

SUMMARY OF MONITORING AND INVESTIGATIVE WORK INTO THE DISTRIBUTION AND HABITAT USE OF THE PILBARA LEAF-NOSED BAT

FMGIB began implementation of the Pilbara leaf-nosed Bat (PLNB) Habitat and Research Plan (the Plan) in April 2021, prior to the approval of the Plan on 1st July 2021, as required by Condition 10-6 of Ministerial Statement 993. A key objective of the Plan was to determine the distribution and use of habitat by the PLNB within the Iron Bridge Project area. Several methods have been employed to monitor the PLNB movements and use of habitat within the Project area.

LONG-TERM MONITORING

A total of 16 long-term monitoring sites using full spectrum ultrasonic detectors were established at Iron Bridge for the purposes of identifying the use of habitat by the PLNB (GHD, 2022). Monitoring sites included 'control' and 'impact' sites, including non-cave sites, such as pools. All units were scheduled to record from 30 minutes before sunset through to 30 minutes past sunrise each night.

PLNB calls were received at all recorder locations (Table 1), indicating that PLNB are active throughout the Iron Bridge study area. Records of the first PLNB call at each detector site showed that Chateau Cave "in" had the earliest activity (following civil twilight), demonstrating the continual diurnal presence of PLNB within the main chamber, followed by Chateau Cave "out". Early detections were also consistently recorded at Lalla Rookh, which is well-known to be an important diurnal roost for both the PLNB and Ghost bat. Early calls were also recorded at Mundagoora Pool, Python Cave and Cave 13, which are consistent being the sites closest located to Chateau Cave. On occasion, some recordings were earlier than the Chateau Cave "out" detector, for example Mundagoora Pool during April 2021 and Python Cave during August 2021, which may be a result of transitory diurnal roosting in, or in close proximity to these locations. Joe's Cave, Craigs Pool, Pool 12, Wayne Manor, Camp Pool and the Abydos Caves are all located several kilometres away from Chateau Cave and first records of PLNB at these detector sites occurred much later on average. This suggests that it is unlikely that any permanent diurnal roosts occur in close proximity to these locations.

Table 1: Average time of first PLNB call by month. Colour scale represents upper (90th = green) and lower (10th = red) percentile values. X = not surveyed # analysis to be completed

Site	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Chateau Cave in	17:19	17:10	17:00	17:10	16:44	17:30	17:42	17:54	18:12	18:21	18:12	17:51
Chateau Cave out	18:35	18:18	18:10	18:19	18:26	18:31	18:40	18:54	19:14	19:30	19:28	19:09
Mundagoora Pool	18:33	18:21	18:16	18:28	18:30	18:40	18:54	19:31	19:55	20:12	20:30	#
Mundagoora Cave 1	x	x	x	x	x	x	x	x	x	21:20	21:37	#
Python Cave	19:10	18:34	18:44	18:15	18:25	18:42	20:07	21:30	20:37	21:16	21:34	#
Cave 13	19:09	18:40	18:20	18:31	19:48	19:10	19:45	19:49	19:51	19:55	20:29	#
Joe's Cave	18:38	x	18:42	18:52	18:52	18:58	19:27	19:18	19:27	19:30	19:17	#
Fig Pool	19:00	18:43	18:29	18:37	18:56	18:59	20:04	19:41	20:12	20:17	20:55	#
Craigs Pool	x	18:59	18:55	19:15	19:18	19:13	18:48	19:28	19:35	19:54	19:35	20:17
Pool 12	20:03	19:25	19:14	19:51	19:28	19:47	19:32	19:33	20:23	21:27	21:06	21:21
Wayne Manor	x	19:18	19:23	19:13	19:30	21:16	19:36	21:27	19:30	20:31	19:08	21:17
Wallaby Cave	x	20:18	19:48	19:57	19:28	21:23		21:54	22:35	21:08	23:14	#
Camp Pool	20:00	19:21	19:17	19:44		20:19	19:09	19:24	19:34	19:27	20:23	#
Cow Pool	x	x	x	19:02	19:07	19:01	19:15	19:09	20:00	#	#	#
Abydos Cave B	x	18:40	19:54		x	x	x	x	x	x	x	x
Abydos Cave D	x		20:03	19:29	x	x	x	x	x	x	x	x
Abydos Cave H	x	19:08	20:27	20:52	20:32	x	x	x	x	x	x	x
Nickos Gorge	x	x	x	x	x	x	x	19:38	x	#	#	#
C6	x	x	x	x	x	x	21:47	22:54	22:08	22:15	22:10	#
Lalla Rookh	x	x	x	x	x	x	18:33	18:49		18:46	18:45	#

Detailed analysis is provided for the following select sites:

Chateau Cave

Over 12 months, 2.6 million PLNB calls (1 second duration) were detected within the main chamber of Chateau Cave. There was a significant difference between survey month activity on the internal Chateau Cave detector, which shows that while PLNB activity was recorded for every detector night and PLNB permanently roost in the structure, activity was still highly variable. This provides an essential insight into the patterns of activity at a permanent diurnal roost and demonstrates the importance of ongoing monitoring.

Activity increased significantly from April to May 2021 and April 2021 was significantly lower than all other survey months. This is likely explained by the reduced number of nights recorded during April 2021. February 2022 was also significantly different to all other months, with low activity recorded. For February, data was recorded in all nights and therefore represents a valid period of low activity. Between May to August 2021, values were

uniformly high, and this period was followed by a drop in activity from September 2021 onwards. This peak in activity during winter months likely represents swarming activity where males and females congregate within caves to mate. The slightly smaller second peak in December 2021 and January 2022 coincides with the expected period of parturition for the species, though pups were not observed in the cave at this time.

Nightly detections recorded on the external Chateau Cave detector was an average of 538, and similar to the internal detector, there was a significance between survey month activity. Activity increased significantly from April to June 2021, with the lowest level of activity being recorded in February 2022, though PLNB were present at the site for all detector nights.

Cave 13

Compared to Chateau Cave, Cave 13 has very low and variable levels of activity with average activity at 106 detections per night for the survey period. Like Chateau Cave, there were significant differences between months at Cave 13. Activity peaked in June 2021 and was lower through other months. Activity in June was significantly different to all other months except July 2021. Compared to the Chateau Cave activity, there was no distinct pattern in Cave 13 average activity throughout the night. The site level differences between average nightly activity at Chateau Cave and Cave 13 highlight the more predictable timing of activity peaks at a permanent diurnal roost compared to that of a nocturnal roost like Cave 13.

The timing of first PLNB call at Cave 13 each night is erratic and does not appear to display a consistent pattern. Although there are numerous first calls within 20 mins of civil twilight (some within 5 mins), the source of these calls is most likely from bats exiting Chateau Cave, as there is little activity data to support bats occupying the main chamber within the roost where PLNB have historically roosted. It is likely PLNB from Chateau Cave visit Cave 13 frequently, given the proximity of the two locations relative to each other (320 m). This is also supported by the apparent correlation between general temporal patterns of activity between the two sites, i.e. the highest activity at Cave 13 coincided with highest levels of activity at Chateau Cave in early June. It is also important to note the microphone was placed at the entrance of the main chamber to record important emergence calls. The infrequent timing of the first calls and lack of activity data before and during the emergence period suggests that PLNB most often use the cave as a nocturnal refuge. This provides additional information to support the transitory diurnal roost classification of the cave.

Python Cave

There was a significant difference between survey month activity on the Python Cave detector. Activity increased significantly from April to May 2021 and April 2021 was significantly lower than all other survey months except October 2021. The greatest levels of activity occurred in August 2021, and while it is unclear what mechanisms caused a later peak than other sites, it is of note that at this time a PLNB was detected at Python Cave via faecal DNA analysis and was also later detected at Chateau Cave.

The average activity throughout the night at Python Cave showed a very different pattern to Chateau Cave, with the peak in activity occurring at midnight. This suggests PLNB generally visit Python Cave during the night and less activity occurs close to sunrise and sunset.

There are at least four nights for each month where the first call is before or within 5 minutes of civil twilight, indicating PLNB were using Python Cave as a diurnal roost. This is also supported by the confirmed PLNB scats within the cave, and observations of PLNB within the cave on the 3 May 2021, 10 Jul 2021 and 9 September 2021. This evidence further supports the classification of transitory diurnal roost for Python Cave.

Mundagoora

The PLNB activity at Mundagoora Pool (average activity per night: 166 detections) differed significantly by month. Between the months of April – November 2021, the detector was located on the downstream edge of the pool, but due to concerns about the detector being inaccessible during the wet season, it was relocated to the upstream side of the pool and placed higher in the landscape. This likely explains much of the variation before and after early November. For the months April – October 2021, the lowest activity occurred in April and July 2021.

There are two nights in August and two nights in September where the first call is before or within 5 minutes of civil twilight, and there are multiple nights during May, June, August and September 2021 where first calls are within 10 mins of civil twilight indicating that PLNB were using a nearby roost. The detector was positioned within a few meters of a permanent natural pool, and not near a known diurnal roost site, although the Mundagoora Pool cave complex (a known Ghost Bat roost located 30 m from the pool) was recently considered as a possible diurnal roost for PLNB based on near civil twilight detections over six consecutive nights. Mundagoora Pool is located 2.4 km south of Chateau Cave and it is possible some early records may originate from this roost.

Joe's Cave

Average activity per night across the survey period was 126. Like all other sites, activity at Joe's Cave differed significantly by month. The pattern in activity throughout the 10 months of monitoring was interesting as it appeared PLNB activity was often highest at Joe's Cave when it was lowest at Chateau, Cave 13 and Python Cave which are all in close proximity and on the same range. Similarly, activity at Joe's Cave was lowest when activity was highest at the other sites. This suggests there may be some level of migration of PLNB across the study area, though activity was not high enough at Joe's to account for the entire reduction in activity observed at Chateau Cave.

Joe's Cave shows a unique pattern in nightly activity compared to other sites assessed. Rather than a peak in activity coinciding with emergence, activity peaked several hours after sunset.

Given the absence of data from May 2021 and most of August 2021 it is likely that overall activity would have been much greater for this site, particularly when compared to historical detector activity data (Specialised Zoological, 2018 and GHD 2021, 2020, 2017). Despite the data gaps there are two consecutive nights in April and September 2021 where the first call was before or within five minutes of civil twilight, and there are multiple nights during April, June and September 2021 where first calls are within 10 mins of civil twilight indicating the PLNB was most likely using the cave as a diurnal roost. This evidence further supports the classification of transitory diurnal roost for Joe's Cave.

ANALYSIS OF SCAT MATERIAL

Analysis of scat samples were used to identify the abundance and breeding status of individual PLNB within a colony, and the movement of individuals to other caves within the study area. Scats were collected at the beginning of each month from eight locations (including Chateau Cave, Cave 13 and Python Cave) from April 2021 through to March 2022.

To March 2022, 550 individual bats have been identified across the Study area. The total number of samples only detected at Chateau is 438, with 123 individual bats detected on at least two months at Chateau Cave. 367 individuals, not part of the network of linked individuals, were detected on one occasion only.

Although scat collection was attempted at Python Cave and Cave 13 from April 2021 to March 2022, in some months no scats were present to be collected. This is likely to explain why there is only one detection of an individual using both Chateau Cave and Cave 13; and four individuals using both Chateau Cave and Python Cave. Whilst scats collected from more distant sites such as Lalla Rookh and Dalton Creek (RHA12) are yet to show a match to other sites within the study area, monitoring had only recently commenced at these sites (November 2021 and February 2022 respectively). In November 2021, there were 16 females and 47 males in Chateau Cave (sex ratio 1:3 females to males). Thus, even though Chateau Cave has been shown to be used by pregnant females and those raising young, the colony is dominated by males. This is consistent with the relatively small proportion of individuals that recorded low progesterone levels in the period from October 2021 onwards.

VISUAL COUNTS

Visual monitoring of the Chateau Cave roost was undertaken to assist with estimating the colony size, particularly during the breeding period. In addition to the full-spectrum recorders, infra-red cameras were used to record the ingress/egress of bats at the entrance of the cave during the emergence period and observe the behaviour of roosting bats within the main chamber. Although emergence counts could not be accurately obtained using the IR video, counts were conducted of PLNB individuals occupying the roosting area of the main chamber. Monthly averages of 135, 113 and 60 from November 2021, December 2021 and January 2022 respectively, though it is important to note that these numbers are not reflective of an entire colony count.

ALTERNATE ROOST HABITAT

The search for an alternative roost in the 30 km study area surrounding Chateau Cave has been a concerted effort utilising a range of novel techniques such as the use of Lidar and thermal drones. The use of a conservation dog to detect an alternative roost is the only approach which has experienced significant delays on account of Covid-19 related travel restrictions followed by the onset of hot weather not suitable for the dogs to work in. Notwithstanding the effort to locate an alternate roost over 12 months, no confirmed permanent diurnal roost sites with evidence of breeding have been located to date. Numerous caves have been assessed but none have characteristics which would be indicative of a permanent diurnal roost such as high humidity and constant temperature. Additionally, no detector sites have activity which is indicative of such a roost. The only other permanent diurnal roost in the study area is the cave referred to as the Dalton Creek roost (RHA12) which requires additional assessment.

The Dalton Creek roost appears to be a large and permanent diurnal roost and is located 28 km southeast of Chateau Cave. The use of eDNA at this site has detected PLNB are present, and detector data reported by Biologic (2020), indicates PLNB activity is ten-fold higher than other PLNB roosts in the Chichester region. In addition at least 40 individuals were recorded in the roost during February 2022, suggesting it is used for part of the breeding cycle given the timing of observations and data collected to date. This roost is the only known roost in the Chichester which is currently not in close proximity to mining activities or within mine adits. If not the only recorded natural roost not exposed to disturbance from mining, it is certainly one of a small few. This emphasises its value for the regional conservation of PLNB and the importance as a site in the network of locations that PLNB from Chateau Cave may utilise.

Habitat modelling

A habitat model was completed to assist with identifying suitable roosting and foraging habitat areas and prospective survey sites within the study area. The area was mapped according to five priority foraging habitat categories identified in conservation advice for the species and to identify prospective survey areas supported by the field data collected to date.

There has been a concerted effort since early 2015 to demonstrate ongoing occurrence, categorise known roost sites and locate additional roost sites for the PLNB within the North Star mine study area. The approach to locate and categorise roost sites has included a combination of desktop and field survey techniques such as:

- Roost habitat assessments included detailed structural and microclimate assessments;
- Targeted sheeting surveys to confirm occupancy of PLNB within roost sites;
- Roost emergency surveys;

- Radio-tracking of PLNB, and
- Long-term monitoring of roost sites using detectors.

Table 2 provides a summary of known and potential roost records and other records (e.g. trap) for PLNB until late 2021 within the study area. Cave occupancy surveys for the PLNB within Cave 13, Joe’s Cave and Chateau Cave during February and September 2016 (see GHD 2016a and 2016b) and December 2019 (see GHD 2020b) and a review of studies undertaken to 2021 have categorised the three sites according to the TSSC Approved Conservation Advice for the Pilbara Leaf-nosed Bat (TSSC 2016) and the DAWE (2021). Three other locations within the study area are known to support or potentially support diurnal roosts (Abydos Mine, C6 and Rha12).

Plate 1 displays all roosts recorded within the study area prior to the recent surveys.

Table 2: Summary of roost and other records for PLNB until 2021

Record Type	Number and Description
Roost Records	
Permanent diurnal or non-permanent breeding roost	Chateau Cave, Dalton Creek roost (Rha12)
Transitory diurnal roost	4 (Joe’s Cave, Cave 13, Python Cave and Caves C, D, E, F, G and H at Abydos mine, Python Cave). Note Abydos mine counted as one located given close proximity of sites.
Potential diurnal roost unknown category	17 (includes cluster of records south of Chateau cave near Rha12 including rha2, rha3, rha5, rha6, rha10, rha7, rha17, rha18, rha25b, rha26, ha6, ha27, ha28).
Potential transitory diurnal roost	C6 and Mundagoora Pool cave complex – historical bat call data suggests diurnal or nocturnal usage.
Nocturnal refuge (based on habitat observations and detector data for some locations)	52+
Potential roost habitat locations (based on helicopter fly by or brief visual inspections but not informed by other data)	21

LiDAR Assessment

Much of the study area is difficult to access due to rugged terrain and lack of vehicle access, which has been a significant constraint to identifying additional PLNB roosts to those that are currently known. Remote sensing is increasingly used to overcome access issues and refine search areas. LiDAR was used in this study to effectively create a 3D model of the terrain.

The LRM decision model narrowed the focus of the search area for alternate caves and facilitated a preliminary desktop assessment of cave characteristics when combined with high-resolution, 3D imagery. Results indicated 526 discrete regions where caves were likely to occur, of which 253 (equal to 253 hectares) were new locations that hadn't been previously surveyed. 120 of these were ground truthed between the 2 – 4 November 2021.

Table 3: Summary of known and potential roost habitat categories which were correctly identified in the LRM model

Roost habitat categories	YES	NO
Permanent diurnal roost or non-permanent breeding roost (Chateau Cave)	1	-
Nocturnal refuge	66	8
Potential diurnal roost – unknown category	12	2
Transitory diurnal roost (includes Joe's Cave, Python Cave and Cave 13)	2	-
Cave – unknown type	5	-
Grand Total	86	10

A drone survey trial was conducted to test if known caves can be detected using thermography, and if so, to systematically search and identify other PLNB roosts within the study area, using the information determined from the LiDAR assessment. Surveys were carried out on three nights in early October 2021. In total, 37 cave-like structures were assessed, including Chateau Cave. Thirteen features that were probably caves were identified from seven pre-determined flight paths.

An assessment of Chateau Cave determined a target temperature of 26°C at the cave entrance, whilst other caves during the survey ranged between 19 - 30°C, while the ambient air temperature ranged between 22 - 25°C. The results were impacted by adverse weather (warmer than average temperatures in early October). Whilst the pilot study demonstrated

some promise in the methodology, it is restricted to periods of the year when the ambient air temperatures are cooler.

Field Assessments

Field assessments were carried out using a combination of roost habitat assessments, eDNA sampling and ultrasonic surveys were undertaken for PLNB of the areas of interest identified from desktop searches, LiDAR and drone assessment for the purpose of identifying roosting sites and areas that may provide roosting habitat. The summary below details the survey effort completed between April 2021 and February 2022.

A helicopter was used to determine opportunities for access to survey areas, refine the prospective search area or eliminate potential roost locations. When it was deemed safe to land and investigate an area on foot a team of two GHD ecologists completed the roost habitat assessment.

Two types of assessment were undertaken based on the ability to safely access sites deemed as potential habitat:

- Helicopter/foot assessment (HA) – For each habitat assessment the area was either searched on foot and/or by observation from the helicopter for potential roost sites, however a detailed habitat assessment was not undertaken due to the lack of suitable roosting habitat or the ability to access the site (e.g. for safety or time constraints). The observer noted if there was any potential for suitable roosting habitat.
- Roost habitat assessment (RHA) – For each site that was deemed safe to access a field sheet was completed to document the roost structure and evidence of use or occupation by bat species. The information documented was used to assist with determining the category of roost.

When a potential diurnal roost location was identified, GHD placed a full spectrum ultrasonic recorder at the location for at least one night to determine if the cave was used as a roost by PLNB based on timing of first calls and number of calls recorded.

Following reconnaissance via either helicopter or by foot, GHD investigated approximately 24 locations (Plate 1). A summary of the key survey results is provided below:

- At least one of the sites investigated (Rha31/Pothole Cave) was confirmed as a new diurnal roost for the PLNB. Based on the information available, the site was categorised as a transitory diurnal roost.
- Additional information was recorded regarding Rha12 (Dalton Creek roost) further confirming that this roost is a permanent diurnal roost and possibly an important part of the breeding cycle of the species.

- At least 11 other sites were determined to provide potential diurnal roosting. These sites appeared to be suitable habitat (e.g. roost size and structure appeared suitable), however due to lack of evidence (e.g. absence of scat, species or other evidence), a category could not be applied.

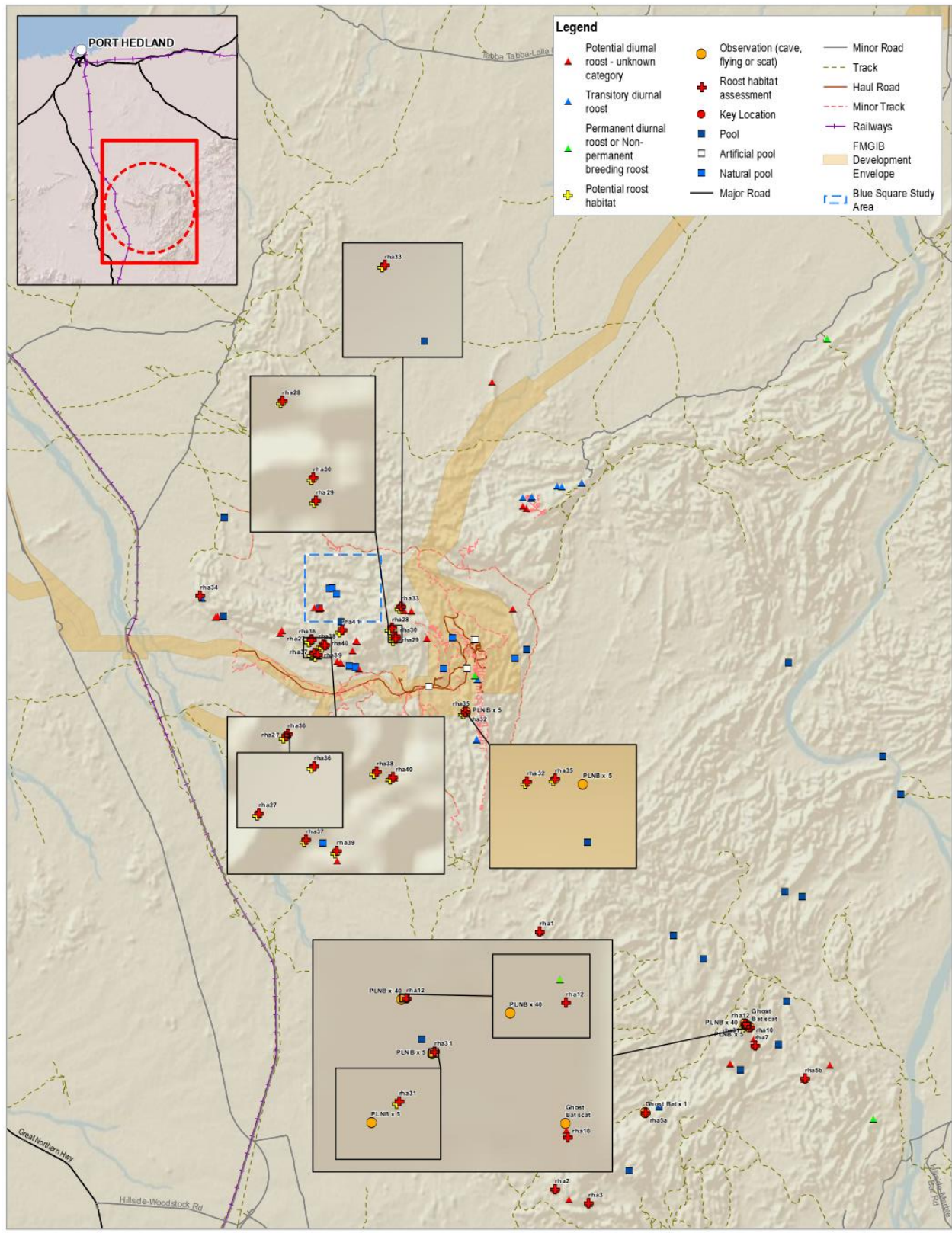


Plate 1: Roosts recorded within the study area

N:\Work\Projects\01\0567179\0567179\0567179_Bat_Habitat_Survey\12548779_BA_Habitat_Survey\12548779_Fig 42_Bat_Habitat_Survey_2021-2022.mxd
 Printed: 11 Aug 2022 - 8:40

Data source: OpenStreetMap, Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, GeoCommunity Map contributors, Map data by Esri, WorldAerodrom, Relief, Copyright © 2014 Esri, Created by sany

FIGURE 41