

**Fortescue Metals Group
North Star Project,
Pilbara leaf-nosed bat colony survey
April 2013**

Prepared for Fortescue Metals Group Limited

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Document Revision History

Date	Issue	Revision History
11 June 2013	Issue A	Early Draft prepared for Fortescue Metals Group
12 June 2013	Issue B	Draft prepared for Fortescue incorporating initial comments received.
18 June 2013	Issue 1	Issue 1 prepared for Fortescue Metals Group review
18 July 2013	Issue 2	Issue 2 incorporating Fortescue comments

Executive Summary

A colony of Orange leaf-nosed bats, Pilbara form (*Rhinonicteris aurantia*) herein referred as Pilbara leaf-nosed bats, has been detected at the Fortescue Metals Group (Fortescue) North Star magnetite ore project, approximately 110 km south of Port Hedland in the Pilbara, WA (Ecologia, 2012; Fortescue, 2012). The colony is one of only 10 known from the Chichester subregion (Bullen 2013). During previous surveys (Ecologia, 2012), the bats from the colony were found to be present at a number of sites within the project area and up to 20 km from the colony. Although previous surveys in the region have been thorough, confirmation of the use of several project area caves as day or maternity roosts has not been made. Bat Call WA (Bat Call) carried out a targeted survey in April 2013 utilising current industry standard systems to confirm the general location of the day roost within the Fortescue project area and then to identify the cave(s) containing the roost.

The scope of the review included:

- Survey the bats activity levels along the length of the study areas with particular focus on five caves that were previously listed as possible roost locations (Ecologia, 2012),
- Interactively assess the recordings made each night to attempt to locate the Pilbara leaf-nosed bat roost,
- Review the structure of suitable roost caves and assess their ability to provide roosting habitat for the bats post mining.

During April 2013, Pilbara leaf-nosed bat activity was measured over 25 recording nights covering 18 sites. Both full spectrum SM2 bat echolocation detectors (all sites) and infra-red lit, high definition video (three nights at two sites) were used. Pilbara leaf-nosed bat activity centred on North Star was found to cover the study area within a circle approximately 10 km radius from the project. One cave within the project boundary, Cave 13, was found to contain a colony of over 200 Pilbara leaf-nosed bats and it was characterised as a day roost and is probably a maternity roost. The bats from this colony were found to be dispersing west, north and east each evening to forage along the high country and creek lines adjacent to the project.

Five caves that were accessible and that were previously identified by Ecologia as potential Pilbara leaf-nosed bat roost were visited and characterised for their suitability and structural integrity. Four caves (Caves 2, 6, 11 and 13) were found to be in stable geological structures and one, Cave 14, was found to be unstable, and unsafe to approach due to extensive roof cracking. Four caves (Caves 2, 6, 11 and 14) were found to be unsuitable as day roosts for Pilbara leaf-nosed bats. Cave 13 was confirmed to contain a roost and was found to be both suitable and stable.

Ghost bats and Northern Quolls in small numbers were also found in Cave '13.

Introduction

Project Background

Fortescue Metals Group (Fortescue) proposes to develop the North Star magnetite deposit as a part of its current Pilbara expansion. The deposit lies in the northern Chichester Ranges, approximately 110 km south of Port Hedland. A colony of the Orange leaf-nosed bat, Pilbara form (*Rhinoicteris aurantia* referred herein as Pilbara leaf-nosed bat, see Armstrong, 2006; previously J.E. Gray, 1845) was recorded from the project area in 2012 (Ecologia 2012). The Pilbara leaf-nosed bat is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Within the state of Western Australia it is listed as a Schedule 1 species under the *Wildlife Conservation Act 1950*.

Fortescue commissioned Bat Call WA (Bat Call) to undertake a study of Pilbara leaf-nosed bat activity and assess the caves within the project area for Pilbara leaf-nosed bat conservation values. In addition, confirm one or more of the caves previously identified (Ecologia, 2012) as a roost location.

Climate

The climate of the Pilbara region of Western Australia is classified as arid tropical with two distinct seasons: a hot wet summer (October – April) and a mild dry winter (May – September). The passage of high pressure systems to the south during winter, produce easterly winds and some precipitation over the inland Pilbara (Van Vreeswyk *et al.*, 2004). During the summer, heat-generated low pressure systems dominate the inland Pilbara region generating intermittent thunder storms. Tropical cyclones develop over warm tropical waters of the Indian Ocean to the north and west between December and April. These often track southwest along the Pilbara coast, or turn inland across the Pilbara bringing destructive winds, widespread rain and flooding (Payne and Tille, 1992).

Based on 110 years of data from the nearest weather station at Marble Bar the mean annual rainfall is 360 mm, with very high seasonal and annual variability (Bureau of Meteorology [BOM], 2013). The mean maximum temperatures at Marble Bar are above 30°C for 9 months of the year and exceed 40°C November to February. Mean

maximum temperatures drop below 30°C during the months of June to August. Mean minimum overnight temperatures exceed 15°C for all but these cool months.

Topography and Geology

The Study Area occurs in the Pilbara bioregion and is more specifically associated with IBRA PIL1 Chichester subregion. This is the northern section of the Pilbara Craton. Archean granite and basaltic plains include significant areas of basaltic ranges (Kendrick, 2001). *Eucalyptus spp.* over *Triodia spp.* (Spinifex) hummock grasses dominate on the skeletal soils of the ranges (Kendrick, 2001). A shrub steppe of acacia spp. over bunch grasses on fine textured soils is found in the valley floors.

The North Star project and the ridges adjacent are dominated by deeply incised, north-south oriented mesas and plateaux that form the high ground between the plains of the tributaries of the Turner River to the west and the Shaw River to the east. The higher ridges of the study area are incised with steep sided gullies and gorges of varying depth. The area contains large numbers of shallow overhangs and deeper shelters. Cave density is low with few very deep, fully dark caves present.

Surface Water

Gorges within and surrounding the project areas are deeply incised and contain many watercourses with ephemeral plunge pool habitats. They drain into Honeyeater Creek and Six Mile Creek to the east and into Lost Boy Creek and an unnamed creek system to the west. All are ephemeral. Only a small number of permanent spring fed pools, including Fig Pool, close to the deposit, exist in the district.

Historical Mining Operations

Throughout the Chichester ranges, a small number of abandoned underground mines provide the requirements for Pilbara leaf-nosed bat roosts and have been colonised (DSEWPaC 2013). No historical underground mining sites exist in the study area. The Pilgan mining centre and the historical Lalla Rookh mine are over 30 km to the northwest and northeast respectively, distances too great for these sites to be the source of the bats at North star.

Bats of conservation significance

The Pilbara region contains 17 species of Microchiropteran bat (microbat). Of these, 12 have the potential to be found in the vicinity of North Star (Van Dyck and Strahan, 2008; McKenzie and Bullen, 2009). Two, *Taphozous georgianus* and *Vespadelus finlaysoni*, are ubiquitous in the shelters and caves of the Chichester ranges and at the study area. Two others are of conservation significance. The Pilbara leaf-nosed bat is a small (10 g) insectivore and the Ghost bat (*Macroderma gigas*) is a large (130 g) carnivorous bat. Both are endemic to northern Australia. Their populations in the Pilbara are isolated from the main tropical populations by the uninhabitable arid zone to the north and east. Both populations are semi-desert adapted and have specific roosting requirements of temperature and humidity (see below).

The Pilbara leaf-nosed bat has been detected in numbers around caves at the North Star Project. It has also been recorded historically at a small number of locations within the district, Table 1. There are few historical records of Pilbara leaf-nosed bats within or adjacent to the study area.

The Pilbara leaf-nosed bat

The Pilbara leaf-nosed bat is listed as Vulnerable by the Commonwealth *EPBC Act*. It is also listed as Schedule 1 (fauna that is rare or likely to become extinct) under *Wildlife Conservation Act 1950*. This species listing is on the basis of the impact to habitats providing suitable roosts with the correct microclimate. It is a geographically isolated form of the tropical Orange leaf-nosed bat (*Rhinoicteris aurantia*, Gray, 1845) separated by approximately 400 km of the Great Sandy Desert. It is known only from the Pilbara and Ashburton bioregions of WA. The few known roosts are concentrated in disused mines and deep cave systems in the eastern Pilbara, in the Hamersley Ranges and in the Barlee Nature Reserve (DSEWPaC, 2013).

The Pilbara leaf-nosed bat is an acrobatic, high-energy flyer that forages for its prey along the gorges and ridgelines surrounding its roost. It is most often observed in flight over water holes or flying along road easements approximately 1 to 2 m off the ground (Churchill, 2008). McKenzie and Bullen (2009) give its “mode” flight speed (i.e. the speed most often measured during free flight) as 6.1 m s^{-1} (22 kph). Author’s unpublished data show the species to be capable of level flight speeds in excess of 8.6 m s^{-1} (31 kph).

Foraging habitat for the Pilbara leaf-nosed bat is diverse. The species generally hunts with a manoeuvrable flight through riparian vegetation in gorges, and over hummock grassland and sparse tree and shrub savannah (Duncan *et al.*, 1999). In the Pilbara it has been observed in *Triodia* hummock grasslands covering low rolling hills and shallow gullies, with scattered *Eucalyptus spp.* along the creeks (Armstrong, 2001; Churchill *et al.*, 1988). The Pilbara leaf-nosed bat has also been recorded over small watercourses amongst granite boulder terrain, over pools and low shrubs in ironstone gorges and around pools in gravelly watercourses with *Melaleuca leucodendron*, such as in Barlee Range Nature Reserve (Armstrong, 2001). It is often detected flying along cliff lines and breakaways where it preferentially forages at the shelters and caves.

In comparison to the roosts of the mesic tropical Orange leaf-nosed bat of the Kimberley and Northern Territory, documented Pilbara leaf-nosed bat roosts contain relatively small numbers ranging from a few individuals to a few hundred, with 30 appearing to be a typical Pilbara roost size based on published data (DSEWPaC, 2013). Recent census work by the author at several roosts in natural caves suggests that several hundred is a more accurate figure (Bullen 2013). Current data suggests that there are less than 25 Pilbara leaf-nosed bat diurnal roosts with 10 being in the east Pilbara region (Bullen 2013). One roost in the Western Hamersley ranges contains many thousand (Bullen 2013) and the nearby Lalla Rookh roost contains over 1500 (author's unpublished data). Across northern Australia the Orange leaf-nosed bat is reliant on roost sites in caves or mine adits with stable, fully dark, very hot (28 – 32 °C) and very humid (96 – 100 %) microclimates (Churchill, 2008). This is a result of their limited ability to conserve heat and water (Churchill, 1991; Armstrong, 2001). Compared to the high number of shallow overhangs and deeper shelters with no dark cave at the rear, caves and abandoned mines deep enough to create this environment are relatively uncommon in the Pilbara (Van Dyck and Strahan, 2008), which limits the availability of diurnal roosts for this species. The Pilbara leaf-nosed bat is subject to rapid dehydration and death within a day if removed from a roosting location with this type of microclimate (Churchill 2008). Additionally, Pilbara leaf-nosed bat roosts located to date are all associated with permanent water pools, usually within a short flying distance of approximately 5 km from roost site (author's unpublished data base).

The species is known to have a typical dry season foraging range of 15 to 20 km from its primary roost caves (Bullen 2013). It does forage at greater distances if suitable water sources are available (Bullen 2013). It also appears to range nomadically from these roosts when wet season conditions allow it to use tree hollow roosts and to consolidate back during the dry (Bullen and McKenzie 2011). It is not known if these ranges apply to males and females equally.

Scope of Works

This scope of works for the project (Fortescue 2012) included as its first part;

- Survey the bats activity levels along the length of the study area, Figure 1, with particular focus on caves that were previously identified as possible roost locations (Ecologia, 2012),
- Interactively assess the recordings made each night to attempt to locate the Pilbara leaf-nosed bat roost,
- Review the structure of suitable roost caves and assess their ability to provide roosting habitat for the bats post mining.

Summary of Previous District Fauna Surveys that detected Pilbara leaf-nosed bats

Pilbara leaf-nosed bats have been detected at a number of sites in the North Star district. There are two known and one projected Pilbara leaf-nosed bat colonies surrounding North Star; Figure 1, Table 1. A large colony of over 1500 bats (author's unpublished data) exists at the abandoned Lalla Rookh mine approximately 35 km to the northeast of the project area. A second large colony of possibly several hundred bats exists near the Soansville-Mt Webber mining centre approximately 40 km to the south. A third as yet undiscovered colony of unknown size exists in the Yule River-Wodgina district approximately 50 km to the west (Bullen 2013).

During the North Star vertebrate fauna surveys conducted in 2012 (Ecologia, 2012) Pilbara leaf-nosed bats were detected generally across the study area and five caves were identified as potential roosts due to the higher than usual activity levels. These caves are listed in Table 2 and are a focus of this study.

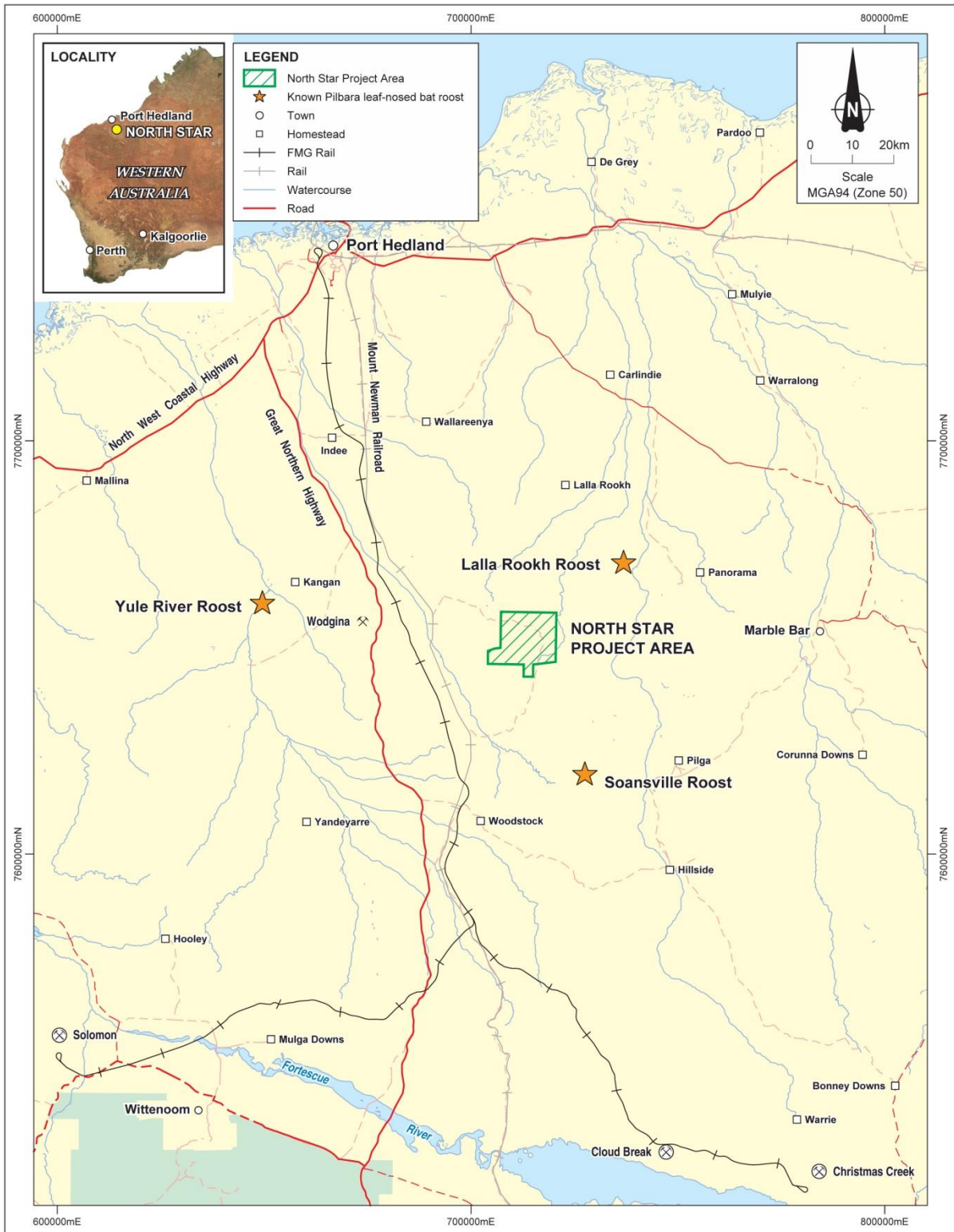


Figure 1: Project area location. Major regional locations are shown as are three known Pilbara leaf-nosed bat roosts in the North Star district

Table 1: Summary of Pilbara leaf-nosed bat records in the North Star district

Date	Record Description	Methodology	Reference	Conservation Significant Species Recorded.
2004	Lalla Rookh colony visual bat sightings	Visual observations at various sites	DSEWPaC, 2013	Pilbara leaf-nosed bats were detected at sites close to the Lalla Rookh mine and at Strelley Gorge, approximately 35 km and 20 km respectively to the northeast of North Star. The colony at Lalla Rookh mine has since been confirmed using echolocation methods to be in excess of 1500 bats (Author's unpublished data).
2010	"Soansville" colony	Visual observation followed by discovery of roost cave using echolocation detectors.	Armstrong, 2001; Author's unpublished data base	Pilbara leaf-nosed bats were detected at several sites including the Soansville mining centre, approximately 40 km to the south of North Star. The colony was subsequently identified at Mt Webber. No census is available as yet.
2010	"Yule River" colony	Multiple echolocation records using SM2 detectors	Author's unpublished data base	Pilbara leaf-nosed bats were detected at several sites including the Wodgina and Mt Dove mining centres, approximately 50 km to the west of North Star. The colony location has not yet been identified. No census is available as yet.
2012	"North Star" colony	Multiple echolocation records using Sm2 detectors	Ecologia, 2012	Pilbara leaf-nosed bats were detected at several sites within and adjacent to the North Star project. Five caves were nominated as possible roost caves. These are North Star caves numbered 2, 6, 11, 13 and 14.

Table 2: Caves nominated as potential Pilbara leaf-nosed bat roost(s) at North Star (Ecologia, 2012)

Cave Number	Easting	Northing	Reference
Cave 2	713307	7643882	Site BatRec2 in Ecologia, 2012
Cave 6	704322	7646345	Site BatRec6 in Ecologia, 2012
Cave 11	713262	7645204	Site BatRec11 in Ecologia, 2012
Cave 13	713368	7647895	Site BatRec13 in Ecologia, 2012
Cave 14	713205	7647235	Site BatRec14 in Ecologia, 2012

Methodology

Survey Team

The survey team consisted of Robert Bullen and Catherine Bullen of Bat Call WA.

Survey Timing and Weather

The field trip was undertaken from 7th to 13th April 2013 in conditions suitable for the detection of Pilbara leaf-nosed bats. A late wet season weather pattern with easterly winds predominated. The weather was hot and dry during the day followed by warm evenings with scattered thunder storms in the surrounding district early in the survey. Daytime temperatures were between 35 °C and 40 °C while minimum night time temperatures were around 25 °C. Sunset and sunrise were at 17:56 and 06:14 during the survey. The moon was new.

Habitat Assessment

A visual assessment of the project area and surrounding district for suitability of Pilbara leaf-nosed bat foraging was undertaken. The assessment was based on the data contained in Ecologia (2012) and the author's unpublished observations of the species collected over fifteen years. Sites for the echolocation recording were selected based on high probability that Pilbara leaf-nosed bats would be either foraging at or commuting past the detector location should they be present.

Cave Assessment

A visual assessment was carried out of the twilight zones of five caves within the project area provisionally identified (Ecologia 2012) as potential Pilbara leaf-nosed bat roosts. The assessment was covered both the suitability of the cave as a roost and also the apparent structural integrity of the cave suggesting its ability to withstand any future nearby mining activities. Criteria for the assessments covered:

- The caves basic geology and orientation
- The caves entrance dimensions, rear chamber dimensions and a description of its internal shape and architecture
- The caves location with respect to foraging and water opportunities.

- The apparent structural stability including an assessment of cracking of the roof and walls as well as noting the presence of any recent collapse deposits.
- The temperature and relative humidity of the cave at the limits of access.

Bat Observations

The study area for bat observations was centred on the North Star project area. The area contained five caves identified by Ecologia (2012) and extended approximately 10 km to the west, north and east from the centre of the deposit, Figure 2. Bat echolocation detectors were used at 18 sites for a total of 25 recording nights, see Figure 3 below.

Full spectrum ultrasonic bat detectors (SM2BAT 384 kHz models, Wildlife Acoustics, USA) were placed each night to record species of bats present. The settings used on each SM2 detector are given in Appendix A. The detectors were collected the next morning and the data reviewed. Pilbara leaf-nosed bat presence was confirmed by recording of distinctive diagnostic ultrasonic calls at the sites.

The SM2BAT recordings, following reformatting as .wav files, were reviewed using COOL EDIT 2000 (Now available as AUDITION from Adobe Systems Inc.). This displayed each call sequence for identification. The number and timing of each call was recorded. Bat activity levels were then assessed from the calls identified, Table 3.

High definition, infra-red lit video (HandyCam model HDR-CX550, SONY, Japan with a 12 volt RAYTEC RM25 IR light) was also used at cave entrances for two nights at Cave 13 and one night at Cave 14. The camera was in place for approximately three hours after sunset at 6PM to record the movements of bats and other animals. An SM2 detector was placed beside the video to record any calls from bats filmed. Observers were placed beside the entrance nearby the video to record any visible movements. An Anabat bat detector with a loud speaker (Anabat II, Titley Electronics, Ballina NSW) was also placed in the entrance to give the observers an aural indication of the movements of any bats using echolocation calls. Additional nights of SM2 recordings were made at these entrances to ensure that the results were not affected by the presence of the IR light and camera.

Temperature and Relative humidity were measured in the cave twilight zones and compared with ambient conditions at the cave entrances using a calibrated small weather station (Model WMR-200, Oregon Scientific, USA).

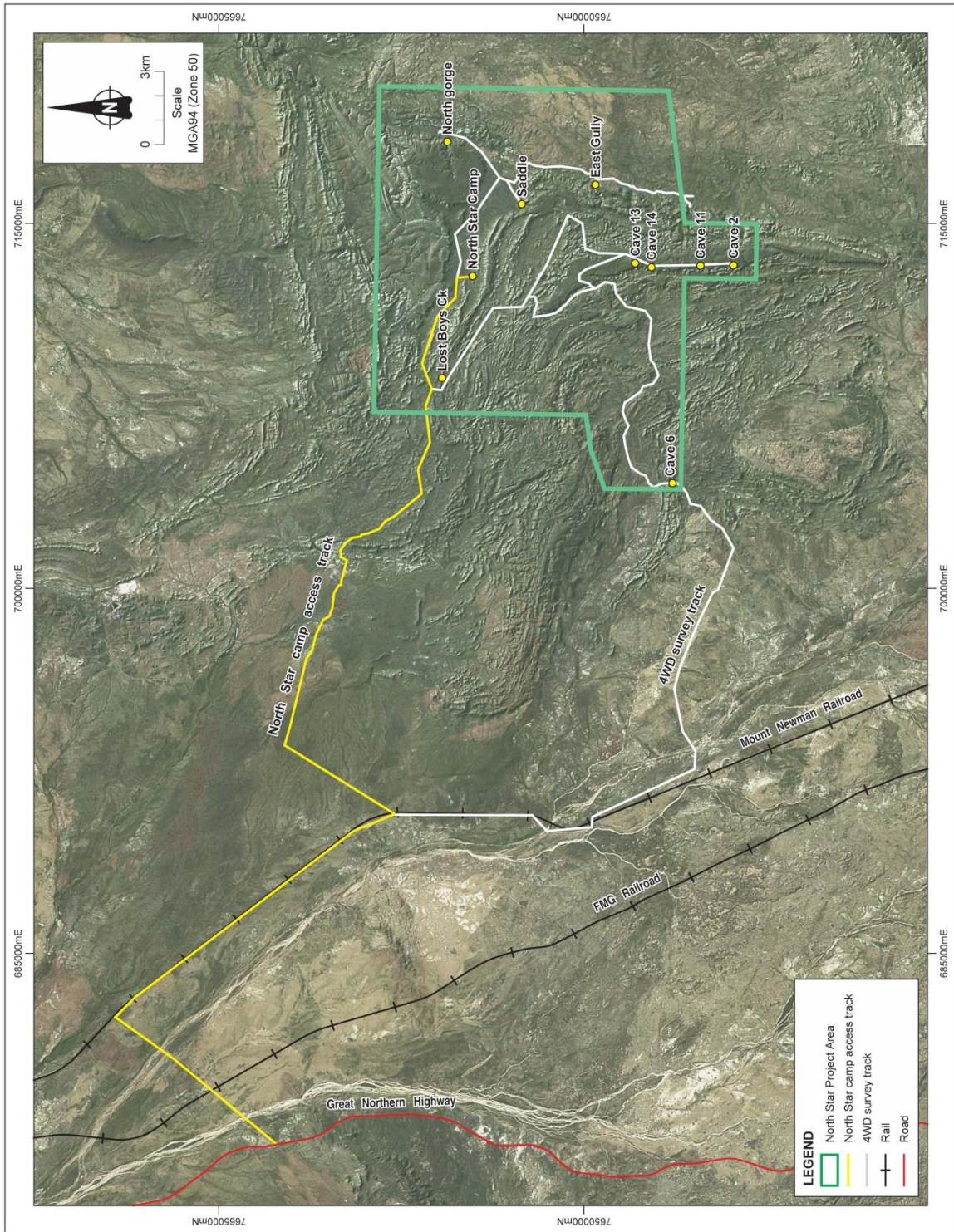


Figure 2: Location and extent of the study area is denoted by sites nominated with yellow pins. The North Star camp access track is indicated in yellow. 4WD tracks used during the survey are indicated in white

Table 3: Criteria for characterising bat recordings into activity levels. Note that these activity levels show a measure of the number of bat passes. They do not directly provide a guide to the usage of the site as a roost, forage, commute site, etc. or the bat headcount. The data though may be used to assist in inferring such results

Bat Activity Rating	Criteria
Low	Species is recorded with call spacing greater than ten minutes.
Medium	Species is recorded with call spacing of less than 10 minutes but greater than 2 minutes. This pattern is observed for a significant time period followed by sporadic records for the remainder of the session.
High	Species is recorded with call spacing less than 2 minutes apart for significant periods followed by regular records for the remainder of the session.

Survey Limitations

The primary objectives of the survey were the complete characterisation of the Pilbara leaf-nosed bat activity at the North Star deposit and the location of any Pilbara leaf-nosed bat colony that may exist in the area. All aspects of the survey including site access, team make-up and experience levels, equipment used including bat detectors and video equipment, logistics and safety support provided by Fortescue were suitable for the task.

The weather conditions and moon phase at the time of the survey were suitable for the task.

No interior searches of caves were carried out beyond the twilight area at the entrance. No activities were undertaken that could cause harm to the bats present.

A census of the number of Pilbara leaf-nosed bats at the sites is impossible to quantify precisely from ultrasonic recordings due to the possibility of multiple passes by individual bats. Activity level based on the criteria given in Table 3 was substituted. At a roost entrance the number of bats present may be suggested using the number of calls although there are a number of factors that make any estimate inaccurate e.g. bats

departing without calling, bats circling within the cave entrance generating multiple recordings and bats departing a secondary entrance out of range of the detector.

Results

Bat echolocation detectors were used at 18 sites (Figure 3) for a total of 25 recording nights. Site descriptions are in Appendix B. Pilbara leaf-nosed bats were detected at all but one site (Opp 3 - Saddle) indicating the widespread presence of the species across the study area. Activity levels ranges from high to low depending upon the site. A Pilbara leaf-nosed bat colony was identified in one cave, Cave 13.



Plate 1. Entrance to cave 13

Activity at Cave 13

Pilbara leaf-nosed bat activity at Cave 13 was high (Figures 3 and 4) with an average over 4 nights of over 500 calls recorded per night. The calls at this cave began approximately 12 minutes after sunset and continued until a similar time before sunrise. The temporal pattern of calls at this cave, figure 4, indicates that the bats are active for the whole night with a peak of activity between sunset and midnight. This pattern is typical of late wet season activity for this species at a roost when the year's pups are fully independent. This indicates that this cave was in use as a roost and the number of calls suggests that the colony numbers in excess of 200 bats. Two video records of the movements of the bats at the caves entrance were made on the nights of the 8th and 11th April. These confirmed the departure of the bats from the cave, plate 2, after sunset.

Identification of the bats on the video was made by comparing the call records from the adjacent SM2 detector.

The pattern of calls on the 8th April, the first night of observation, showed a much lower call count than the subsequent three nights. On this night, a light on the video camera illuminated the entrance of the cave. There were also several lightning storms in the area that also periodically illuminated the cave entrance. While no rain was recorded near the cave entrance, bats are known to fly at greatly reduced activity levels during lightning storms, presumably to reduce the possibility of predation by Ghost bats and other predators that hunt by sight. The observers at the cave entrance saw bats departing without using echolocation as indicated by the absence of calls from the Anabat speaker.

An unusual, rarely recorded, result occurred on the 9th when nearly 200 calls were detected in a short period just after sunset followed by a more typical build-up of calls over the following hour. This spike was attributed to a small number of bats flying in circles within the entrance prior to departing for the nights foraging.

The observation session at the entrance was repeated on the 11th April with the entrance illuminated only by the infra-red light. A high call count of approximately 600 was made that night.

This cave also housed small colonies of the Ghost bat (see below) and two common species of Pilbara bat, the common sheath-tailed bat (*Taphozous georgianus*) and Finlayson's cave bat (*Vespadelus finlaysoni*).

Activity at Caves 2, 11 and 14 on the deposit

Activity levels at one other cave ('11) was medium while low activity was recorded at the other two caves ('2 and '14). The temporal pattern of calls at these three caves with calls spread across the night is typical of bats foraging away from their roost. Detectors placed on the rim of the ridge line close to the cave entrances recorded similar temporal patterns but lower call numbers than the detectors at the cave entrances. This result indicates that the bats from the colony at Cave 13 are using the full length of the deposit ridge as preferred foraging.

Activity at Cave 6 and other sites distant from the deposit

Pilbara leaf-nosed bat activity was recorded across the study area distant from the deposit ridge. The locations of the sites and the call temporal patterns are presented in figures 3 and 4. Medium activity was recorded at Cave 6 (approximately 200 calls) and in the creek line directly below (approximately 30 calls). Cave 6 is 9 km west of Cave 13. High activity (over 800 calls per night) was recorded at an ephemeral water hole on Lost Boy creek at site Opp 1, 9 km northwest of Cave 13 (Figure 3; Photo in appendix B). The high activity level is attributed to the water hole being one of the last end of wet season ephemeral pools along this major creek line attracting insect swarms. Medium activity levels were recorded at two additional spring fed pool sites with water present, Opp 7 Fig Pool (80 calls) and Opp 2 North Gorge (100 calls), 3 and 9 km north of Cave 13 respectively. Low activity levels with less than 10 calls per night were detected at five other sites (Opp 4, 5, 6, 8 and 9). Detectors at these sites were placed in dry locations. Only one site, the dry saddle above the bore near the camp, Opp 3 on figure 2, did not detect Pilbara leaf-nosed bats although they were detected nearby in 2012 (Ecologia 2012).

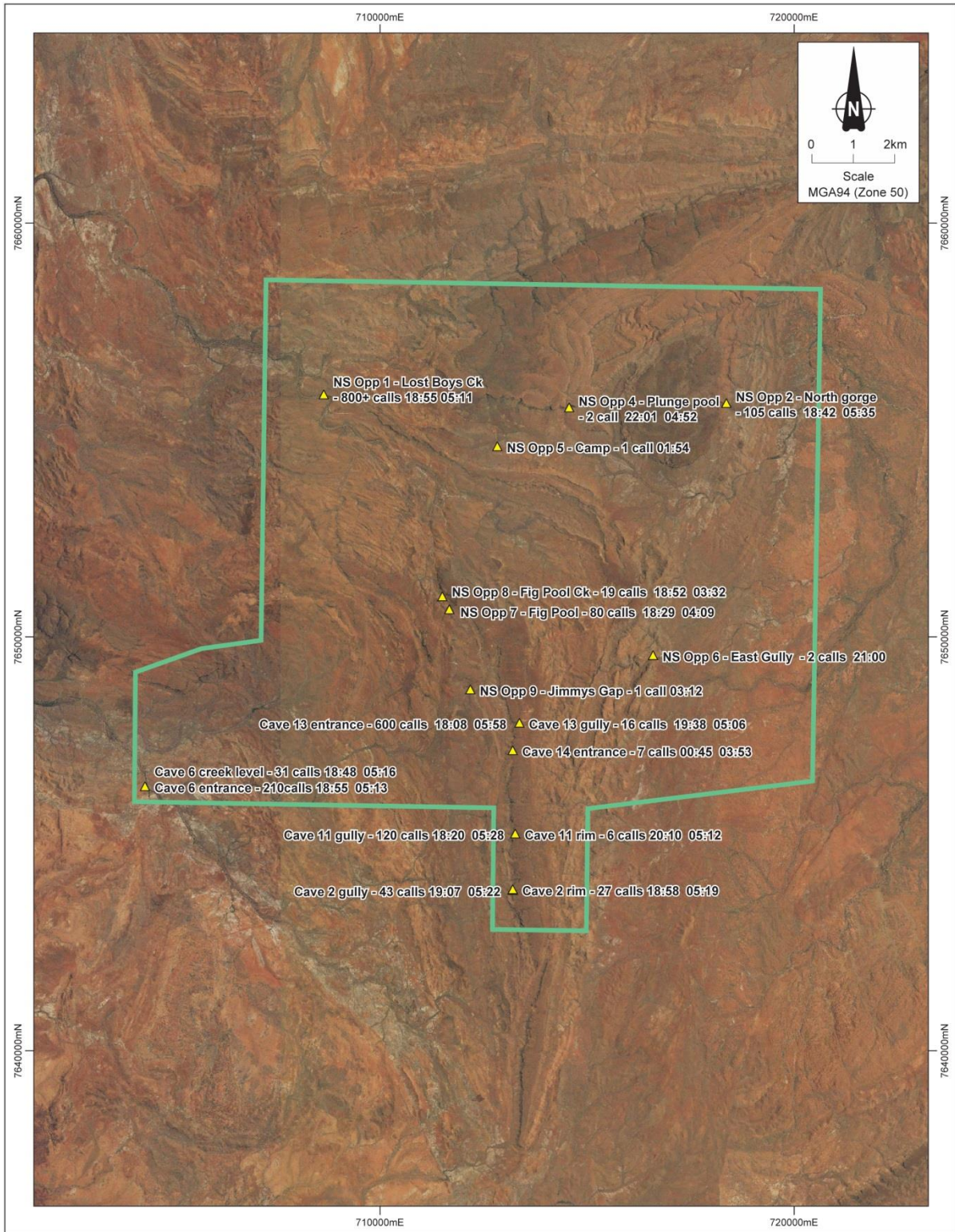
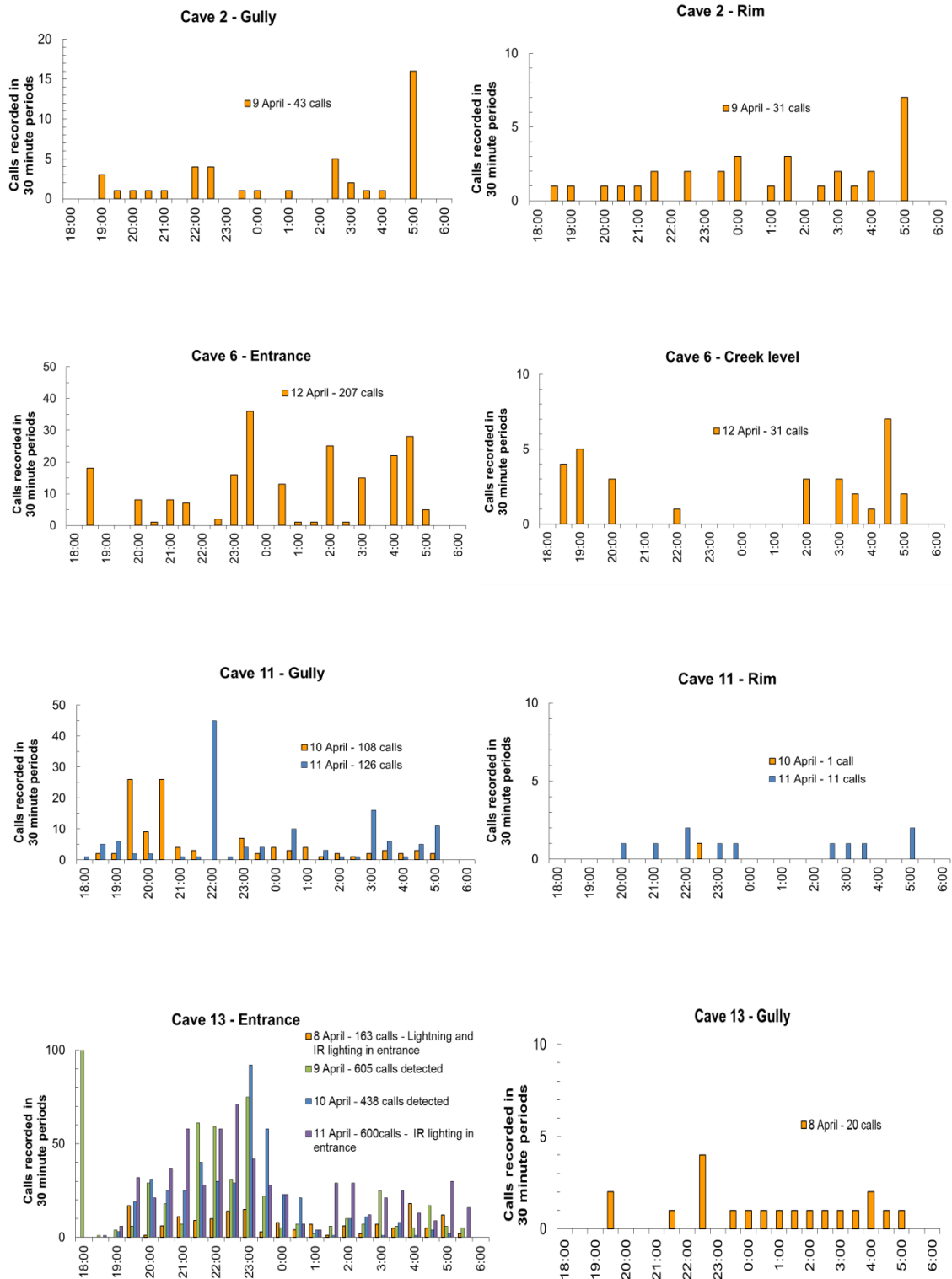
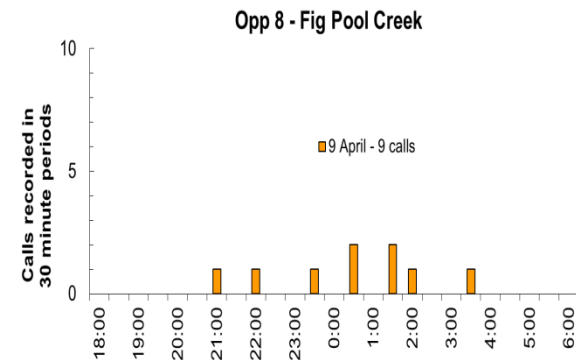
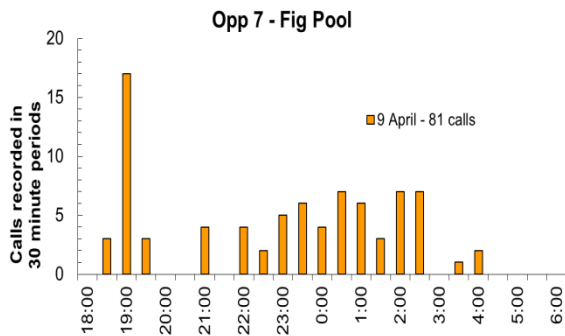
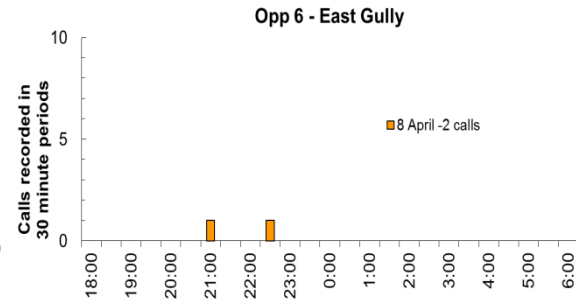
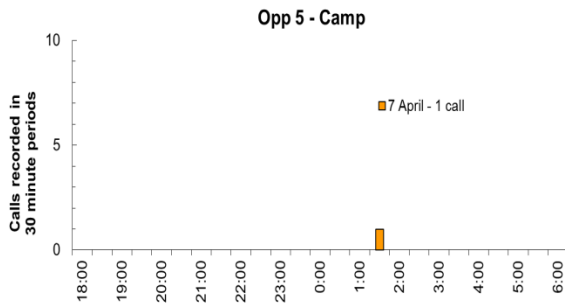
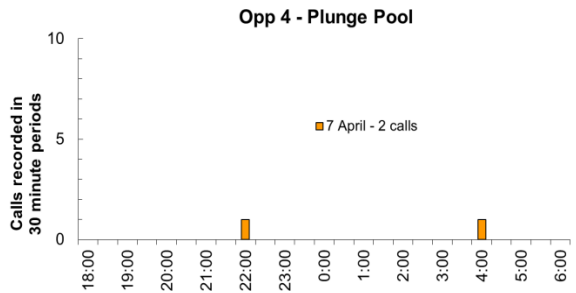
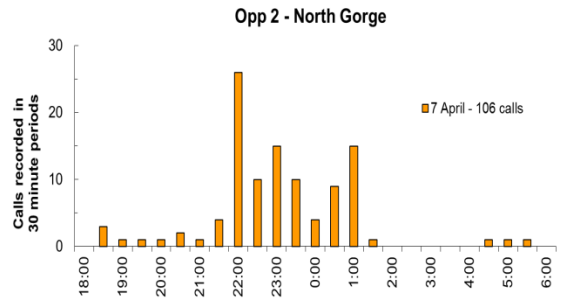
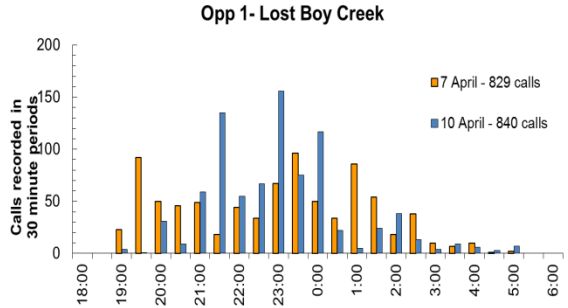
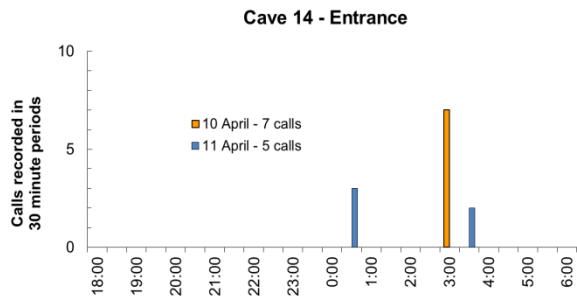


Figure 3. Pattern of Pilbara leaf-nosed bat detections. Nightly call count (average for multi-nights) and the time of the earliest and latest detections are given for each of the seventeen sites where the bat was detected. The eighteenth site with no detections was at Opp3 - Saddle, approximately 3.5 km southeast of Opp 5 - Camp

Figure 4. Temporal patterns of Pilbara leaf-nosed bats recorded during the survey





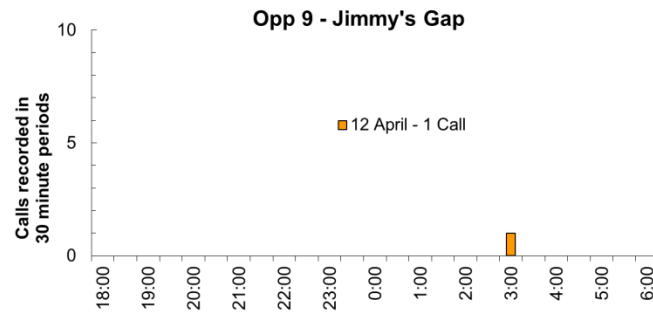
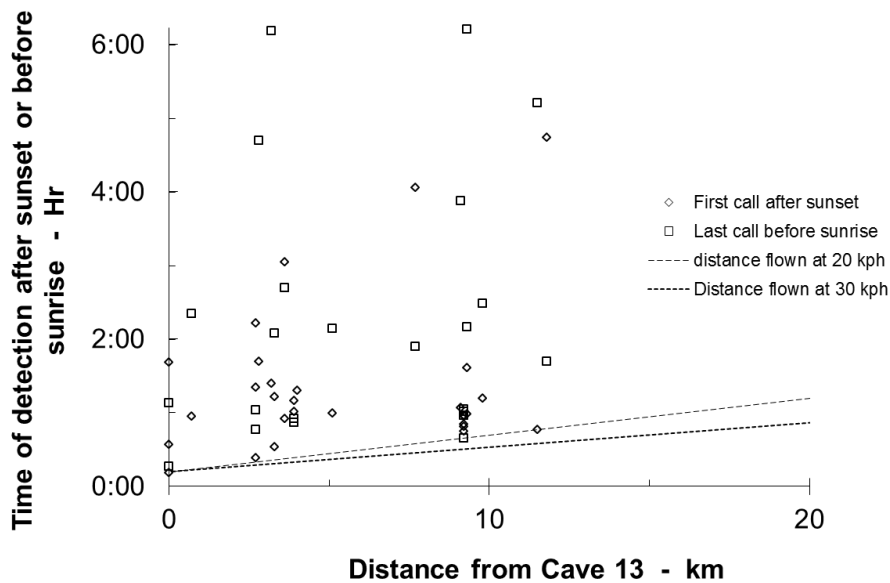


Plate 2. Image of a Pilbara leaf-nosed bat departing from Cave 13. Identification was confirmed by synchronising the SM2 recording adjacent to the camera

Pilbara leaf-nosed bat dispersal pattern

The time of the first and last calls detected at all sites is shown in figure 5 against distance from Cave 13. This pattern shows that all calls at all sites could be reached by bats flying at the known commuting speed of approximately 20 kph (McKenzie and Bullen 2009). This shows no evidence of a second roost within the study area and that the bats detected are probably all coming from the primary roost. Bats from any secondary roost would appear as records below the 20 kph boundary.

Figure 5. Dispersal of Pilbara leaf-nosed bats departing the roost at North Star colony. Data from this survey and from previous surveys at North Star (Ecologia, 2012) are included. The diamonds and squares represent the earliest and latest detections after sunset and before sunrise. This pattern shows that all detections within 15 km from the colony can be reached from Cave 13 at normal commuting flight speeds



Other conservation significant species detected during the study

The video in the entrance of Cave 13 detected two other conservation significant species using the cave.

A small number of Ghost bats (*Macroderma gigas*) were recorded exiting the cave, both visually (1 daylight sighting) and by the video, plate 3. The low number of records suggests that the colony numbers less than five. These bats appeared from the same rear chamber as the Pilbara leaf-nosed bats.

Plate 3. Image of a Ghost bat taken from the infra-red lit video at the entrance of Cave 13. Identification was confirmed by the greater size of the Ghost bat compared to the other bat species present



Two observations were made of a Northern Quoll (*Dasyurus hallucatus*) in the cave entrance, plate 4. The Quoll appeared twice from a crack in the roof and spent a minute on the floor at the rear of the cave on both occasions, apparently wary of the camera and IR light set-up, before returning to the crack in the cave roof.

Plate 4. Image of a Northern Quoll taken from the infra-red lit video at the entrance of cave 13



Discussion of results

The data collected during this survey confirms the persistence of a colony of Pilbara leaf-nosed bats at North Star. This colony was inferred to be in excess of 200 and is considered a typical size east Pilbara colony. It is one of a few known in a natural cave in the Eastern Pilbara. The range of 8 to 10 km for detections suggested by the data, compared with the 15 to 20 km more usual for the species, is due to the selection of sites in proximity to North Star project and does not represent the limit of the foraging range of the bats from the colony.

The high call counts at Cave 6, Lost Boy Creek and North Gorge appear to be associated with the presence of open water near-by these sites. The call count at all three sites are notable as they begin soon after the departure of bats from Cave 13 roost. This fast dispersal is thought to be due to the limited amount of open water available for the bats for drinking in the district. Areas of open water were adjacent to the second and third of these sites. Cave 6 is thought to have open water present a short distance downstream although this was not confirmed during the survey.

Call counts at Jimmy's Gap and Fig Pool were low. At the former site, this is thought to be due to the main western dispersal route passing directly from Cave 13 to the creekline containing Cave 6, a line that passes to the south of the mesa that is south of Jimmy's Gap. At the latter site, it is thought that the numbers of bats that approach the pool are reduced by the heavy shrub and tree growth (see photograph in Appendix B). The main northern dispersal route is suggested by the pattern to be along the walls of the deposit and along Lost Boy Creek. To the east the data suggests that the bats are moving northeast along the ridgelines at least as far (10 km) as the water holes in the gorge containing Opp Site 2.

The Pilbara leaf-nosed bat colony is considered regionally significant being one of only 10 (Bullen 2013) supporting the presence of the species in the eastern Pilbara region. Data collected by Ecologia (2012) and during this study have shown the ridges, cliff lines and watercourses surrounding the colony provide preferred foraging habitat for the species with a medium to high activity rating. The estimate of size of the colony is approximately 200 and is typical for natural cave colonies in the Pilbara. The nearest known colonies are 30 to 60 km to the north east, west and south (Bullen 2013).

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Appendix A. SM2 Audio settings used during survey



Parameter	Setting
Sample rate	384,000 kHz
Channel used	Left
Compression protocol	WAC4 (12 bit audio samples)
Gain - left channel	0.00
Digital high pass filter Left channel	fs/48 (giving 8 kHz minimum frequency)
Triggering level Left channel	6SNR (adaptive +6 dB triggering)
Triggering window Left channel	1.0 sec.

Note: These settings are as recommended in Wildlife Acoustics (2010) except the high pass filter. This is set lower to 8kHz to record any *Tadarida australis* that may be present

Appendix B. Site details. Coordinates are exact locations of detectors and may vary slightly from the coordinates given in Ecologia (2012)

Site	Description	Easting	Northing	
Cave 2	Two SM2 units deployed. One in cave entrance. One on rim above cave.	713203	7643847	
Cave 6	Two SM2 units deployed. One in cave entrance. One in creekline below cave.	704322	7646345	
Cave 11	Two SM2 units deployed. One in gully above cave entrance. One on rim above cave.	713262	7645204	
Cave 13	Two SM2 units deployed. One in cave entrance. One in creekline 50 m below cave. Video deployed for two nights	713368	7647895	
Cave 14	One SM2 deployed in cave entrance. Video deployed for one night.	713205	7647235	
Opp 1 Lost Boy Creek	SM2 deployed adjacent to the last ephemeral pool in the creek bed	708640	7655825	

Site	Description	Easting	Northing	
Opp 2 North Gorge	SM2 deployed on rock outcrop beside ephemeral creek line	718363	7655616	
Opp 3 Saddle	SM2 deployed on rock outcrop on rocky saddle above tank.	715790	7652577	
Opp 4 Plunge Pool	SM2 deployed on rock outcrop above plunge pool downstream extremity	714566	7655509	
Opp 5 Camp	SM2 deployed on tank, under light at rear of camp.	712830	7654542	No photo available
Opp 6 East Gully	One SM2 deployed on rock outcrop near ephemeral creekline exiting gorge	716592	7649522	
Opp 7 Fig Pool	One SM2 deployed beside permanent spring fed pool.	711673	7650631	

Site	Description	Easting	Northing	
Opp 8 Fig Pool Creek	One SM2 in ephemeral creekline	711504	7650944	
Opp 9 Jimmy's gap	One SM2 in centre of gap between two high rocky cliffs	712180	7648695	

Appendix C: Characteristics of caves assessed during this study

	Cave 2	Cave 6	Cave 11	Cave 13	Cave 14
Pilbara leaf-nosed bat activity level	Low	Med	Med	High	Low
Basic Geology	A shallow shelter in stable rock. No cave present behind shelter.	Unknown rock type that appears to contain copper ore.	Inaccessible entrances appear to be deep shelters in the BIF.	Cave is between dura-crust cap layer and underlying BIF high in the landscape	Cave is between dura-crust cap layer and underlying BIF high in the landscape
Entrance description	Single entrance	Single entrance	Multiple	Single entrance	Single entrance
Entrance dimensions W x H (m)	4m x 2m	10m x 5m	25m x 3m	8m x 3m	5.1m x 3m
Entrance collapsed, tight or open	Open	Open	Open	Open	Open
Entrance orientation	West	East	North	North	West
Cave grouping	Alone on a cliff wall	Alone in a gully	A group of entrances side by side	Alone in a gully	Alone on a cliff wall
Location on slope	In a gully high on the deposit	Low in landscape above creekline with approx. 15 m of rock overhead.	In a gully high on the deposit.	High on landscape with approx. 10 m of rock overhead.	High on landscape with approx. 15 m of rock overhead.
Cave depth	3 m	5 m	Unable to determine	Unknown depth rear chambers visible but inaccessible.	> 20 m.

	Cave 2	Cave 6	Cave 11	Cave 13	Cave 14
Cave interior description	A deep overhang	A large shallow shelter	Unable to determine	High roof of rear chamber visible	No domed chamber visible
Rear passages that may have roosts	No	No	Unable to determine	Rear chamber visible	Yes
Distance from current mining operations	Within future pit boundary	Within proposed infrastructure corridor	Within future pit boundary	Within proposed pit boundary	Within proposed pit boundary
Local PLN foraging opportunities	Good	Excellent	Good	Excellent	Excellent
Internal temperature and relative humidity	Ambient	Ambient	Ambient at entrance. Unable to access rear chamber	Ambient at entrance. Unable to access rear chamber	Ambient at entrance. Unable to access rear chamber
Type of PLN bat roost assessed	Night foraging site	Night foraging cave	Night foraging cave	Maternity roost	Night foraging cave
Other conservation significant species present.				Ghost bat and Northern Quoll	
Assessed cave stability	Stable structure	Stable structure. Solution cave. No evidence of cracking of loose rock in roof or walls	Stable structure. No evidence of cracking or loose rock in roof or walls from vantage point	Stable structure. A classic solution cave. No evidence of cracking or loose rock in roof or walls	Fragile rock around entrance. Large cracks run upwards from roof and are open to sky.