoralis* and *Xanthorrhoea johnsonii* on uplands and highlands on granite) were also included in the offset area calculation as they are considered suitable spectacled flying-fox foraging habitat. Based on an analysis of these regional ecosystems there is estimated to be 360 ha of potential foraging habitat for the spectacled flying-fox within the offset area (**Table 4**; **Figure 5**). The actual extent and quality of foraging habitat within the offset area will require field verification; however, as the offset area neighbours the project area, the foraging habitat within the offset area is expected to be similar to the foraging habitat identified in the project area (i.e. Myrtaceous trees).

The offset area's proximity to the project area decreases the risk of the offset not succeeding as the comparable vegetation communities and environmental values increases the effectiveness of the offset. In addition, the connectivity of vegetation between the offset area and the Baldy Mountain Forest Reserve, Herberton Range State Forest and the Herberton Range National Park via the Herberton range reduces the risk of the offset not being effective as the continuity of remnant vegetation facilitates flora and fauna dispersal and ecological resilience.

The proposed offset area is not currently reserved by law or planning regulations or agreed to under other schemes or programs; therefore, securing and managing the proposed offset area will deliver a new conservation gain for the impacted protected matter. To determine that the proposed offsets are in proportion to the level of statutory protection that apply to the spectacled flying-fox, the offsets assessment guide has been completed as part of the offset implementation (CO2 Australia 2014). A summary of the results of this assessment are presented in Section 5.2.

Offsets will be implemented in accordance with MNES fauna national recovery plans and/or the threat abatement and recovery recommendations in the DoTE Species Profile and Threats Database thereby ensuring that the offsets are effective, timely, reasonable and scientifically robust.



Ratch/Australia Corporation - Mount Emerald Wind Farm

LOCATION DIAGRAM

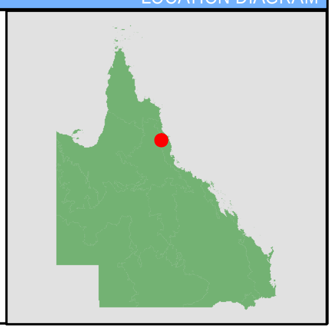


Figure 5:
Spectacled flying-fox
habitat within the offset

Mount Emerald Wind Farm
Offset area
Offset lots
Protected areas
Spectacled flying-fox habitat (approx 360 ha)

0 0.25 0.5 0.75 1
Kilometres
1:35,000
(A4) GCS GDA 1994

N

DATA SOURCE:
Proposed offset area provided by Ratch-Australia Corporation
as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

DATE	AUTHOR	REQUESTED BY
05-05-2014	RF	LW

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Bare-rumped sheathtail bat

The distribution, habitat preferences, biology and threats of the bare-rumped sheathtail bat are poorly known (DoTE, 2013); however, based on museum records and previously collected specimens, the project area is likely to contain suitable habitat (i.e. mature eucalyptus woodland) (RPS, 2012; DoTE, 2013).

Securing the proposed offset area is expected to maintain the viability of the species population by counterbalancing the habitat lost as a result of project actions. The availability of bare-rumped sheathtail bat roosting habitat within the offset area was calculated based on the presence of the following regional ecosystems:

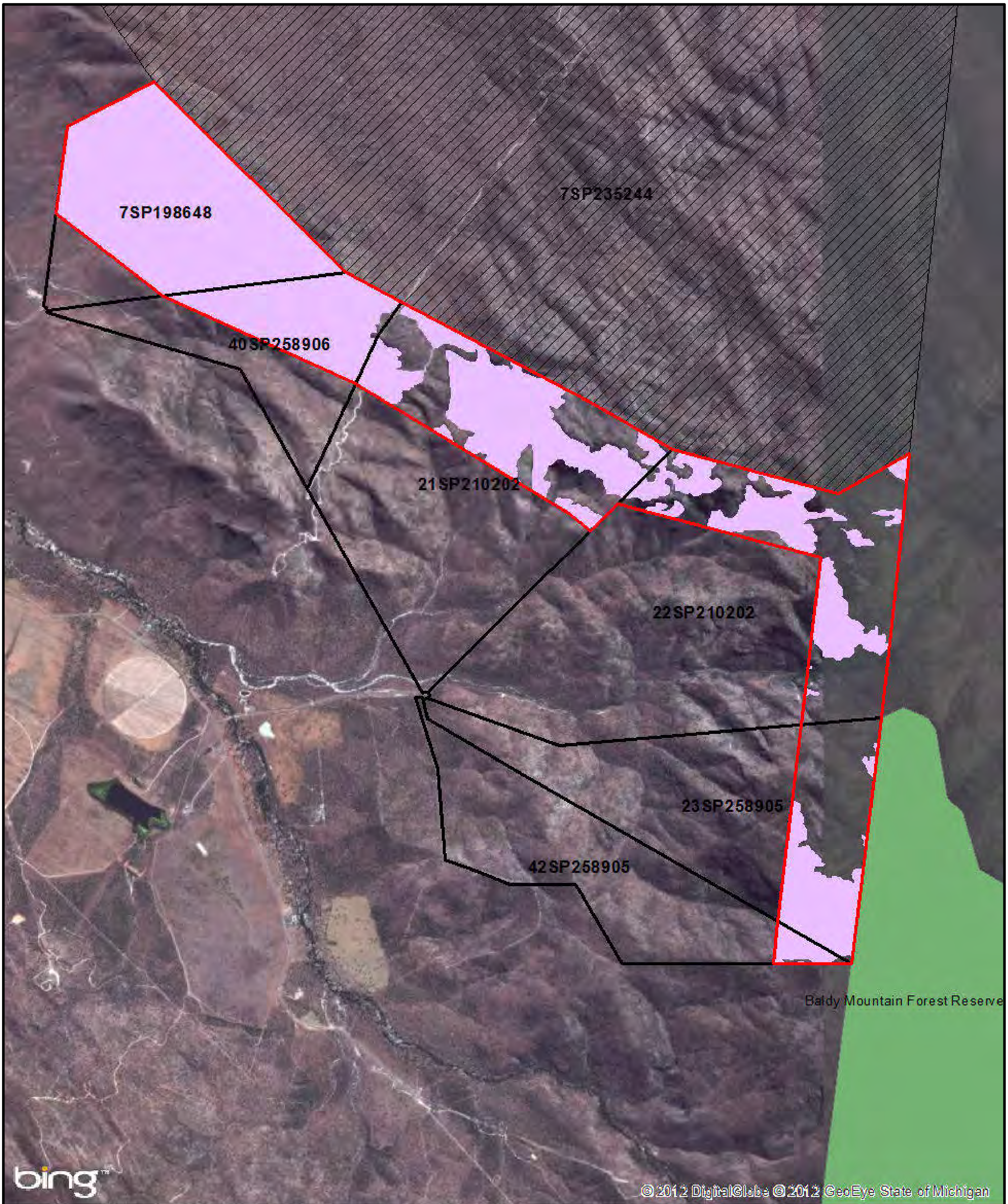
- 9.12.2, 9.12.30a, 7.12.34 – eucalypt forests
- 9.12.4c, 9.12.7a – open woodlands
- 9.12.20 – low woodlands containing eucalypts.

Based on an analysis of these regional ecosystems there is estimated to be 391 ha of potential roosting habitat for the bare-rumped sheathtail bat within the offset area (**Table 4; Figure 6**). The actual extent and quality of roosting habitat within the offset area will require field verification; however, as the offset area neighbours the project area, the habitat within the offset area is expected to be similar to the bare-rumped sheathtail bat habitat identified in the project area (RPS, 2012).

The offset area's proximity to the project area decreases the risk of the offset not succeeding as the comparable vegetation communities and environmental values of the two areas facilitate the effectiveness of the offset. In addition, the connectivity of vegetation between the offset area and the Baldy Mountain Forest Reserve, Herberton Range State Forest and the Herberton Range National Park via the Herberton range reduces the risk of the offset not being effective as the continuity of remnant vegetation facilitates flora and fauna dispersal and ecological resilience.

The proposed offset area is not currently reserved by law or planning regulations or agreed to under other schemes or programs; therefore, securing and managing the proposed offset area will deliver a new conservation gain for the impacted protected matter. To determine that the proposed offsets are in proportion to the level of statutory protection that apply to the bare-rumped sheathtail bat, the offsets assessment guide has been completed as part of the offset implementation (CO2 Australia 2014). A summary of the results of this assessment are presented in Section 5.2.

Offsets will be implemented in accordance with the MNES fauna national recovery plans and/or the threat abatement and recovery recommendations in the DoTE Species Profile and Threats Database thereby ensuring that the offsets are effective, timely, reasonable and scientifically robust.



Ratch/Australia Corporation - Mt Emerald Wind Farm

Figure 6: Potential bare-rumped sheathtail bat habitat within the offset area

Bare-rumped sheathtail bat habitat (approx 390 ha)
Project area
Offset area
Offset lots
Protected areas

DATA SOURCE:
Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V6.1 (2011)
- Habitat areas assessed by CO2 Australia (desktop analysis only)

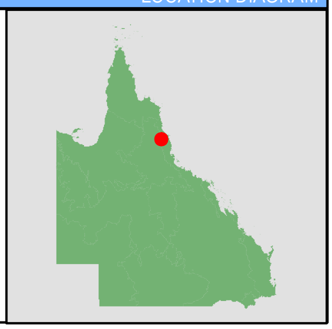
DATE	AUTHOR	REQUESTED BY
25-11-2013	RF	LW

N

CO2

0 0.25 0.5 0.75 1
Kilometres
1:35,000
(A4) GCS GDA 1994

LOCATION DIAGRAM



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Grevillea glossadenia

The proposed offset area is expected to maintain the viability of *Grevillea glossadenia* by securing habitat of equal or higher quality and managing the threatening processes currently identified in the DoTE Species Profile and Threats database (i.e. resource operation, weed encroachment and stochastic events).

The proposed offset area is mapped as containing 167 ha of *Grevillea glossadenia* habitat (**Table 4**; **Figure 7**). The availability of habitat in the offset area was calculated based on the presence of the following regional ecosystems:

- 7.12.57
- 7.12.65k
- 7.12.30

Regional ecosystem 7.12.57 was found to support *Grevillea glossadenia* in the project area and the atlas of living Australia has records of the species within the offset area. The actual extent and quality of habitat within the offset area will require field verification; however, as the offset area neighbours the project area, the habitat within the offset area is expected to be similar.

The offset area is not currently subject to resource development permits or applications and is of little risk of resource exploration or development due to the area's steep topography. Weeds have the potential to establish within the offset area as a result of project actions within the adjacent project area; however, weeds will be managed as part of an offset area management plan to ensure that populations do not become established in the offset area.

The implementation of the direct offset area is expected to wholly acquit the project's offset requirements; however compensatory measures such as addressing the scientific knowledge gaps relating to the montane heath vegetation community would be advantageous in achieving a conservation outcome.

The offset area's proximity to the project area decreases the risk of the offset not succeeding as the comparable vegetation communities and environmental values of the two areas facilitate the effectiveness of the offset. In addition, the connectivity of vegetation between the offset area and the Baldy Mountain Forest Reserve, Herberton Range State Forest and the Herberton Range National Park via the Herberton range reduces the risk of the offset not being effective as the continuity of remnant vegetation facilitates flora and fauna dispersal and ecological resilience.

The proposed offset area is not currently reserved by law or planning regulations or agreed to under other schemes or programs; therefore, securing and managing the proposed offset area will deliver a new conservation gain for the impacted protected matter. To determine that the proposed offsets are in proportion to the level of statutory protection that apply to *Grevillea glossadenia*, the offsets assessment guide has been completed as part of the offset implementation (CO2 Australia 2014). A summary of the results of this assessment are presented in Section 5.2.

Offsets will be implemented in accordance with MNES flora and fauna national recovery plans and/or the threat abatement and recovery recommendations in the DoTE Species Profile and Threats Database thereby ensuring that the offsets are effective, timely, reasonable and scientifically robust.

Homoranthus porteri

The proposed offset area is expected to maintain the viability of *Homoranthus porteri* by securing habitat of equal or higher quality. Habitat loss as a result of vegetation clearing is expected to impact 5.1 ha of potential *Homoranthus porteri* habitat in the project area. The proposed offset area is mapped as containing 117 ha of *Homoranthus porteri* habitat (**Table 4**; **Figure 7**). The availability of habitat in the offset area was therefore calculated based on the presence of the following regional ecosystems above 900 m ASL:

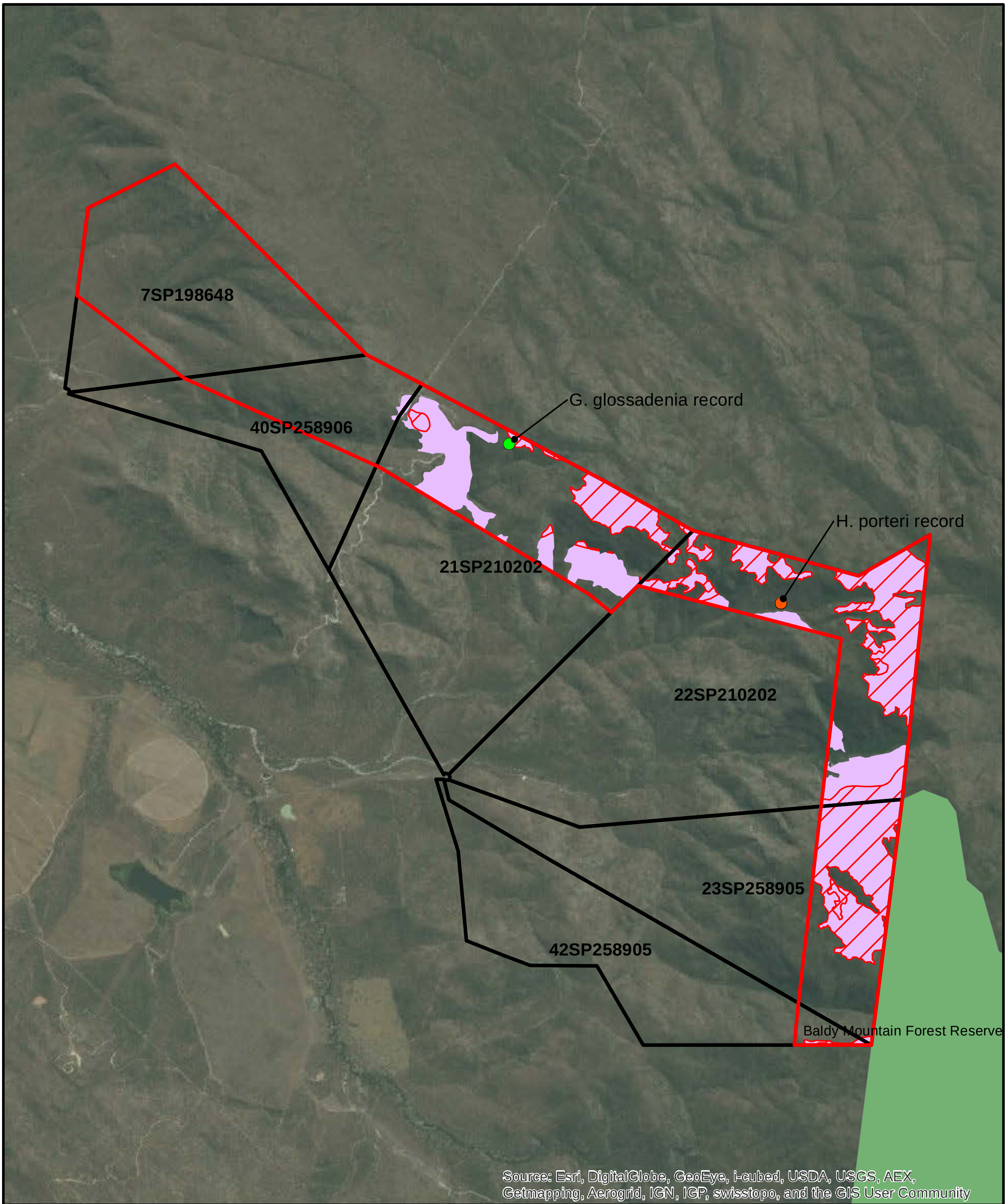
- 7.12.57
- 7.12.65k
- 7.12.30

Regional ecosystem 7.12.57 was found to support *Homoranthus porteri* in the project area and the atlas of living Australia has records of the species within the offset area. The actual extent and quality of habitat within the offset area will require field verification; however, as the offset area neighbours the project area, the habitat suitability within the offset area is expected to be similar.

The implementation of the direct offset area is expected to wholly acquit the project's offset requirements (with respect to the *Homoranthus porteri* population); however compensatory measures such as addressing the scientific knowledge gaps relating to the montane heath vegetation community would be advantageous in achieving a conservation outcome.

The offset area's proximity to the project area decreases the risk of the offset not succeeding as the comparable vegetation communities and environmental values of the two areas facilitate the effectiveness of the offset. In addition, the connectivity of vegetation between the offset area and the Baldy Mountain Forest Reserve, Herberton Range State Forest and the Herberton Range National Park via the Herberton range reduces the risk of the offset not being effective as the continuity of remnant vegetation facilitates flora and fauna dispersal and ecological resilience. Furthermore, while this species does not have recorded threats, management plans to address the threatening processes that generally affect other rare plants species, such as weed encroachment, will be implemented to increase the effectiveness of the offset.

Offsets will be implemented in accordance with MNES flora and fauna national recovery plans and/or the threat abatement and recovery recommendations in the DoTE Species Profile and Threats Database thereby ensuring that the offsets are effective, timely, reasonable and scientifically robust. To determine that the offsets are in proportion to the level of statutory protection that applies to the protected matter, the offsets assessment guide has been completed as part of the offset implementation (CO2 Australia 2014). A summary of the results of this assessment are presented in Section 5.2.



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LOCATION DIAGRAM

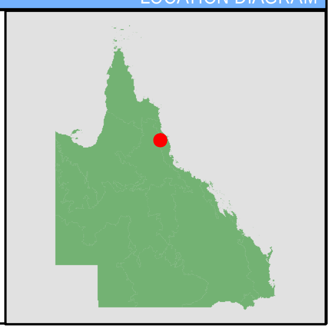

Figure 7:
Flora habitat
within the offset

- Offset area
- Offset lots
- Protected areas
- H. porteri habitat (approx 115 ha)
- G. glossadenia habitat (approx 165 ha)
- G. glossadenia record
- H. porteri record

0 0.25 0.5 0.75 1
Kilometres
1:35,000 (A4) GCS GDA 1994

N

DATA SOURCE:
Proposed offset area provided by Ratch-Australia Corporation as PDF on 11/11/2013
The following datasets are © State of Qld 2013:
- Cadastral Data (Aug 2013)
- Protected Areas of Queensland - Boundaries (2012)
- Vegetation Management Act Regional Ecosystems V8 (2013)
- Habitat areas assessed by CO2 Australia (desktop analysis only)
- Species records from Atlas of Living Australia Records (May 2014)

DATE	AUTHOR	REQUESTED BY
05-05-2014	RF	LW

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5.2. PRELIMINARY RESULTS OF OFFSETS ASSESSMENT GUIDE

Based on the results of the offset assessment using the EPBC Act offsets assessment guide (CO2 Australia 2014), there is sufficient potential for RAC to configure an offset area that is compliant with the requirements of the Australian Government's EPBC Act Offsets Policy on the proposed offset property. While this assessment is preliminary in nature, the values generated from the offsets assessment guide indicate that the proposed offset is suitable to acquit the offset requirements of the project and the percentage of impact offset is over 100% for all values.

The offset area provides for the long term protection of habitat for the five threatened species and through the implementation of adaptive management practices the quality of the habitat will be improved and maintained over time. The actual extent and quality of the habitat within the offset area will require field verification and the final offset configuration will be determined based on the results of these surveys.

Table 5: Offsets assessment guide results

OFFSETS ASSESSMENT GUIDE PARAMETER	MNES				
	northern quoll	spectacled flying-fox	bare-rumped sheathtail bat	*Grevillea glossadenia*	*Homoranthus porteri*
Size of impact area:	57.7 ha	57.7 ha	57.7 ha	10.2 ha	5.1 ha
Quality of impact area:	8	3	7	7	7
Start quality of offset area:	8	3	7	7	7
Future quality with offset:	9	4	8	8	8
Future quality without offset:	6	3	6	6	7
Confidence in results:	50%	70%	70%	70%	50%
Risk of loss with offset:	2%	2%	2%	2%	2%
Risk of loss without offset:	5%	5%	5%	5%	5%
Confidence in results:	70%	70%	70%	70%	70%
Time over which loss is averted:	20 years	20 years	20 years	20 years	20 years
Time until ecological benefit:	5 years	Immediate	Immediate	5 years	5 years
Minimum offset area:	315[4] ha	213 ha	300 ha	50 ha	57 ha
Minimum % of impact offset:	100%	100%	100%	100%	100%
Maximum offset area:	347[4] ha	360 ha	391 ha	167 ha	117 ha
Maximum % of impact offset:	112%	155%	133%	346%	207%

[4] Includes denning habitat only; however, 236 ha of potential foraging habitat is also available within the proposed offset area.

5.3. LANDHOLDER CONSULTATION

Through consultation, RAC has determined that the landholders of the identified lots are amenable to securing the offset area for conservation purposes; however, further assessments of the offset area are necessary and relevant contractual agreements will be required to be negotiated and established. In addition, if approved by DoTE, the offset area will need to be secured in perpetuity through a legally-binding mechanism.

5.4. COMPENSATORY MEASURES

RAC's preferred offset delivery method is direct offsets; however, should additional offsets be required, compensatory measures are available. The draft Mount Emerald Wind Farm Flora Report (RPS, 2013) recommended the following compensatory offsets.

Plant Translocation Plan

A translocation plan based on the criteria and guidelines detailed in the Guidelines for the translocation of threatened plants in Australia (Vallee et al., 2004) should be developed to identify MNES plant species appropriate for relocation as well as target and recipient sites.

Research Opportunities

The unique and threatened vegetation communities (e.g. montane heath land) and fauna populations (e.g. northern quoll) in the project area present an opportunity to study and address scientific knowledge gaps relating to:

- northern quoll ecology, population dynamics, response to disturbance
- montane heath succession after disturbance
- the effects of weeds on the establishment and succession of montane heath species
- fire ecology as it relates to montane heath communities
- floristic inventory
- flora endemism
- flora rehabilitation
- soil-seed bank dynamics
- horticulture of specialist plants.

Literature and Interpretive Material

Flora and fauna within the project area is poorly represented in the current literature, apart from occasional taxonomic work (RPS, 2013). Interpretive literature and associated material could be prepared to describe the unique characteristics of the project site and to provide educational sources for a general audience. The northern quoll, for example, is relatively widespread in the project area and provides a unique opportunity to document this regional proportion of the population. The development of this project provides an opportunity to study the rare and threatened species in the project area.

Revegetation

Replacing native weeds with native plants along the existing road verges from Granite Creek to the base of the project area will reduce the capacity for weeds such as grader grass and molasses grass to spread. In addition, the replacement of weeds with native plants will increase visual amenity into the site. Revegetation may also be undertaken in the vicinity of each turbine.

6. OFFSET IMPLEMENTATION

RAC is committed to offsetting the residual impacts of the project on MNES and has developed an approach to offset implementation which ensures offsets deliver an overall conservation gain for the impacted species and are delivered in a timely manner. An overview of offset implementation, including tasks and timeframes, is provided in **Table 6**. These tasks and timeframes are subject to change due to a number of variables, including regulatory approval, regulatory requirements, landholder negotiation, climatic conditions, land access, stakeholder inactivity and other unexpected delays. Details of each of the components associated with offset implementation are provided below.

Table 6: Implementation plan

IMPLEMENTATION TASK	TIMEFRAME
Assessment of the proposed offset area against the offsets assessment guide for each impacted MNES, including field surveys where required	Preliminary assessment complete The offsets assessment guide will be updated following field surveys post wet season
Negotiations to establish an offset agreement with the landholder of the offset property	July 2013 – ongoing
Preparation of a detailed offset proposal for submission to DoTE	Following field surveys post wet season
Preparation of an offset area management plan for submission to DoTE	Draft plan completed February 2014
Registration of a relevant instrument on land title to protect the offsets environmental values in perpetuity.	November 2014 Subject to DoTE approval of OAMP and RAC Board Approval for project construction.
Implementation of the offset area management plan	November 2014 Subject to DoTE approval of OAMP and RAC Board Approval for project construction.

6.1. FIELD ASSESSMENT OF OFFSET AREA

Field assessments of the offset area will be undertaken following the wet season and will include flora and fauna surveys, where appropriate. The aim of the field assessment is to inform the final assessment using the offsets assessment guide, verify that the values identified through desktop assessments are present and confirm the suitability of the property as an offset. Field assessments will also inform the size and the management requirements of the offset area.

6.2. LANDHOLDER NEGOTIATIONS

RAC is currently in consultation with the landholder of the offset area and has determined that they are amenable to securing the offset area for conservation purposes. Once offset suitability has been confirmed through the application of the offsets assessment guide, negotiations with the landholder will commence to establish an offset agreement which will include:

- long-term access arrangements for the offset area
- responsibilities of each party, including, but not limited to, the landholder being party to a legally binding agreement and an offset area management plan (OAMP)
- details of the financial compensation payable to the landholder for long-term access to the offset area.

6.3. OFFSET PROPOSAL

In accordance with Sections 6, 7 and 8 of the EPBC Act offsets policy a detailed offset proposal will be prepared for submission to DoTE. The offset proposal will address the overarching principles of the policy and include the results of offsets assessment guide calculations for each impacted MNES. The offset proposal will detail the:

- specific attributes of the protected matter being impacted
- scale and nature of the impact
- duration of the impact
- details of the proposed offset
- extent to which the proposed offset actions correlate to and adequately compensate for the impacts on the protected matter
- conservation gain to be achieved by the offset
- current land tenure of the offset and the proposed method of securing and managing the offset for the of the impact
- time it will take to achieve the proposed conservation gain
- level of certainty that the proposed offset will be successful
- suitability of the location of the offset.

6.4. OFFSET AREA MANAGEMENT PLAN

The offset area will be supported by an OAMP. A draft OAMP was prepared in accordance with the Queensland Department of Natural Resources and Mines' offset management plan template in February 2014. The OAMP will be finalised in consultation with regulators, RAC and the relevant landholders and will then be submitted to the regulators for endorsement and will include:

- a map of the offset area, including GPS points
- the type and location of values to be offset
- the offset area management objectives and outcomes
- activities that will be undertaken to achieve the management objectives and outcomes
- an analysis of the risks to achieving the management objectives and outcomes
- a monitoring and reporting program
- estimated time until the offset management objectives and outcomes will be achieved
- identification of all registered interests including mortgages, leases, subleases, covenants, profit-a-prendre, easements and building statements, that have been registered on title under the *Land Act 1994* (Qld) and *Land Title Act 1994* (Qld).

Once approved, the OAMP will be implemented. Implementation includes ongoing management, monitoring and reporting until the objectives of the OAMP have been achieved.

6.5. LEGALLY BINDING MECHANISM

The offset area will be secured by a legally binding mechanism. The appropriate mechanism will be determined through negotiation with RAC, the regulators and the landholder and may include.

- conservation park, nature refuge, resource reserve or national park as recognised by the *Nature Conservation Act 1992* (Qld)
- conservation agreements under the EPBC Act
- voluntary declaration under the VM Act

- statutory covenant under the *Land Title Act 1994* (Qld) for freehold land or *Land Act 1994* (Qld) for non-freehold land.

Based on information received from the Queensland Government, the preferred mechanism for protection is a statutory covenant. A statutory covenant is typically used to secure remnant vegetation and is a written agreement that is registered under the Queensland *Land Title Act 1994* (freehold) or the Queensland *Land Act 1994* (non-freehold) on the title of the land. The terms of the covenant are binding on all successors of the title. The parties to the covenant are the covenantee (the landholder) and the covenantor (a statutory body representing the State or local government).

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Appendix 36

RACL Environmental Record

Prepared by RATCH Australia Corporation Limited

HSE HAZARDS

DOCUMENT No. TMP-2000-EV-0001

1.0 PURPOSE

To outline the process to be followed for identifying and assessing the HSE hazards and relevant HSE legal requirements associated with Transfield Services operations and Supplier/Subcontractor activities, products and services.

2.0 SCOPE

This procedure applies to all Transfield Services operations, sites and offices. It applies to the management of HSE hazards that arise in the course of activities at these sites and offices.

The exact requirements of this procedure must be implemented as defined. Deviation from this procedure is only permissible where the stated criteria cannot be fulfilled and the deviation is approved by the respective Industry HSE Manager or Operations General Manager. Approvals shall be via e-mail and maintained as a record with all other document approvals, refer TMP-0000-QA-0005 – Document Control Procedure.

2.1 Adoption of a Client's Hazard Controls, Procedures & Processes

A client's hazard controls, procedures and processes can be considered for adoption under any or all of the following circumstances:-

1. A gap analysis has been undertaken against Transfield Services' procedures and processes and no inconsistencies have been identified between the client's and Transfield's identified procedures and processes.
2. The gap analysis finds that the client's procedures and processes are equal to or better than those identified by Transfield Services
3. The client's hazard controls, procedures and processes comply with regional legislative requirements.
4. Application of Transfield Services' procedures and processes would be inconsistent with the client's system requirements and in doing so would have the potential to increase risks associated with the hazards in question.

In order for the client's hazard controls procedures or processes to be adopted, the following written authorisations must first be obtained:-

1. Hazard Controls: authorisation by the Industry HSE Manager
2. Procedures and processes: authorisation by the ANZ Executive General Manager HSEQ

3.0 DEFINITIONS

Activity – A task (or group of related tasks) performed as part of the works on the site or contract that involves safety or environmental hazards and has the potential to cause harm. Tasks performed by Suppliers/Subcontractors over which Transfield Services has influence shall also be considered, e.g. Suppliers subcontractors working under Transfield Services systems/processes, directly supervised by Transfield Services, etc.

Hazard – is an event or occurrence, a condition or substance that has the potential to:

- Harm people or the environment
- Damage property, plant, equipment or the environment, and
- Cause a loss or interruption to the business.

Pathway – The mechanism or way in which a hazard can cause harm.

Impact – The combination of person(s) or thing(s) that may be harmed by a hazard and the nature, extent and severity of the harm that may be caused.

Legal requirements – HSE obligations including those that are established by Commonwealth, State/Region or Local Government legislation (Acts, Regulations, Planning Instruments etc; those that are specific to a particular site or operation that are established by regulatory authorities, e.g. Work Cover, EPA) contained in licences, permits, planning consents, environmental improvement notices etc; and those that are specific to a particular site or operation that are established by the Client and are contained in the service contract or alliance agreement between Transfield Services and the Client, or in supporting documentation.

Principal Risks – A series of standards that form the basis on which our operational Health and Safety Management Systems are built, worldwide. The standards include; confined spaces, cranes and lifting equipment, emergency response, new starters, plant and equipment, spill prevention and control, vehicles and driving, working at heights, working on isolated plant and installations and working with hazardous substances.

Controls – the identified measures / activities to be implemented in order to eliminate or minimise the risks associated with the hazards identified. Controls implemented shall be based on the hierarchy of controls principle, compliant with any minimum legislatively required standard and incorporate any associated licensing, certification or registration requirements.

4.0 PROCEDURE

4.1 Introduction

4.1.1 It is a Transfield Services requirement that each site develops and maintains a HSE Hazards Register as part of its OSP. This register must contain a list of all the activities performed that have the potential to cause harm to either an individual and/or the environment and an assessment of any health, safety or environmental hazards. It will also list any control measures and procedures that are currently in place to manage these hazards.

4.1.2 The HSE Hazards Register should be developed in conjunction with the HSE Objectives and Actions Register (TMP-2000-EV-0011 and TMF-2000-EV-0008) for the site or operation.

4.1.3 The HSE Hazards register is designed to document all identified hazards and their control measures that can be eliminated or mitigated through the use of our risk management process, such as:

- The Risk Assessment Worksheet TMF-0000-RM-1001 filled in when implementing TMP-0000-RM-1001 Risk Management. The Risk Assessment Worksheet is intended to address the management of contract level risks
- The job analysis and job start processes, and
- Legislatively required hazard risk assessments such as those for plant and equipment, hazardous substances, manual handling etc.

4.1.4 Section 4.3 shows the process flow that should be followed in completing the HSE Hazards Register. The register is initially populated using the output from a preliminary hazard review, which includes the following elements:

- Identification of the activities performed by the site or operation
- Identification of the HSE hazards associated with each activity
- Assessment of each hazard using the Hazard-Pathway-Impact model and risk analysis matrix
- Identification of the HSE legal requirements, codes and standards relevant to each activity or hazard
- Benchmark and alignment against client HSE systems and process
- Identification of controls based on the hierarchy of controls that are compliant with legislative, client and Transfield Services requirements, and
- Determining when the requirement for a Job Analysis or Job Start should be applied to each activity.

4.1.5 A range of sources will need to be reviewed in order to effectively identify the legal requirements associated with the work activity and should include:

- Lawlex Alerts and to the Australian Legal Information Institute (AustLII) database – Lawlex Alerts are sent to HSE Personnel via email to advise on updates to legislation.
- Review of any applicable licences, permits, development consents and regulatory notices, and
- Review of relevant contracts, agreements and supporting documentation.
- Review of statutory body websites.
- Information from self insurer organisations of which Transfield Services is a member.

4.1.6 Where a legal requirement is identified, the relevant legislation, code, standard or other reference shall be recorded in the HSE Hazards Register (TMF-2000-EV-0006 or TMF-9000-SA-0010 as appropriate) against the relevant activity or hazard. Relevant legal requirements must also be referenced in the job analysis documents.

4.1.7 The overall degree of risk associated with each activity, i.e. extreme, high, medium or low, is assessed using the likelihood and consequence table taking into account the nature of the identified hazards, the environment in which the activity is performed and the existing hazard controls.

Note In some cases an activity may be borderline between two risk categories. In these cases the highest of the two risk categories shall be applied.

4.1.8 The development and implementation of the HSE Hazards Register shall be undertaken using a consultative process such as via workshops or similar and must include representation of employees and/or subcontractors who have full knowledge on the scope of activities that will be performed on the contract. Client requirements also need to be considered when developing the Hazard Register.

4.1.9 Other personnel who may participate in the development and implementation of the HSE Hazards Register include:

- Health, Safety and Environmental Coordinator and Representatives
- Contract Manager
- Quality Coordinators
- Schedulers, planners and engineers
- HSE Committee Members, and
- Client and other relevant stakeholders.

4.1.10 Common hazards and / or risks to consider when developing your hazards register include:

- Falls – including falling objects, people falling from height or slips and trips
- Electricity – electrical current or lightning
- Manual handling and/or ergonomics – overexertion or repetitive movement
- Machinery and equipment – being hit, hitting objects, being caught in or between machinery or equipment
- Hazardous substances such as acids, hydrocarbons and asbestos
- Extremes of temperature
- Radiation – like microwaves, lasers, ultraviolet light or welding arc flashes
- Excessive noise
- Biological agents such as bacteria and viruses
- Psychological stress such as harassment, violence, conflict or time pressure, and
- Public safety.
- Environmental impacts
- Training of new starters (employees & contractors) in relevant procedures and hazard management processes i.e. JA's & Hazard registers.

Activities that involve any of Transfield Services' identified Principal Risks must be listed on the Hazard Register.

4.1.11 When assessing the risk, some items to consider include:

- The frequency that the task is performed
- The complexity of the task being performed
- The work environment and whether it is variable, unpredictable or potentially hazardous.
- The history of incidents and near misses
- Whether significant or unusual hazards are present
- The duration of and/or proximity to exposure
- The capability of existing controls to eliminate or mitigate the hazard and
- The potential to impact neighbours

RISK ANALYSIS MATRIX

4.1.12 The following risk matrix shall be applied in the preparation of the HSE Hazards Register:

Likelihood (L) of Occurrence		
1	**Rare**	An incident is unlikely to occur
2	**Unlikely**	An incident is unlikely to occur in the next 5 years
3	**Moderate**	An incident could be expected to occur in the next year
4	**Likely**	An incident could be expected in the next 6 months
5	**Almost Certain**	An incident is expected to occur during the next month

Consequence (C) of Result		
1	**Insignificant**	No injury, or Minor first aid, or no environmental impact
2	**Minor**	First aid injury, or negligible environmental impact
3	**Moderate**	Medical treatment required, or environmental impact contained
4	**Major**	Lost time injury, or Some detrimental impact on environment
5	**Catastrophic**	Death or permanent disability, or Major impact on environment

Likelihood \ Consequence	1	2	3	4	5
5	H	H	E	E	E
4	M	H	H	E	E
3	L	M	H	E	E
2	L	L	M	H	E
1	L	L	M	H	H

E = Extreme	**H = High**
M = Moderate	**L = Low**

RISK CONTROL PRIORITIES

4.1.13 Assessed risk must be assigned a risk control priority in accordance with the table below.

Hazard Risk Rating	Priority for Control
Extreme	Immediate application of controls or cease operation until it can be appropriately controlled.
High	To be appropriately mitigated within the time of the shift, work or task time and a permanent control within 3 months.
Medium	Within 6 months.
Low	When an appropriate alternative can be sourced.

ADDITIONAL RISK CONTROL DOCUMENTATION TO BE COMPLETED

4.1.14 The following risk management practice and/or documentation shall be completed in the following circumstances:

- **High and Extreme HSE risk**: A Job Analysis (TMP-2000-SA-0003) must be in place and reviewed by the individual or group performing the work prior to work commencing *each time* the activity is performed. The job analysis must be reviewed and updated if there is going to be any changes to the work process being carried out.
- **Medium HSE risk**: A Job Start must be completed each time the activity is performed. A Job Analysis may be undertaken at the discretion of the assessment team, work crew or HSE Coordinator or at the direction of the Supervisor. **Note**: The client or contract may require a JA to be completed for all activities.
- **Low HSE risk**: Controls outlined in the HSE Hazard Register should be applied to these activities however no documented controls are required prior to work commencing on a day-by-day basis.

Note: Where a Job Analysis is not developed at the time and location where the works are to occur, a Job Start must be undertaken prior to the work commencing to assess any previously unidentified hazards. Any additional hazards must be recorded and communicated along with the control measures implemented.

Note: A higher level of control can be applied at the discretion of the individual or group performing the work, e.g. where an activity is classified as medium risk a Job Analysis can be done, but a lower level of control can only be applied with the approval of the relevant Industry HSE Manager.

4.1.15 The requirement for the above risk management practices to be undertaken is in addition to;

- standard HSE procedures,
- compliance documentation such as certificates of competency,
- workplace inspections,
- observations,
- pre-start inspections on plant and equipment,

- Documented risk assessments required under legislation for regulated hazards such as:
  - Hazardous Substances and Dangerous Goods (TMP-2000-EV-0010)
  - Manual Handling (TMI-2000-SA-0006)
  - Plant and Equipment (TMP-2000-SA-2004)
  - Work at heights (TMI-2000-SA-0003)
  - Confined Space Entry (TMP-2000-SA-0005)
  - Noise Management (TMP-2000-SA-2003)

Refer to corresponding procedures in brackets for more details on the requirements and risk assessment process.

RISK ACCEPTANCE CRITERIA

4.1.16 The following criteria must be applied prior to work commencing where risks associated with an activity have not been able to be mitigated to a low risk rating.

Hazard Risk Rating	Responsible	Process
Extreme	General Manager Executive General Manager (prior notification) Client (as appropriate)	The General Manager shall review methods in consultation with the relevant Contract Manager, and Industry/Business Unit HSE Manager. Once satisfied the appropriate control measures have been defined and can be implemented, the General Manager shall approve acceptance of the risk. Prior notification shall be given to the EGM of any task/job rated as extreme. Consider client involvement/notification as appropriate.
High	Contract Manager Client (as appropriate)	The Contract Manager and client shall review methods of control in consultation with the relevant Supervisor, and Business Unit HSE Manager. Once satisfied the appropriate control measures have been defined and can be implemented, the Contract Manager shall approve acceptance of the risk.
Medium	Supervisor	The Supervisor shall review the controls and approve acceptance of the risk through the Job Analysis or Job Start Process.
Low	Supervisor	Work may proceed without approval. The Supervisor shall review the controls through the Job Start Process.

CONTROLLING IDENTIFIED HAZARDS

4.1.17 All control measures must be based on and consider the hierarchy of control and be compliant with any applicable legislation, regulations, codes of practice and Australian & New Zealand Standards. The residual risk resulting after the implementation of hazard controls is to be as low as reasonably practicable (ALARP).

HIERARCHY OF HAZARD CONTROL

Most Effective Method	**Elimination**	Achieved by removing the hazardous plant, equipment, substances, etc., or by discontinuing the work process.
	Substitution	Achieved by replacing hazardous plant, equipment, substances, etc., with a safer alternative.
	Engineering Controls	Achieved by isolating, guarding, fitting alarms, lights, exhaust ventilation and similar.
	Administration Controls	Achieved by introducing or changing the work method to reduce the risk exposure. It may also include signage, routine maintenance, additional supervision, training and enforcing correct practices.
Least Effective Method	**Personal Protective Equipment (PPE)**	This is a short term or last resort control measure. It is used when other means of controlling the hazard are not adequate or feasible.

VERIFICATION OF THE HSE HAZARDS IDENTIFICATION AND CONTROL PROCESS

4.1.18 The responsible manager must review the completed risk register and satisfy themselves that the hazard identification, risk assessment and control process has been carried out in accordance with this procedure.

The process of identifying HSE Hazards on site will also be the subject of Transfield Services' annual Operational System Audit.

MONITOR AND REVIEW PROCESS

4.1.19 The content of the HSE Hazard Register must be monitored and reviewed in consultation with the relevant stakeholders, including the HSE Committee and Management.

4.1.20 Monitoring must be performed at least monthly and in accordance with the requirements of the Management Review procedure (TMP-0000-QA-0002). Further monitoring can be undertaken, the frequency of such will be dictated by the level of exposure, the sensitivity and reliability of the control strategies employed and as per their position in the 'Hierarchy of Controls'.

4.1.21 Specifically, controls implemented at the higher end of the hierarchy will require less frequent monitoring due to their inherent reliability compared to controls implemented at the lower end, such as PPE and administrative controls, which need more frequent monitoring. This is because controls at the lower end of the hierarchy are more prone to failure and tend to be reliant on behaviour.

4.1.22 Monitoring the HSE Hazard Register is also required to ensure:-

- Ongoing compliance to legislation
- Ongoing compliance to HSE system documentation
- Temporary or permanent changes to plant and operational processes.
- Temporary or permanent changes impacting on safe operating conditions

4.1.23 A review of the HSE Hazard Register shall occur at least once per year in accordance with the requirements of the Management Review procedure (TMP-0000-QA-0002) to ensure its contents remain effective, relevant and compliant. The effectiveness of the implemented controls can be established by:

- Examination of records of injuries and Worker's Compensation claims
- Evaluation of inspection checklists and reports from quantitative measures such as noise assessments
- Observation of the implemented controls and any associated work practices
- Qualitative reports such as feedback from safety committees/representatives, workplace surveys and employee questionnaires
- Results from OHS management audits, and
- Evaluating compliance with legislative and non-statutory requirements.
- Evaluating compliance to HSE Management system documentation
- Ensuring scope changes within the contract are captured.
- Ensuring industry changes or relevant improvements in hazard management techniques are captured.
- Confirming temporary or permanent changes to plant and operational processes are detailed.
- Identifying and addressing any other changes impacting on safe operating conditions

4.1.24 Update / amend the HSE Objectives and Actions register / business plan where appropriate to accommodate any improvement initiatives or significant changes arising from the review of the HSE Hazard Register

COMMUNICATION

4.1.23 Employees must be made aware of hazard register details and procedures relevant to the tasks they will be undertaking. Any changes to the register must be communicated promptly and a program must be in place to ensure ongoing awareness of hazards and controls

TRAINING

4.1.25 All personnel participating in or approving the outcomes of Transfield Services' hazard management practices must be trained relevant to the risk level and tasks they will be undertaking. The timing of training must also be commensurate with the risk to health and safety. Where a high or extreme risk has been determined then the hazard management team must as a minimum comprise of person that has completed training and been deemed competent in hazard management methodology. Evidence of the level of competence/training can be provided via a combination of:

- Transfield Services Induction Training records

- Construction induction training records
- Transfield Services HSE training records,
- External HSE training records/qualifications, and
- Completion of Transfield Services Job Analysis Toolbox and Assessment.

4.1.26 Competence in hazard management will be determined on the basis of evidence of training participation in any of the above in combination with the completion of a Job Analysis that has been reviewed by another Transfield Services employee and accepted without requirement for change.

4.2 Process Flow

PROCESS STEPS		Site Manager	HSE Coordinator	Quality/CIP Coordinator	Site HSE Committee	Industry HSE Manager	DOCUMENTATION
4.2.1	Preliminary Hazard Review - Identify the activities						TMF-2000-EV-0006 or TMF-9000-SA-0010 HSE Hazards Register Appendix A shows an example of a completed HSE Hazard Register.
4.2.2	Preliminary Hazard Review - Identify the Legal Requirements						Lawlex Alerts AustLII database
4.2.3	Preliminary Hazard Review - Identify the control measures						TMF-2000-EV-0006 or TMF-9000-SA-0010 HSE Hazards Register
4.2.4	Preliminary Hazard Review - Assess the overall level of HSE risk						TMP-2000-SA-0003 Job Analysis and Job Start
4.2.5	Send the completed HSE Hazards register to the Industry HSE manager for review.						TMF-2000-EV-0006 or TMF-9000-SA-0010 HSE Hazards Register
4.2.6	Monitor the HSE Hazards Register on a regular basis.						TMF-2000-EV-0006 or TMF-9000-SA-0010 HSE Hazards Register TMF-2000-EV-0008 HSE Objectives and Actions Register
4.2.7	Review the HSE Hazard Register						TMF-2000-EV-0006 or TMF-9000-SA-0010 HSE Hazards Register
4.2.8	Update / amend the HSE Objectives and Actions register / business plan						TMF-2000-EV-0008 HSE Objectives and Actions Register

4.3 Example of Completed Register

Appendix A shows an example of a completed HSE Hazards Register TMF-2000-EV-0006. This Hazard Register format shown is not mandatory however all details and columns shown in the example must be included as a minimum in any HSE Hazard Register template being used.

5.0 REFERENCE DOCUMENTATION

TMP-0000-QA-0005	Document Control
TMP-0000-QA-0002	Improvement, Review and Monitoring Cycles Procedure
TMP-2000-SA-2008	Legal Requirements Identification, Access and Review
TMP-2000-SA-0003	Job Analysis and Job Start
TMP-2000-EV-0011	HSE Objectives and Actions
TMP-0000-RM-1001	Risk Management
TMF-0000-RM-1001	Risk Assessment Worksheet
TMF-2000-EV-0008	HSE Objectives and Targets Register
TMF-2000-EV-0006	HSE Hazards Register
TMF-9000-SA-0010	New Zealand Hazard Register
TMS-0000-SA-0003	Global Standard – HSE Hazard Management
TMP-2000-SA-2004	Plant & Equipment Hazard Management
TMP-2000-EV-0010	Hazardous Substances and Dangerous Goods
TMI-2000-SA-0006	Manual Handling
TMI-2000-SA-0003	Work at heights
TMP-2000-SA-0005	Confined Space Entry
TMP-2000-SA-2003	Noise Management

Australian Legal Information Institute website www.austlii.edu.au

Standards Australia www.standards.org.au

Appendix A

HSE Hazard Register

Contract/Project: ____________

Date Developed: ____________

Date last reviewed: ____________

Approved By: ____________

Date Approved: ____________

Development Team: ____________

Risk Analysis

Likelihood (L) Of Occurrence
1 Rare
2 Unlikely
3 Moderate
4 Likely
5 Almost Certain

Consequence (C) of Result
1 Insignificant
2 Minor
3 Moderate
4 Major
5 Catastrophic

Risk Level Matrix (R)

Likelihood	Consequence 1	2	3	4	5
5	H	H	E	E	E
4	M	H	H	E	E
3	L	M	H	E	E
2	L	L	M	H	E
1	L	L	M	H	H

E - Extreme, H - High, M - Moderate, L - Low

TRANSFIELD SERVICES

Hierarchy of Controls

1	Eliminate
2	Substitute
3	Engineer
4	Administrative Control
5	PPE

Controls should be selected based on the Hierarchy of Controls

Activity	OHS or ENV	Location	Hazard	Mechanism / Pathway of Harm	Impact	Risk Rating L	Risk Rating C	Risk Rating R	JA/Job Start Required	Control measures (Must use Hierarchy): Legal Requirements	TSL Documentation	Client Documentation	New Risk Rating L	New Risk Rating C	New Risk Rating R
Working at Heights	OHS		Falling	N/A	N/A	4	4	E	JA Required	Victorian OHS Act 2004 Victorian OHS Regs 2007 Prevention of Falls in General Construction Compliance Code	PRC Working at Heights TMS-0000-SA-0016 PRC Checklist TMF-2000-SA-2016 Working at Heights TMI-2000-SA-0003 TMP-0915-SA-0046 Manboxes TMP-0915-SA-0020 Height Work TMI-0915-SA-0003 W@H		2	3	M
Cranes & Associated Lifting Equipment	OHS		lifting over live equipment	N/A	N/A	4	4	E	JA Required	Victorian OHS Act 2004 Victorian OHS Regs 2007 Building & Construction Workplaces (code of practice No 13 1990) Plant (Code of practice No 19	PRC Cranes & Associated Lifting Equipment TMS-0000-SA-0010 PRC Checklist TMF-2000-SA-2011 TMP-8001-SA-0039 RIGGING AND LIFTING EQUIPMENT TMS-0000-SA-0013 Plant & Equipment		2	3	M
Isolated Plant & installations	OHS		removing valve	N/A	N/A	4	4	E	JA Required	Vic OHS Act 2004 OHS (Major Hazard facilities) Regs 2000	PRC Working on Isolated Plant & Equipment TMS-0000-SA-0017 PRC Checklist TMF-2000-SA-2017 TMP-0915-SA-0013 FLANGES, COUPLINGS AND JOINTS		2	3	M
Spill Prevention $ control	OHS		decanting of fuels	N/A	N/A	4	4	E	JA Required	Dangerous Goods Act 1985 Dangerous Goods Regs OHS (Major Hazard facilities) Regs 2000 Dangerous Goods Storage and Handling (Code of Practice	PRC Working with Haz. Sub. & Dan. Goods TMS-0000-SA-0018 PRC Checklist TMF-2000-SA-2018		2	2	L
Confined Space Entry	OHS		Entry for mechanical works	N/A	N/A	4	4	E	JA Required	Victorian OHS Regs 2007 Victorian Compliance Code (Confined Space) 2008	PRC Confined spaces TMS-0000-SA-0009 PRC Checklist TMF-2000-SA-2009 TMI-0915-SA-0005 Confined Space Entry TMP-0915-SA-0007 Confined Space Entry		3	2	M
Emergency Response	OHS		responding to site alarm	N/A	N/A	4	4	E	JA Required	OHS (Major Hazard facilities) Regs 2000	PRC Emergency Response TMS-0000-SA-0011 PRC Checklist TMF-2000-SA-2011 TMI-0915-SA-0006 Muster Instructions TMI-0915-SA-0006 Prestart Performa		2	3	M

Transfield Worley Power Services

HEALTH, SAFETY & ENVIRONMENT POLICY

Transfield Worley Power Services is committed to protecting the health and safety of all employees and ensuring that our activities are safe for the environment and the greater community.

Our Principles

- All incidents are preventable
- No task is so important that the risk of injury to people or damage to the environment is justified and;
- Effective HSE management is a critical foundation for sustainable management.

Our Objectives

- No injuries to anyone, anytime
- Respect the community and the environment
- To show leadership in the field of HSE management
- To work in a responsible and sustainable manner

Our Methods

Transfield Worley Power Services will meet these objectives by:

- Promoting a positive culture that maintains a focus on communication, consultation and employee engagement in all aspects of HSE management;
- Promoting ecological sustainability as part of our culture;
- Providing sufficient information, training, supervision and resources for staff to implement our HSE management systems;
- Applying risk management principles to the identification and control of hazards, work practices and behaviours that could cause accidents, injuries, illness, pollution or environmental harm;
- Measuring, monitoring and improving the effectiveness of our HSE management systems;
- Maintaining responsibilities and accountabilities of all employees and management personnel for the implementation of our HSE management system;
- Complying with all legal and regulatory requirements;
- Integrating HSE management into all aspects of the organisation;
- Building relationships with business partners who aspire to the same HSE standards; and
- Reporting publicly and annually on HSE performance, measured against objectives and targets.

This commitment to HSE is our highest priority and will not be compromised.

This Policy applies to all operations where Transfield Worley Power Services is performing work and covers all our activities and services.

Gareth J. Mann | Chief Executive Officer

Our Values | Commitment | Collaboration | Performance | Innovation

RATCH-Australia Corporation
A Ratchaburi Holdings and Transfield Services Company

CORPORATE SOCIAL RESPONSIBILITY POLICY

1. BACKGROUND

RATCH-Australia Corporation Limited (ACN 106 617 332) (**RAC**) is an unlisted public company, which is owned by the following two shareholders:

(a) RH International (Singapore) Corporation Pte. Ltd. (company number 201018924M) (**RHIS**), holding 80% of the ordinary shares in RAC (**Ordinary Shares**); and

(b) Transfield Services Limited (ACN 000 484 417) (**TSE**), holding 20% of the Ordinary Shares in RAC,

(together, the **Shareholders**).

RAC has Shareholders whereby:

(a) Ratchaburi Electricity Generating Holding PCL, the parent company of RHIS is listed on the Stock Exchange of Thailand; and

(b) TSE is listed on the Australian Securities Exchange.

RAC is committed to responsible corporate governance and risk management and accordingly, has endorsed this Corporate Social Responsibility **(CSR)** Policy as part of its governance framework. This policy should be read in conjunction with other corporate policies of RAC and the Code of Conduct. References in this policy to RAC include its related entities.

2. SCOPE

This policy applies to all employees of RAC, the Directors of RAC, and if applicable persons seconded to and providing services to RAC (**Relevant Persons**).

This policy does not form part of an employee's contract of employment or employment agreement with RAC, and does not give rise to contractual rights or liabilities. However, to the extent that this policy requires an employee to do or refrain from doing something, it constitutes a direction from RAC with which employees must comply. Failure to comply may result in disciplinary action up to and including termination of employment.

3. PURPOSE OF THIS POLICY

The primary purpose of this policy is to confirm and communicate RAC's commitment to CSR and to ensure that it conducts itself in an ethical and responsible way. RAC continuously strives for improvement in environmental, social and economic performance and will always aim to behave with respect and consideration for people, communities and the environment. In conjunction with this approach, RAC's overarching objective is to operate profitably, fulfilling its obligations to both its shareholders and the community.

RAC recognises these obligations and aims to fulfil them by endorsing a sustainable business model, building a diverse and skilled workforce, maintaining its commitment to the community, managing its environmental impact and providing a safe and healthy working environment. In seeking to achieve RAC's CSR objectives, it will also make the necessary budgetary proposals to the Board on an annual basis.

4. SUSTAINABLE BUSINESS MODEL

RAC believes that the existence and development of a responsible and sustainable business practice is fundamental to delivering shareholder value and protecting shareholder investment, achieving long term growth and success, improving efficiency and bringing a positive effect to the rest of society.

4.1 Regulatory and Legal Compliance

RAC will always aim to deliver services to a high standard whilst simultaneously ensuring that it conforms with all legal requirements, including those under legislation and regulations. RAC recognises the importance of operating within the law and continuously monitors compliance with legal and regulatory matters at all times whilst mitigating areas of risk where and when it can.

4.2 Continuous Improvement and Corporate Governance

RAC is committed to the ongoing and continuous improvement of its business practices, policies and strategies. RAC regularly reviews its Corporate Governance framework and believes it to be the foundation of social responsibility. Good Corporate Governance is needed to enable a business to maximise its long term value and perform in a responsible manner, allowing an organisation to strike a balance between its social and individual goals.

4.3 Business Relations

RAC aims to build and develop strong relationships with all of its stakeholders, including shareholders, customers, suppliers, contractors, consultants and the community within which it operates. This is based and built upon the implementation of measures encouraging transparency, mutual trust, understanding and respect within those relationships. This is essential in order to achieve growth and sustainability, whilst also ensuring that RAC sustains and increases its good will and reputation in the market place.

4.4 *Competing fairly and ethically*

RAC aims to at all times compete fairly and to demonstrate ethical business practices, so that all stakeholders can have trust and confidence in the services that are provided by RAC. RAC strictly follows relevant competition laws, is committed to delivering services to a high standard and in an ethical manner, and does not or will not facilitate, tolerate or condone any form of bribery, money laundering, corruption, theft or the acceptance / provision of inappropriate gifts and/or hospitality.

5. PEOPLE

Recognition of basic human rights is fundamental to RAC and RAC is committed to;-

- protecting and upholding fundamental human rights at all of our operations and projects;

- respecting the rights and interests of communities in which we operate, including respect for diverse cultures and heritages of local communities and the rights of indigenous peoples;
- respecting that employees have a right to reasonable work conditions and remuneration and that it will comply with relevant workplace and employment legislation and implement a work environment based on the principles of equality and diversity;
- not using forced, compulsory or child labour;
- ensuring no employee will be treated less favourably than another on discriminatory grounds and any form of harassment, bullying or victimisation is completely prohibited.

RAC believes employees are instrumental to its success and aims to attract and retain employees that reflect a high standard of business values and ethics. RAC recognises that business performance is dependent on individual contributions and therefore encourages and promotes the continuous development of its employees, with the aim of boosting both individual and organisational capabilities. RAC seeks to provide an environment for self-development and opportunities based on merit, and will continue to aid its workforce where it can and promote innovation and collaboration within the organisation to add value to its people, clients and the communities it works with.

By establishing a sustainable workforce, and by building employee skills, the business will continue to develop and flourish and will assist in fostering a healthy and productive community. Corporate success and social and economic welfare are interdependent and one cannot thrive without the success of the other.

6. COMMUNITY AND SOCIAL IMPACT

With assets spread throughout Australia, the longevity and success of RAC is very much dependant on the strength of its relationships with local communities where those assets are based, and understanding the potential impact it can have at a social, cultural and economic level. In conjunction with this understanding, RAC aims to provide adequate support and open communication channels to those local communities in an effort to address concerns in a proper and timely manner.

Consequently, RAC endeavours to have a positive impact on the local communities it engages with and seeks to build upon community partnerships and relationships by working together to ensure mutual trust and acceptance is achieved.

RAC requires its employees to respect local business customs and existing social structures that are present. In addition, employees are obliged to respect the culture and customary needs of local and indigenous communities.

7. ENVIRONMENT

As a developer of renewable energy in Australia, implementing sustainable measures and ensuring the protection of the environment are fundamental to RAC's long term objectives and philosophy. Investments in renewable energy are both environmentally and commercially sustainable and RAC currently owns three wind farms that are significantly reducing Australia's greenhouse emissions. In addition, RAC continues to improve the environmental ratings of its other power generation assets by continuously revising for economically possible ways of reducing its carbon emissions.

As RAC continues to grow, it strives to promote preservation and restoration of the environment, by managing and minimising the environmental impact of its operations and activities and fully respecting environmental laws and regulations.

RAC encourages employees to take care and demonstrate responsibility towards the environment and to report any incident that may have a hazardous effect. RAC continuously strives to ensure its employees are aware of how they can reduce the consumption of energy and resources and implement strategies focused on waste minimisation and recycling where possible.

Ensuring the protection of the environment and implementing sustainable solutions are paramount to the success of RAC, its people and the communities in which it serves.

8. HEALTH AND SAFETY AGENDA

RAC, through its Occupational Health and Safety Policies, aims to provide and maintain a safe and healthy work environment for all its workers, and is committed to achieving a 'zero injuries' standard throughout the workplace.

RAC requires all workers to comply with all safety policies, procedures rules and instructions, whilst it is a fundamental objective of RAC that best-practice health and safety management practices are incorporated into all of its operations.
RAC is committed to compliance of all Occupational Health and Safety standards, legislation, codes of practice and both Australian and industry standards.

9. REVIEW OF THIS POLICY

The Company Secretary of RAC will be responsible for maintaining this policy and for liaising with RAC Management to ensure it is updated as circumstances warrant. A formal review of this policy will take place annually. Relevant Persons will be notified of any changes to this policy or its application from time to time
This policy will be submitted for review by RACC, who will make recommendations to the Board of RAC. The Board of RAC will be responsible for approving this policy and any material changes.

CARBON POLICY

RATCH-Australia Corporation
A Ratchaburi Holdings and Transfield Services Company

1. BACKGROUND

RATCH-Australia Corporation Limited (ACN 106 617 332) (**RAC**) is an unlisted public company owned by the following two shareholders:

(a) RH International (Singapore) Corporation Pte. Ltd. (company number 201018924M) (**RHIS***)*, which holds 80% of the ordinary shares in RAC (**Ordinary Shares**); and

(b) Transfield Services Limited (ACN 000 484 417) (**TSE**), which holds 20% of the Ordinary Shares in RAC),

(together, the **Shareholders***)*.

RAC has Shareholders whereby:

(a) Ratchaburi Electricity Generating Holding PCL, the parent company of RHIS is listed on the Stock Exchange in Thailand; and

(b) TSE is listed on the Australian Securities Exchange.

RAC is committed to responsible corporate governance and risk management and accordingly, has endorsed this policy as part of its governance framework. References in this policy to 'RAC' include its related entities.

2. PURPOSE OF THIS POLICY

The primary purpose of this policy is to make the management of the implications of the *Clean Energy Act* 2011 (Cwlth) and associated legislation and regulation (**Clean Energy Legislation**) an integral part of good business practice which supports business decisions and mitigates risks across RAC's assets, in order to safeguard value for the Shareholders. The Clean Energy Legislation introduces a carbon pricing mechanism (**CPM**) in Australia, effective from 1 July 2012.

This policy is to be provided to the Facility Agent as required under the Syndicated Facility Agreement between RAC as Borrower, Australia New Zealand Banking Group Limited as Facility agent and others dated 30 June 2010 (as amended) (**SFA**).

The information in this policy is current as of 4 July 2012. This policy was provided to the Facility Agent on 25 June 2012. This policy is to be periodically reviewed by the RAC CEO and General Counsel and formally reviewed annually (refer sections 12 and 13).

The objectives of this policy are to ensure that:

(a) The implications of the Clean Energy Legislation for RAC are considered in strategic planning and management processes, and that all people involved in RAC management are aware, trained and motivated to implement RAC's carbon strategy; and

(b) The RAC Board are informed in a timely manner about the implications of the Clean Energy Legislation on the RAC business.

3. SOURCE OF OBLIGATIONS

This policy has been prepared having regard to the following:

(a) The Clean Energy Legislation;
(b) RAC's Risk Management Policy;
(c) RAC's Energy Trading Policy;
(d) The SFA;
(e) External legal advice including the law firm report initially provided by Baker & McKenzie on 30 April 2012 and then updated on 25 June 2012, pursuant to clause 19.1(a)(ii) of the SFA; and
(f) RAC's existing contractual arrangements with respect to its fossil fuel-fired electricity assets, namely the Kemerton, Collinsville and Townsville power stations.

4. OVERVIEW OF CPM

As stated above in section 2, the Clean Energy Legislation has been enacted by the Australian Federal Government to implement a CPM, which will commence on 1 July 2012.

The CPM will operate as follows:

a) **a fixed price (tax) period between 1 July 2012 and 30 June 2015,** where the price of carbon units starts at $23 per tonne for a facility exceeding 25,000 tonnes CO_2e per annum, then rises by about 5% per annum; and
b) **a flexible price (emissions trading scheme) period from 1 July 2015 onwards**, where the price of carbon units is set by the market. Notwithstanding, there will be a price floor of $15 per tonne initially, increasing by 4% per annum. There will also be a price cap set by 31 May 2014 of $20 per tonne above the expected 1 July 2015 international permit price, with an increase of 5% per annum.

An entity with 'operational control' of a facility exceeding 25,000 tonnes CO_2e per annum, is liable under the CPM. An entity has 'operational control' of a facility if it has the greatest authority to introduce and implement any or all of the operating, health and safety or environmental policies for the facility.

Management approval: 30 April 2012 Initial Board Approval : 26 June 2012 Review Date: 31 October 2013 Subsequent Board Approval: 31 October 2012 Version number: 3	**Responsible Officer:** Steve Loxton – CEO **Knowledge Manager:** Patricia Clifford – Executive Assistant to CEO and CFO **Document No:**

5. CONTEXT OF THIS POLICY

This policy only applies to RAC's wholly-owned assets that are expected to exceed the CPM threshold test by emitting more than 25,000 tonnes CO2e during a compliance year (1 July to 30 June). As at 4 July 2012, these assets are:

a) Collinsville Power Station, located in Queensland (**Collinsville PS**).
b) Kemerton Power Station, located in Western Australia (**Kemerton PS)**; and
c) Townsville Power Station, located in Queensland (**Townsville PS)**.

This policy does not specifically apply to:

a) RAC's wind farm assets and wind development portfolio, as these assets are not carbon-emitting assets and therefore do not attract CPM; and
b) RAC's partially-owned assets, being BP Kwinana Cogeneration Plant in Western Australia and Loy Yang A Power Station in Victoria as RAC will not be the directly liable entity for the purposes of CPM. These assets are operated and managed at an asset level by non-RAC management, who will have their own policies. During the period in which RAC maintains partial ownership, RAC will however seek to influence those policies through its representatives' presence on the relevant Boards for these assets.

6. OVERVIEW OF CPM IMPLICATIONS ON RAC

For the reasons discussed in section 8.1 below, RAC will be the 'liable entity' for CPM under the Clean Energy Legislation, for its carbon-emitting assets. A liable entity is required for each compliance year (1 July to 30 June) to surrender 75% of the number of carbon units equal to its provisional emissions number for that year in June with a further 25% required in February of the following year once its emissions number has been confirmed.

The implications of the CPM are to be broadly managed by RAC in three main ways:

(a) By centralising CPM liability for RAC assets with RAC through contractual amendments to the O&M alliance agreement (**O&MAA**) with Transfield Services (Australia) Pty Ltd (**TSAPL**) (see section 8.1 below);
(b) By either bearing the liability and passing through all costs to off-takers under the power purchase agreements (**PPAs**)/other contractual arrangements or transferring CPM liability to off-takers with a Liability Transfer Certificate (**LTC**). This is the case for Kemerton and Townsville PS. Where in exceptional circumstances, a facility is a merchant plant, as Collinsville PS will be from 1 July 2012, RAC will bear the liability, but continually monitoring CO2e emissions as generated, as a key factor for when to generate (see section 8 below); and

(c) By seeking to obtain Australian Government transitional assistance under the Energy Security Fund, including cash assistance and the provision of free carbon permits, and investigating opportunities under the Contract for Closure Program (see section 11 below).

7. EXPECTED EMISSIONS

7.1 Historical National Greenhouse Emissions Reporting (NGER) data

The historical NGER data for Collinsville PS, Kemerton PS and Townsville PS is as follows:

		Kemerton PS	Townsville PS	Collinsville PS
2008/09	Scope 1 emissions (tCO2-e)	192,598	453,268	663,015
	Gross Electricity Generated (MwH)	314,923	1,138,979	541,790.650
	Emissions Intensity	**0.61**	**0.40**	**1.22**
2009/10	Scope 1 emissions (tCO2-e)	147,428	531,604	488,708
	Gross Electricity Generated (MwH)	242,955	1,364,341	396,529
	Emissions Intensity	**0.61**	**0.39**	**1.23**
2010/11	Scope 1 emissions (tCO2-e)	109530	369478	568,788
	Gross Electricity Generated (MwH)	176521	914778	457,808.51
	Emissions Intensity	**0.62**	**0.40**	**1.24**

7.2 Estimate of CPM liability for the 2012-13 financial year

Based on 2012-13 budgeted generation figures, we estimate the CPM liability for each of RAC'S wholly-owned carbon emitting assets to be as follows:

(a) Townsville PS

For the 2012-2013 financial year, RAC's estimate of CPM liability for Townsville PS is approximately $8.3 million (using an emissions intensity of 0.4).

(b) Kemerton PS

For the 2012-2013 financial year, RAC's estimate of CPM liability for Kemerton PS is approximately $1.5

million (using an emissions intensity of 0.62).

(c) Collinsville PS

As discussed, in section 8.2 below, the PPA at Collinsville PS was terminated on 29 June 2012. RAC is still reviewing its operating regime post termination of the PPA, including under the Contract for Closure Program with the Australian Government. Accordingly, an estimate of RAC's CPM liability is not currently capable of forecast.

8. RAC's CPM STRATEGY

RAC management has obtained external legal advice on the implications of the CPM for RAC's wholly-owned assets and this advice has been used as the basis for developing RAC's CPM strategy.

8.1 Centralising 'operational control' with RAC

On 27 April 2012, RAC and TSAPL effected certain amendments to the O&MAA, with the intention being that RAC is the entity with operational control under the Clean Energy Legislation and National Greenhouse and Energy Reporting Act 2007 (**NGER Act**) for its carbon emitting facilities. Under the O&MAA amendments, RAC has the greatest authority to introduce and implement any or all of the operating, health and safety or environmental policies for the facilities. Hence, RAC is directly liable for CPM and responsible for NGER Act obligations. Prior to this, the O&MAA and specific asset site agreements did not specifically address whether RAC or TSAPL had operational control. Notwithstanding this, TSAPL undertook obligations under the NGER Act for RAC's carbon emitting assets.

It is in RAC's interest to assume operational control for its wholly owned carbon emitting assets, as it centralises its CPM compliance obligations. In particular, it allows RAC to better manage the impact of the CPM on its business either by bearing the liability and passing through costs to its off-takers under the PPA or other agreements, or transferring its liability to off-takers under a LTC.

8.2 Collinsville PS

RAC and Stanwell Corporation Limited entered into an agreement to terminate the existing PPA for Collinsville PS. This termination is to take effect on 29 June 2012, after all of the conditions precedent were either satisfied or waived on 15 June 2012.

Following completion, Collinsville PS will operate as a merchant plant from 1 July 2012. Therefore, it will not be in a position to contractually pass through the CPM or enter into an LTC with another party.

RAC will review its operating regime post termination of the PPA. RAC will monitor its C02-e emissions as generated, and if it is to generate, it is likely to do so in summer months when electricity prices are high. It will focus on generating when the carbon tax inclusive power price is greater than short-run marginal operating cost.

8.3 Kemerton PS

Electricity Generation Corporation trading as Verve Energy (**Verve**) is RAC's electricity off-taker for Kemerton PS under a PPA.

RAC can fully pass through liability to Verve for CPM compliance costs under change in law provisions set out in the Kemerton PPA.

Notwithstanding these contractual pass-through rights, RAC and Verve are investigating whether it would administratively cleaner for the parties to enter into a LTC, with the effect that CPM compliance liability would transfer to Verve and no longer sit with RAC. These discussions are ongoing, however Verve's preference is that an LTC only be considered during the flexible price period. As requested by Verve, RAC has provided Verve with a change in law notice under the PPA on 7 June 2012. This means that RAC will bear the CPM liability, but fully pass through its costs to Verve under the Kemerton PPA. It is anticipated that the amending deed to the PPA, which is required to formally effect the change in law, will be executed by RAC and Verve in Q3 2012.

8.4 Townsville PS

AGL Energy Limited (**AGL**) and Arrow Energy Pty Limited (**Arrow**) are joint venture partners in respect of the Townsville PS off take, with each purchasing 50% of generation under a PPA.

The PPA for the Townsville PS does not deal explicitly with the imposition of a carbon price.

In respect of AGL's 50% share, AGL entered into a written agreement with RAC on 23 February 2011, whereby AGL agrees to accept carbon pass-through for its 50% share as a change event under the Townsville PPA. During the fixed price period, AGL will pay cash to RAC for the cost of emission units purchased and surrendered. Subsequent to this, AGL will transfer to RAC the number of eligible emission units required for RAC to acquit its CPM surrender obligations in respect of Townsville PS.

In respect of Arrow's 50% share, RAC and Arrow are currently in discussions on whether Arrow will accept a contractual pass-through or whether Arrow will instead accept direct liability under an LTC. Arrow has indicated its preference is to accept an LTC, in which case the parties will pursue negotiations with both Arrow and AGL to enter into an LTC arrangement as soon as possible, but in any case prior to the first CPM carbon unit surrender date in June 2013.

On 27 June 2012, AGL and Arrow provided a consolidated response to RAC which indicated that AGL and Arrow will take on 50% each of RAC's emissions liability at Townsville PS with effect from 1 July 2012 for the shorter of the remaining duration of the PPA and carbon legislation via the 'Declared Designated Joint Venture' (**DDJV**) mechanism. The DDJV mechanism operates similar to an LTC, however its application is designed for unincorporated joint ventures. In this case, RAC will retain reporting obligations with respect to Townsville PS under section 19 of the National Greenhouse and Energy Reporting Act 2007 (Cwlth) (**NGER Act**), however CPM surrender liability under section 20 of the Clean Energy Act and reporting requirements under sections 22A and 22AA of the NGER Act will be transferred from RAC to AGL and Arrow in proportion to their participating percentages in respect of the Townsville PS. It is anticipated that the DDJV application will be submitted to the Clean Energy Regulator in Q3 2012. In the event that the DDJV is not approved, or there is non-compliance by the parties with their statutory obligations and the DDJV is revoked, then the costs incurred by RAC under the Clean Energy Legislation will be dealt with by passing-through these costs to AGL and Arrow in the form set out in the letter agreement between RAC and AGL dated 23 February 2012.

8.5 New Assets

In relation to any future acquisition of operating carbon-emitting assets that attract CPM liability, RAC will review those assets' CPM arrangements as part of any due diligence process. The outcome of this review will be considered by RAC Management and Board as part of the final decision to invest and factored into the terms of the acquisition documents. In relation to any future development of greenfield carbon-emitting assets attracting CPM liability, RAC will seek to incorporate full pass-through or LTC arrangements into the terms of its power purchase agreement with off takers.

9. TRADING STRATEGY

On account of RAC's strategy detailed in section 8 above, it is unlikely that RAC will enter into contractual arrangements or purchase, sell or trade carbon products (other than buying permits to satisfy surrender obligations). Further given RAC's preference to pursue cost pass through or an LTC arrangement with its off-takers, such an issue is likely to only be relevant with respect to Collinsville PS.

10. COMMITMENT TO REDUCE CARBON EMISSIONS

It is RAC's general objective to reduce carbon emissions for its carbon-emitting facilities. RAC will continue to explore opportunities to reduce carbon emissions going forward, in conjunction with its off-takers.

11. COMMONWEALTH GOVERNMENT TRANSITIONAL ASSISTANCE

RAC will continue to pursue opportunities under Commonwealth Government initiatives to secure transitional assistance for its business upon the introduction of the Clean Energy Legislation.

The Government has allocated about $8.7 million under the Energy Security Fund in relation to Collinsville PS. RAC received this cash funding on 22 June 2012. In relation to free carbon units, RAC received a certificate of eligibility from the Clean Energy Regulator on 4 June 2012. In addition, RAC is investigating opportunities for assistance for Collinsville PS under the Contract for Closure Program. As detailed in section 8.2 above, the outcome of discussions with the Government in relation to this program will influence the operating regime at Collinsville PS from 1 July 2012, following termination of the PPA.

12. ADMINISTRATION OF CARBON POLICY

The day to day responsibility for the strategy in accordance with this policy rests with the RAC CEO and General Counsel.

The CEO and General Counsel will work with RAC Management and line managers to establish, and maintain the endorsed policy across the RAC business and ensure that nominated staff are adequately trained.

13. REVIEW OF THIS POLICY

Under clause 19.1(c) of the SFA, this policy must be implemented and complied with in all material respects and must not be amended in a material way except with the consent of the Facility Agent (acting on the instructions of the Majority Participants, acting reasonably).

The RAC CEO and General Counsel will be responsible for reviewing this policy periodically and for liaising with RAC Management to ensure it is updated as circumstances warrant. A formal review of this policy will take place annually.

Any proposed material changes to this policy will be submitted for review by the Risk, Audit and Compliance Committee, who will make recommendations to the RAC Board. The RAC Board will be responsible for approving this policy and any material changes, in conjunction with the consent of the Facility Agent under the SFA.