



mainroads
WESTERN AUSTRALIA

EPBC 2016/7656 Annual Compliance Report

Great Northern Highway Upgrade Stage 2:
Muchea to Wubin – Muchea North

21 September 2020 – 21 September 2021

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ATTACHMENT 1: ARTIFICIAL NEST BOX MONITORING REPORTS

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1 INTRODUCTION

Great Northern Highway forms part of the National Highway Network and provides a strategic freight link between Perth and the State's north, as well as Darwin and the Northern Territory. Between 2000 and 2009, Stage One of the Great Northern Highway Muchea to Wubin Upgrade project was completed, which saw 76 km of the highway upgraded to National Highway standard.

In 2014 a comprehensive planning review was undertaken of the full Muchea to Wubin link along the highway. A series of construction packages were prioritised following the review, which included town bypasses, wider roads, more passing lanes, flattening crests and easing curves, safer roadsides, more rest stops and additional facilities for heavy vehicles.

Jointly funded by the Australian and Western Australian Governments, the \$384.8 million project will improve road safety, increase freight efficiency and reduce traffic delays, improve travel times and access, improve roadside amenities, and enhance the environmental value of roadsides.

The key objectives for the project include:

- Improved safety
- Increased freight efficiency and reduced traffic delays
- Improved network reliability - improving travel times and enhancing network access
- Enhanced travel wellbeing - improvements in roadside amenities for rest and driver information
- Contribution to sustainable and viable communities - by balancing community concerns, economic, community safety and network access issues
- Enhancement of the environment - by undertaking practices to retain and improve the environmental value of roadsides.

1.1 Approval under the Environment Protection and Biodiversity Conservation Act 1999

Proposed construction of the Muchea North (Old Gingin Road to Chittering Roadhouse) package was referred to the then Department of the Environment and Energy (DoEE; 'the Department') now termed the Department of Agriculture, Water and the Environment (DAWE) for assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The referral was determined to be a Controlled Action with the controlling provision being "listed threatened species and communities"—namely, Carnaby's Cockatoo (*Calyptorhynchus latirostris*) and the Star Sun-orchid (*Thelymitra stellata*). The referred works were assessed through Preliminary Documentation. The Department issued conditional approval for these works to proceed on 10 August 2018 (EPBC 2016/7656).

1.1.1 Purpose of this Report

Construction of the Action commenced on 21 September 2018. This compliance report has been produced as required by Condition 12 of EPBC approval 2016/7656. Table 1 of this report outlines the compliance with each condition of approval over the 12-month period between 21 September 2020 and 21 September 2021.

Construction of the Action has been completed, however completion criteria for revegetation and use of artificial hollows by Carnaby's Black Cockatoo have not yet been achieved. Reporting will continue annually under Condition 12 of EPBC 2016/7656.

2 COMPLIANCE

Condition No.	Condition	Status
1	The approval holder must not clear more than 52.5 hectares of Carnaby's Black Cockatoo habitat within the project area and can only clear up to six of the hollows identified as 'hollow with evidence of use' and up to eight of the hollows identified as 'suitable hollows', in Attachment 1.	Compliant. No clearing was undertaken during the reporting period
2	To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must undertake all efforts to avoid clearing the known nesting hollow and suitable nesting hollow identified in Attachment 2. Within one month of the completion of clearing, the approval holder must provide the Department with evidence that these hollows have not been cleared or a detailed assessment of why clearing of these hollows could not be avoided.	Compliant. The suitable nesting hollows and known nesting hollows identified in Attachment 2 have not been cleared, as confirmed to the Department in an email on 11 April 2019.
3	<p>Within 7 days prior to clearing of any area of Carnaby's Black Cockatoo habitat, the approval holder must investigate and document all potential nesting trees within the area to be cleared to determine if there are any hollows that are being utilised, or are capable of being utilised, by the Carnaby's Black Cockatoos for nesting. The investigation must be undertaken by a suitably qualified person.</p> <p>a. If any Carnaby's Black Cockatoo(s) is detected utilising any hollow in any tree, the approval holder must:</p> <ul style="list-style-type: none"> i. clearly identify and mark the identified nesting tree ii. maintain a register of nesting trees iii. only clear the identified nesting tree and vegetation within a 10 metre radius of the tree, if a suitably qualified person has verified that the hollow in the tree are no longer being used by the Carnaby's Black Cockatoo iv. record the location of any known nesting hollow or suitable nesting hollow, identified during the 	Compliant. No clearing was undertaken during the reporting period

Condition No.	Condition	Status
	<p>investigations, that are additional to the nesting hollows identified in Attachment 1.</p>	
4	<p>To mitigate and offset the loss of known nesting hollows and suitable nesting hollow the approval holder must:</p> <ul style="list-style-type: none"> a. install at least three artificial nesting hollows for each known nesting hollow and suitable nesting hollow cleared b. install at least ten of the artificial nesting hollows required by Condition 4.a prior to the clearing of any known nesting hollow or suitable nesting hollow with all remaining hollows to be installed prior to the beginning of the next breeding season following the commencement of the action. c. maintain the pre-impact breeding density of the Carnaby's Black Cockatoo within the project area by undertaking adaptive management of the artificial nesting hollows to maximise the likelihood that the installed artificial nesting hollows are used by the Carnaby's Black Cockatoo d. adaptive management may cease when at least one artificial nesting hollow for each known nesting hollow cleared has shown evidence of use by the Carnaby's Black Cockatoo, as verified by the suitable qualified person, for three consecutive years; the artificial nesting hollow in use for three consecutive years need not be the same artificial nesting hollow each year e. if after nine years from commencement of the action the outcome identified in Condition 4.d is not met, the approval holder must <ul style="list-style-type: none"> i. submit to the Minister for approval the details of an offset that meets the requirements of the EPBC Environmental Offsets Policy and will compensate for the permanent loss of known Carnaby's Black Cockatoo breeding hollows 	<p>Compliant.</p> <ul style="list-style-type: none"> a. No known or suitable nesting hollows were cleared in the reporting period. b. As above c. No adaptive management actions have been required for this reporting period. Monitoring of hollow usage and breeding shows that 12 of the 39 artificial hollows installed, were used for breeding in the 2020-21 breeding season, which is higher than the six confirmed breeding events recorded prior to commencement of the action. d. The required period of three consecutive years has not yet been achieved. e. Not applicable for the 2020-2021 reporting period. f. Main Roads commissioned Phoenix Environmental Sciences to undertake the required monitoring as provided in Attachment 1. No maintenance actions have been required.

Condition No.	Condition	Status
	<ul style="list-style-type: none"> ii. submit to the Department a detailed assessment of the factors that cause the failure to achieve the outcome identified in Condition 4.d f. Each artificial nesting hollow installed must: <ul style="list-style-type: none"> i. be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify any maintenance requirements ii. be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season iii. not be installed in a manner that requires additional clearing of Carnaby's Black Cockatoo habitat or within 10 metres of the edge of the road seal to reduce the risk of vehicle strike. 	
5	<p>For the purposes of Condition 4, the maximum number of hollows to be cleared that are additional to the hollows identified in Attachment 1 must not exceed four and at least half of all artificial nesting hollows installed must be installed within 500 m of the project area.</p>	<p>Compliant.</p> <p>No clearing or installation of artificial nesting hollows was undertaken during the reporting period.</p>
6	<p>All data, enquiries and findings of the monitoring required by Condition 4 must be provided to the Department, DBCA and published on the approval holder's website to contribute to broader research into the use of artificial nesting hollows by the Carnaby's Black Cockatoo. Publication must occur within one year of the environmental outcome identified in Condition 4.d being achieved or after nine years from the commencement of the action if the environment outcome is not met by that time.</p>	<p>Not applicable.</p> <p>A time period of one year from the outcome identified in Condition 4.d has not yet been reached.</p>
7	<p>To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must revegetate at least 19.69 hectares of land with species that are known to provide foraging and breeding habitat for the Carbaby's</p>	<p>Compliant.</p>

Condition No.	Condition	Status
	<p>Black Cockatoo, in the area identified in Attachment 3. The objective of revegetation works is to re-establish a self-sustaining vegetation cover, integrate with the surrounding ecosystem, which provides Carnaby's Black Cockatoo habitat.</p> <p>The approval holder must adhere to the following during all revegetation works:</p> <ul style="list-style-type: none"> a. revegetation must begin within one year of commencement of the action and must have commenced within all the areas identified for revegetation in Attachment 3, within one year of the completion of construction b. flora species identified as Carnaby's Black Cockatoo habitat must not be planted within 10 metres of the edge of the road seal to reduce the risk of vehicle strike c. revegetation works may cease once a suitably qualified person has verified that the revegetated areas meet the completion criteria d. once the completion criteria have been achieved, all areas of revegetation must be inspected once every 2 years, during Spring, for at least a further 20 years to ensure the completion criteria are being maintained e. undertaken corrective actions to improve vegetation quality within the revegetated areas, within 3 months of becoming aware that an area of revegetation no longer meets the completion criteria; corrective actions may cease once the completion criteria have again been achieved. 	<ul style="list-style-type: none"> a. All revegetation for the proposal was completed prior to this reporting period. Initial revegetation activities commenced on 20 August 2019, approximately 11 months after commencement of the action and all areas identified for revegetation were completed in July 2020, one month after construction works were completed. <p>Revegetation monitoring was undertaken in Spring 2020 and remedial works undertaken to address identified deficiencies in revegetation success.</p> <ul style="list-style-type: none"> b. No flora species identified as Carnaby's Black Cockatoo habitat have been planted within 10 metres of the edge of the road seal. c. Revegetation has not yet been verified to meet the completion criteria. d. Revegetation has not yet been verified to meet the completion criteria. e. Revegetation has not yet been verified to meet the completion criteria.
8	<p>To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must prepare and submit a <i>Construction Environmental Management Plan</i> (CEMP) for the approval of the Minister. The approval holder must not commence the action unless the Minister has approved the CEMP. The approved CEMP must be implemented.</p>	<p>Compliant.</p> <p>The Minister approved the CEMP on 5 September 2018 and the action commenced on 21 September 2019. Main Roads has implemented the approved CEMP.</p>

Condition No.	Condition	Status
	<p>The CEMP must be prepared in accordance with the Department's Environmental Management Plan Guidelines and include, but not be limited to:</p> <ul style="list-style-type: none"> a. design principles and practices to minimise clearing of Carnaby's Black Cockatoo habitat – for example, road micro-alignment, traffic management alternatives to side roads b. measures to prevent impacts to Carnaby's Black Cockatoo habitat during construction, including to: <ul style="list-style-type: none"> i. prevent and/or control site access, weeds, <i>Phytophthora</i> dieback, erosion, dust and fire ii. delineate vegetation to be retained through, for example, the erection of temporary fencing or signage to avoid accidental clearing or disturbance outside of the impact area c. management measures, including in relation to fencing and access controls, to permanently restrict access to adjacent road reserves d. objectives, targets and completion criteria for post construction rehabilitation measures such as site clean-up and weed management, including information on the mapping, monitoring and removal of noxious weeds e. objectives and targets for landscaping and revegetation works required by Condition 7, including details on site preparation works, seeding planting programs, success rates, ongoing management post establishment and details of replanting requirements if success rates are not achieved f. clear objectives and performance indicators for all management actions, mitigation measures and practices prescribed by the CEMP including details of the monitoring to be undertaken to demonstrate the effectiveness of the measures g. corrective actions for circumstances where an action, mitigation measure or practice prescribed by the CEMP fails to meet, or is 	

Condition No.	Condition	Status
	<p>unlikely to meet, its prescribed objectives, and trigger action points at which these corrective actions will be implemented</p> <p>h. timeframes for implementing the above measures.</p>	
9	<p>To compensate for the loss of up to 52.5 hectares of foraging habitat, and 744 potential breeding trees for the Carnaby's Black Cockatoo the approval holder must, within one year after the commencement of the action, provide the Department with the offset attributes, shapefiles and textual descriptions and maps to clearing define the location and boundaries of the Ippolo Road Offset and Banovich Road Offset, that the approval holder has transferred to the DBCA.</p>	<p>Compliant.</p> <p>Main Roads provided a letter and information to the Department on 12 November 2018 to satisfy the requirements of this Condition</p>
10	<p>Within 30 days after the commencement of the action, the approval holder must advise the Department in writing of the actual date of commencement.</p>	<p>Compliant.</p> <p>The action commenced on 21 September 2018, with written notification provided to the Department by email on 27 September 2018.</p>
11	<p>The approval holder must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the plan required by this approval (Condition 8), and make them available upon request to the Department. Such records may be subject to audit by the Department of an independent auditor in accordance with section 458 of the EPBC Act or used to verify compliance with the conditions of this approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.</p>	<p>Compliant.</p> <p>Main Roads has maintained records in accordance with this condition and their legal obligations under the <i>WA State Records Act 2000</i>.</p>
12	<p>Within three months of every 12 month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the Department at the same time as the</p>	<p>Compliant.</p> <p>This 2020-2021 Compliance Assessment Report will be published on the Main Roads website at the same time as the provision of this report to the Department.</p>

Condition No.	Condition	Status
	<p>compliance report is published. Reports must remain on the website for the life of this approval. The approval holder must continue to comply with this condition until such time as agreed to in writing by the Minister.</p>	
13	<p>Upon the direction of the Minister, the approval holder must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister. The independent auditor must be approved by the Minister prior to the commencement of the audit. Audit criteria must be agreed to by the Minister and the audit report must address the criteria to the satisfaction of the Minister.</p>	<p>Not applicable.</p> <p>The Minister has not yet directed Main Roads to conduct an independent audit of compliance with EPBC 2016/7761's conditions of approval.</p>
14	<p>The approval holder may choose to revise a management plan approved by the Minister under Condition 8 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the approval holder makes this choice they must notify the Department in writing that the approved plan has been revised and provide the Department, at least four weeks before implementing the revised plan, with:</p> <ul style="list-style-type: none"> a. an electronic copy of the revised plan; b. an explanation of the differences between the revised plan and the approved plan; and c. the reasons the approval holder considers that taking the action in accordance with the revised plan would not be likely to have a new or increased impact. 	<p>Compliant.</p> <p>The approved CEMP was revised on 25 October 2018. No further revision has been undertaken during this reporting period.</p>
15	<p>The approval holder may revoke their choice under Condition 14 at any time by notice to the Department. If the approval holder revokes the choice to implement a revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.</p>	<p>Not applicable.</p> <p>Main Roads has not elected to revoke their choice under Condition 14.</p>

Condition No.	Condition	Status
16	<p>If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then:</p> <ul style="list-style-type: none"> a. Condition 14 does not apply, or ceases to apply, in relation to the revised plan; and b. The approval holder must implement the plan approved by the Minister. <p>To avoid any doubt, this condition does not affect any operation of Conditions 14 and 15 in the period before the day the notice is given.</p>	<p>Not applicable.</p> <p>No notice from the Minister was received in relation to the CEMP amended in accordance with Condition 14.</p>
17	<p>Conditions 14, 15 and 16 are not intended to limit the operation of section 143A of the EPBC Act which allows the approval holder to submit a revised plan to the Minister for approval.</p>	<p>Compliant.</p> <p>The approved CEMP has not been further revised during this reporting period.</p>
18	<p>Unless otherwise agreed to in writing by the Minister, the approval holder must publish all management plans referred to in these conditions of approval on their website for the duration of this approval. Each management plan must be published on the website within 1 month of being approved by the Minister or being submitted under Condition 12 and must remain on the website for the life of this approval.</p>	<p>Compliant.</p> <p>The approved CEMP was first published on Main Roads' website on 2 October 2018. The plan is available here: https://www.mainroads.wa.gov.au/projects-initiatives/projects/regional/Great-northern-highway-muceha/</p>

3 ATTACHMENTS

Attachment	Title
Attachment 1	Artificial nest box monitoring reports

Attachment 1: Artificial nest box monitoring reports



PHOENIX

ENVIRONMENTAL SCIENCES

Black cockatoo breeding activity census 2018-19 for Muchea North

Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project

Prepared for Muchea to Wubin Integrated Project Team (Main Roads
WA, Jacobs and Arup)

October 2019

Final report



Black cockatoo breeding activity census 2018-19 for Muchea North.

Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project.

Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

Draft Report

Authors: John Scanlon, Karen Crews

Reviewer: Anna Leung

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A. Leung	Final report	B	24/10/2019

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[Phoenix Environmental Sciences Pty Ltd](#)

1/511 Wanneroo Rd BALCATTWA WA 6021

P: 08 6323 5410

E: admin@phoenixenv.com.au

Project code: 1220-GNH-JA-VER

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Appendix 1	Results for all hollows in 2017-18 and 2018-19 breeding season
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1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by the Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup) to undertake a Carnaby's Cockatoo breeding activity census over the 2018-19 breeding season within and surrounding the disturbance footprint for the Muchea North project area (Figure 1). This report presents the results of the census.

1.1 BACKGROUND

Muchea North is part of the Great Northern Highway (GNH) Muchea to Wubin Upgrade Stage 2 Project and entails proposed upgrade works to the GNH between Old Gingin Road and Chittering Roadhouse, approximately 63 km north of Perth. The proponent for Muchea North is Main Roads Western Australia ('Main Roads') who, together with industry partners Arup and Jacobs, have formed the Integrated Project Team (IPT).

Detailed black cockatoo habitat assessments conducted as part of the baseline assessments for the Muchea North Project (Phoenix 2015, 2017) recorded all potential breeding trees of species known to support black cockatoo breeding and identified suitable nesting hollows and hollows with evidence of use.

The Commonwealth Department of Environment and Energy (DoEE) deemed Muchea North a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC ref: 2016/7656), with a contributing factor being proposed impacts to Carnaby's Cockatoo (*Calyptorhynchus latirostris*) habitat, including suitable nesting hollows. The species is listed as a matter of national environmental significance (NES) under the EPBC Act, with the conservation status of 'Endangered'. It is also listed as Endangered under the *WA Biodiversity Conservation Act 2016*.

The Muchea North proposal was approved by the Commonwealth Minister for the Environment on 10 August 2018. Conditions of approval in relation to Carnaby's Cockatoo included:

Condition 4: To mitigate and offset the loss of known nesting trees and suitable nesting hollows the approval holder must:

- a. install at least three artificial nesting hollows for each known nesting hollow and suitable hollow cleared*
- b. install at least ten of the artificial nesting hollows required by Condition 4a prior to clearing of any known nesting hollow or suitable nesting hollow with all remaining hollows to be installed prior to the beginning of the next breeding season following the commencement of the action*
- c. maintain the pre-impact breeding density of the Carnaby's Black Cockatoo within the project area by undertaking adaptive management of the artificial nesting hollows to maximise the likelihood that the installed artificial nesting hollows are used by the Carnaby's Black Cockatoo*
- d. adaptive management may cease when at least one artificial nesting hollow for each known nesting hollow cleared has shown evidence of use by the Carnaby's Black Cockatoo, as verified by the suitable qualified person, for three consecutive years, the artificial nesting hollow in use for three consecutive years need not be the same artificial nesting hollow each year.*
- e. n/a*
- f. each artificial nesting hollow installed must*

- i. *be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify maintenance requirements.*
- j. *be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season.*

A native vegetation clearing permit (NVCP) for Muchea North (Permit no. 7563/2) has been approved by the WA Department of Water and Environmental Regulation (DWER) under the *Environmental Protection Act 1986* (EP Act). Permit conditions include the following in relation to artificial black cockatoo nest hollows:

"9. Fauna management – black cockatoo nesting trees

- (a) *Prior to undertaking any clearing of black cockatoo nesting trees outside of the period 1 March to 31 May, the Permit holder shall engage a fauna specialist to conduct a fauna survey of those trees to identify any that are being utilised by *Calyptorhynchus latirostris* (Carnaby's black cockatoo) or *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo)*
- (b) *Where a black cockatoo nesting tree(s) being utilised by Carnaby's cockatoo or forest red-tailed black cockatoo is identified, the Permit Holder shall monitor the black cockatoo nesting tree(s) to determine when the chick(s) has fledged; and*
- (c) *The Permit Holder shall not clear a black cockatoo nesting tree identified as being utilised by Carnaby's cockatoo or forest red-tailed black cockatoo until the chick(s) had fledged.*

"10. Fauna management – artificial black cockatoo nest hollows

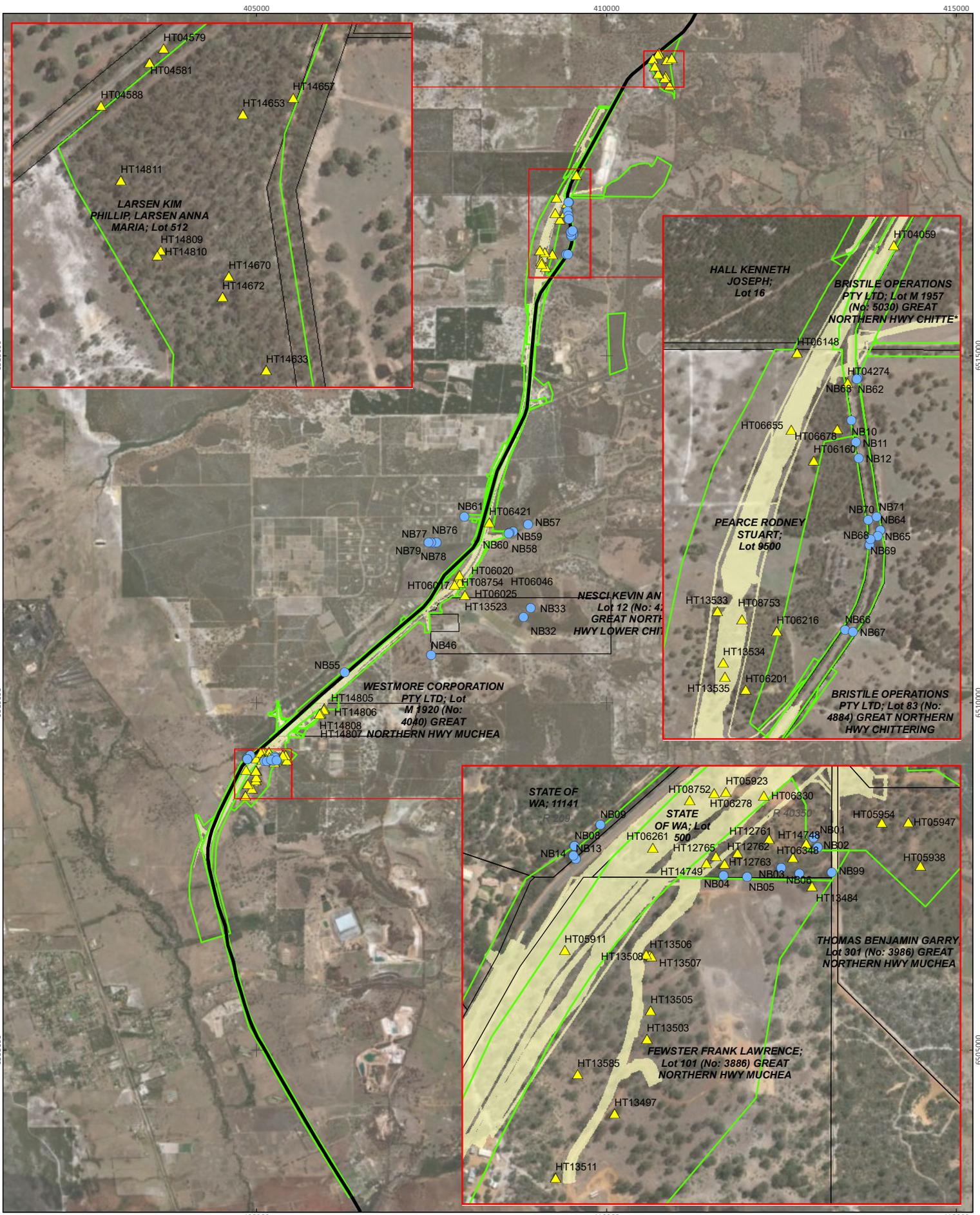
- (c) *The Permit Holder must monitor and maintain the installed artificial black cockatoo nest hollows for a period of at least ten years.*
- (d) *Monitoring and maintenance must be undertaken in accordance with the guidelines provided in Schedule 2."*

To support Condition 4c of EPBC 2016/7656, Main Roads commissioned Phoenix to undertake baseline monitoring of confirmed and suitable nesting hollows recorded within the Muchea North EPBC Act Approval Boundary and wider baseline survey (Phoenix 2015, 2017) study area (the study area; Figure 1). The initial baseline monitoring program was conducted in the 2017-18 breeding season (August 2017 – February 2018) and assessed hollow usage of suitable nesting hollows and hollows with evidence of use within the study area (Phoenix 2018).

Phoenix was subsequently commissioned to undertake a second year of monitoring for hollow usage within the study area in the 2018-19 breeding season. This report incorporates the results of the second monitoring season into the nesting hollow usage dataset for Muchea North.

In addition, artificial nesting hollows were installed for Muchea North in accordance with Condition 4a and 4b of EPBC 2016/7656 at the start of the 2018-19 breeding season. These nest boxes were also monitored for activity during the program, where possible¹, to support Condition 4f of EPBC 2016/7656 and Condition 9c of clearing permit 7563/2.

¹ Not part of original scope, this activity was added in during the program. Artificial nest boxes were only monitored if time permitted, and where accessible.



Jacobs: Great Northern Highway Muechea to Wubin Upgrade
 Stage 2: Carnaby's black cockatoo breeding activity census
 (2018-2019 breeding season)

Project No	1220
Date	18-Jun-19
Drawn by	AL
Map author	AL

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Disturbance footprint
- Road
- Monitored hollows**
- Artificial nesting hollow
- ▲ Natural nesting hollow

Figure 1
Study area and sampling sites



1.2 SCOPE OF WORK

The scope of work was as follows:

1. Conduct a census of all known nesting trees and trees with suitable breeding hollows for Black Cockatoo within the study area – visit each tree monthly between August and February and inspect for evidence of breeding activity of these hollows
2. Time permitting, inspect artificial nesting hollows installed for Muchea North for evidence of breeding activity
3. Prepare a brief memo report documenting the results and providing an estimated utilisation rate considering the 2017-18 and 2018-19 census data.

2 CENSUS METHODOLOGY

Black cockatoos are known to “prospect” for breeding hollows to find the most suitable hollow to lay their eggs. This involves going in and out of the hollow and chewing off around the entrance to the hollow. Chewing around the hollow is often in preparation for egg-laying, as the base of the hollow is lined with these woodchips. Each year the same breeding pair may return to the same hollow, or a different hollow to breed. For Carnaby’s Cockatoo, from egg-laying to fledging of the chick takes approximately 14-16 weeks (DoEE 2019). Recent chewings are generally detectable by fresh marks which are usually a brighter red/orange colour than old chewings and un-chewed wood.

In the most recent breeding season, site visits were undertaken to the study area roughly monthly between August 2018 and February 2019: 21 August, 21 September, 19 October, 28 November, 3 January 2018 and 5 February.

Each hollow was inspected for evidence of nesting activity such as prospecting (adults investigating the hollow), fresh chewing around the hollow entrance or females perched at the entrance to the hollow. Trees with evidence of nesting activity were investigated using a pole camera to determine if eggs or chicks were in the nest when adults were not around (i.e. out foraging; this was to avoid disturbance).

Baseline surveys for Muchea North identified a total of 57 trees in the study area containing suitable nesting hollows for black cockatoos, of which 25 had evidence of nesting activity (Table 1). In the 2017-18 breeding season, 37 of these were monitored as the remaining 20 were unable to be assessed due to access constraints.

In the 2018-19 season, 47 natural nesting hollows and 36 artificial nesting hollows were monitored (Table 1). This included two new natural hollows added to the census in the current season and 14 trees that were not accessible in the 2017-18 season. Twelve further natural nesting hollows were not monitored; five of these were not able to be accessed, three were not relocated and four hollows were removed from monitoring in the 2017-18 season due to collapse, cracks forming or tree death.

In this report:

- *confirmed breeding event* – means eggs were seen in hollow and/or other clear evidence observed that chick was present (i.e. female seen at hollow entrance when brooding eggs and/or parents seen preparing to feed chick in the hollow)
- *evidence of nesting activity* – means chewing around the hollow entrance and/or bird seen prospecting hollows. It does not necessarily mean that a breeding event took place that year; however, it is evidence that the hollow is suitable and was considered and may have been used in previous years.

Table 1 Monitored hollows

HT ID*	Baseline records (pre 2017-18)	Species	Monitored 2017-18	Monitored 2018-19
HT04059	Evidence of nesting activity, artificial hollow	<i>Eucalyptus wandoo</i>	Yes	Yes
HT04274	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT04579	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT04581	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT04588	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus accedens</i>	Yes	Yes
HT05911	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	No
HT05923	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT05938	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No
HT05947	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No
HT05954	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06017	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes
HT06020	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes
HT06025	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT06046	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT06148	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No
HT06160	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06201	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06216	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	Yes	Yes
HT06261	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06278	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06330	Not suitable	<i>Eucalyptus wandoo</i>	No	Yes
HT06348	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT06421	Evidence of nesting activity	<i>Corymbia calophylla</i>	No access	No access
HT06655	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No
HT06678	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT08752	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT08753	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT08754	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes
HT12761	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No	No
HT12762	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT12763	Evidence of nesting activity (FRTBC)	<i>Eucalyptus wandoo</i>	Yes	Yes
HT12765	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT13484	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT13497	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes
HT13503	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes

Black cockatoo breeding activity census 2018-19 for Muchea North

Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

HT ID*	Baseline records (pre 2017-18)	Species	Monitored 2017-18	Monitored 2018-19
HT13505	Suitable, no evidence of breeding	<i>Eucalyptus sp.</i>	No access	Yes
HT13506	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT13507	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT13508	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT13511	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes
HT13523	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes
HT13533	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT13534	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT13535	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT13585	Not suitable	<i>Corymbia calophylla</i>	No	Yes
HT14633	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14653	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14657	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14670	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	No
HT14672	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14748	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14749	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14805	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access
HT14806	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access
HT14807	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access
HT14808	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access
HT14809	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14810	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
HT14811	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes
NB01	n/a		n/a	Yes
NB02	n/a		n/a	Yes
NB03	n/a		n/a	Yes
NB04	n/a		n/a	Yes
NB05	n/a		n/a	Yes
NB06	n/a		n/a	Yes
NB08	n/a		n/a	Yes
NB09	n/a		n/a	Yes
NB10	n/a		n/a	Yes
NB11	n/a		n/a	Yes
NB12	n/a		n/a	Yes
NB13	n/a		n/a	Yes
NB14	n/a		n/a	Yes
NB32	n/a		n/a	Yes

Black cockatoo breeding activity census 2018-19 for Muchea North
Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

HT ID*	Baseline records (pre 2017-18)	Species	Monitored 2017-18	Monitored 2018-19
NB33	n/a		n/a	Yes
NB46	n/a		n/a	Yes
NB55	n/a		n/a	Yes
NB57	n/a		n/a	Yes
NB58	n/a		n/a	Yes
NB59	n/a		n/a	Yes
NB60	n/a		n/a	Yes
NB61	n/a		n/a	Yes
NB62	n/a		n/a	Yes
NB63	n/a		n/a	Yes
NB64	n/a		n/a	Yes
NB65	n/a		n/a	Yes
NB66	n/a		n/a	Yes
NB67	n/a		n/a	Yes
NB68	n/a		n/a	Yes
NB69	n/a		n/a	Yes
NB70	n/a		n/a	No
NB71	n/a		n/a	Yes
NB76	n/a		n/a	Yes
NB77	n/a		n/a	Yes
NB78	n/a		n/a	Yes
NB79	n/a		n/a	Yes
NB99	n/a		n/a	Yes

* HT = habitat tree (natural); NB = nest box (artificial)

3 RESULTS

3.1 CENSUS RESULTS 2018-19 BREEDING SEASON

Eight of the trees in the monitoring program were felled during the 2018-19 breeding season for the Muchea North Project, including three with hollows that recorded evidence of nesting activity in 2017-18 (Appendix 1). On this basis, the 2018-19 breeding season does not represent a true baseline, and therefore the results for the new artificial nesting hollows – erected to offset the cleared natural hollows – have been included in the 2018-19 census.

Confirmed breeding events were recorded in three hollows by Phoenix, two natural nesting hollows and one artificial nesting hollow (Table 2; Figure 2). Evidence of nesting activity was observed in a further three natural nesting hollows and two artificial nesting hollows (Table 2; Figure 2).

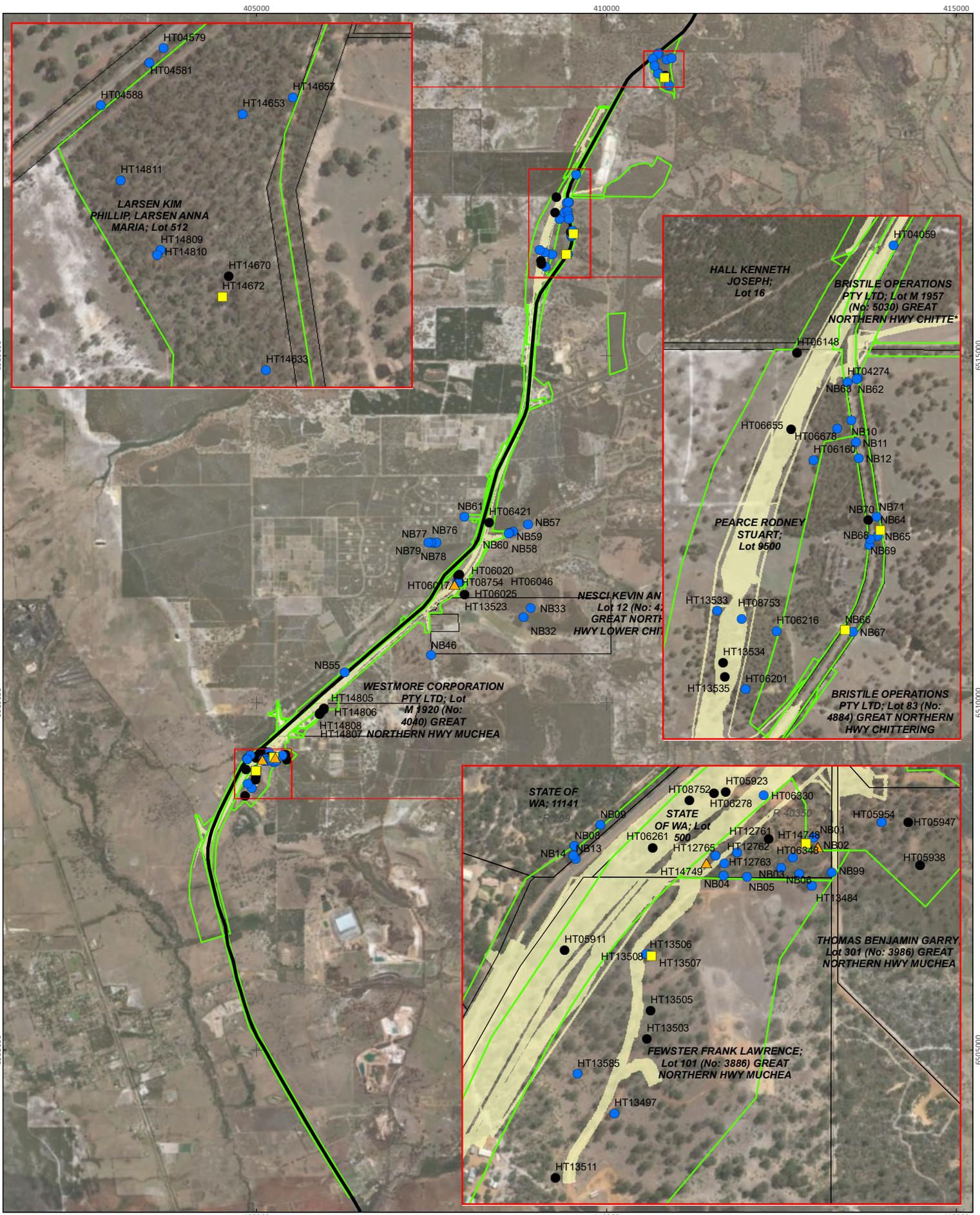
Of the confirmed breeding events:

- HT08754 – is presumed to have resulted in successful fledgling of chick. Chick photographed.
- HT14749 – is presumed to have resulted in successful fledgling of chick. The hollow is too high to inspect with a camera but activity observed suggests chick present.
- NB02 – laying of eggs is suspected but unknown if chick hatched or fledged.

No evidence of nesting was observed in 30 of the natural nesting hollows (Appendix 1). Four natural nesting hollows that were not accessible in the 2017-18 season were considered no longer suitable for use by black cockatoos and no longer require monitoring (Appendix 1).

Table 2 Evidence of breeding records by Phoenix during the 2018-19 census

HT ID	Inspection date						Result_2018-19	Photo
	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019		
HT08754	No access	No flush	No flush	No flush	No flush	CBC chick photog. prev. week	Confirmed breeding event. Assumed successful.	
HT14749	No flush	Carnaby's: pair prospecting + other female in hollow with 2 entrances, female squabbling calls.	No flush (could be present with chick)	Carnaby's M+F flushed, +F inside ?feeding young	No flush	No flush, no activity all morning	Confirmed breeding event. Assumed successful.	
NB02	n/a	n/a	No flush	CBC Pair flew off and returned, F entered box. ?laying (by sound). Too high for camera.	No flush	No flush	Confirmed breeding event. Unknown if successful.	
NB66	n/a	n/a	CBC F on box, flushed	CBC 1F on nest	No flush. Camera check, empty. CBC calls to W	No flush	Evidence of nesting activity	Plate 1
HT13507	No flush	No flush	No flush	No flush. Fresh chewing	No flush	No flush	Evidence of nesting activity	
HT14672	No flush	No flush	No flush. Redtail foraging traces	No flush	No flush	No flush	Evidence of nesting activity	
HT14748	No flush	No flush	Flushed CBC female	No flush. Camera check: empty	No flush	No flush	Evidence of nesting activity	Plate 2
NB64	n/a	n/a	No flush; CBC pair in upper branches, M feeding F	No flush	No flush	No flush	Evidence of nesting activity	



Jacobs: Great Northern Highway Muechea to Wubin Upgrade
 Stage 2: Carnaby's black cockatoo breeding activity census
 (2018-2019 breeding season)

Project No	1220
Date	18-Jun-19
Drawn by	AL
Map author	AL

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Disturbance footprint
- Road
- Results**
- ▲ Confirmed breeding event
- Evidence of nesting activity
- No evidence of breeding
- Not surveyed (no access, no longer suitable, not located, tree felled)

Figure 2

Monitoring result for 2018-19 breeding season

PHOENIX
ENVIRONMENTAL SCIENCES



Plate 1 NB66 19 October 2018



Plate 2 HT14748 19 October 2018

3.2 COMPARISON BETWEEN 2017-18 SEASON AND 2018-19 SEASON

Abundance of confirmed nesting events and evidence of nesting activity was lower in the 2018-19 breeding season compared with the 2017-18 season (Table 3).

The average number of confirmed breeding events over the two seasons is five. The average number of hollows observed with evidence of nesting activity, but no confirmed breeding event is 10.

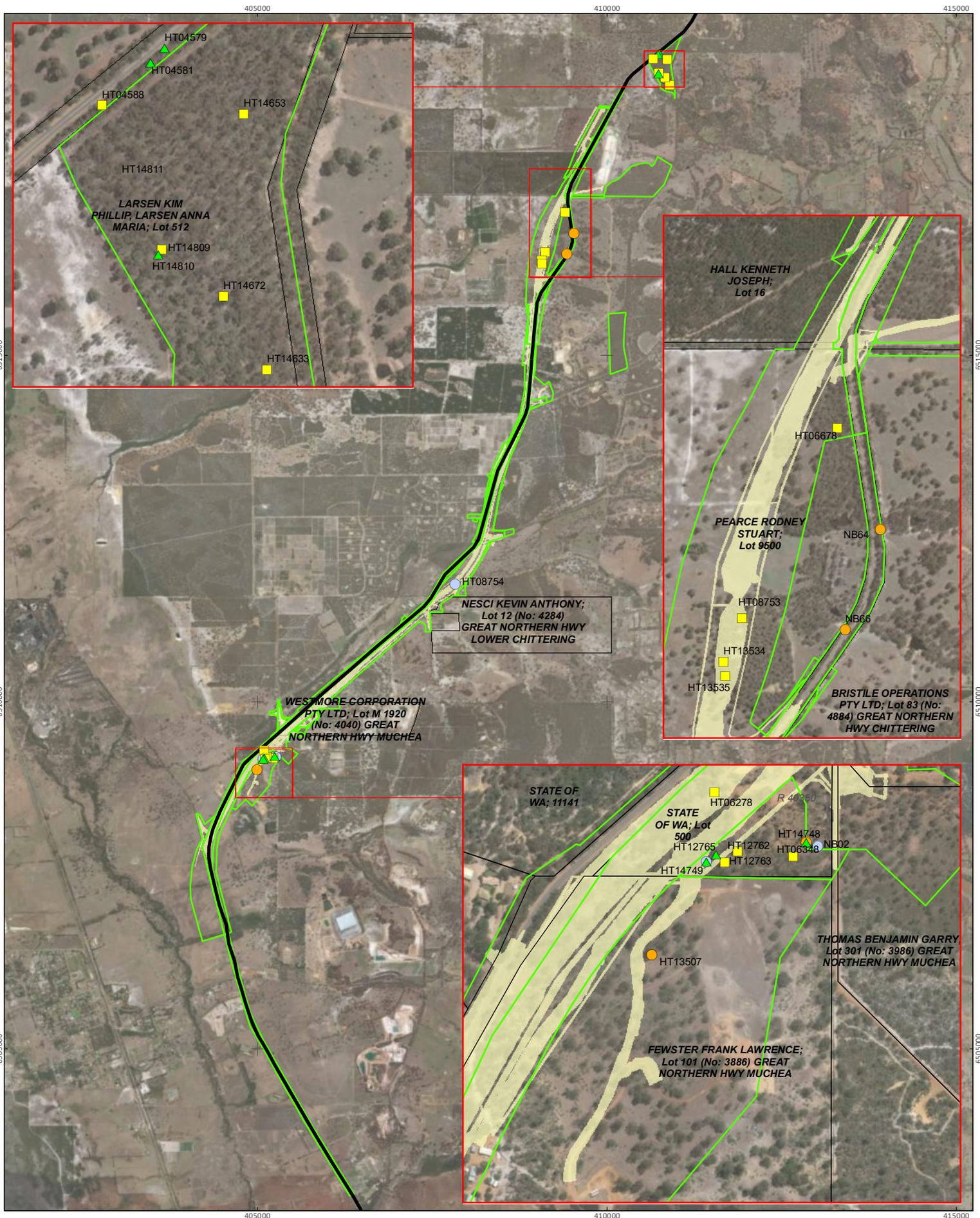
Breeding events and evidence of nesting activity in 2018-19 were identified in the same general areas as in the 2017-18 season, including the two areas that were identified as having a higher rate of breeding activity, Reserve 40350 and Lot 512 (Figure 3). The 2018-19 results indicate however that breeding activity is also occurring elsewhere in the study area and is not limited to these two lots.

Three hollows, HT14749, HT14672 and HT14748, recorded breeding activity over both seasons (Appendix 1). The remaining hollows with breeding activity in 2018-19 were either not accessible in the 2017-18 season or were new artificial hollows (Appendix 1). Four hollows with confirmed breeding events in 2017-18 and 12 hollows with evidence of nesting activity in 2017-2018 were not recorded with any activity in 2018-19.

Table 3 Summary of results for 2017-18 and 2018-19 breeding seasons

Result type	Baseline records pre 2017-18 ¹ Natural hollows and existing artificial hollows	2017-18 breeding season Natural hollows and existing artificial hollows	2018-19 breeding season All hollows {natural&existing artificial hollows/new artificial hollows}	Average across 2017-18 and 2018-19 All hollows
Confirmed breeding event	n/a	6	3 {2/1}	5
Evidence of nesting activity	24	14	5 {3/2}	10
No evidence of breeding	35	13	63 {30/33}	38
No longer suitable, not accessible, not sampled, felled	n/a	26	25 {24/1}	26

¹ Evidence of nesting activity recorded at some point. Not annual census data and cannot be compared with annual census results.



Jacobs: Great Northern Highway Muchea to Wubin Upgrade
 Stage 2: Carnaby's black cockatoo breeding activity census
 (2018-2019 breeding season)

Project No	1220
Date	18-Jun-19
Drawn by	AL
Map author	AL

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Disturbance footprint
- Road

- 2018-2019 breeding season**
- Confirmed breeding event
 - Evidence of nesting activity
- 2017-2018 breeding season**
- ▲ Confirmed breeding event
 - Evidence of nesting activity

Figure 3
 Confirmed breeding events and
 Evidence of nesting activity across
 the 2017-2018 and 2018-2019
 breeding seasons



4 CONCLUSION

Three confirmed breeding events were observed in the 2018-19 season and evidence of nesting was observed in a further five hollows, with both natural and artificial nesting hollows showing activity.

The difference in nesting activity recorded between the 2017-18 and 2018-19 seasons is not unexpected as the sample size for this monitoring program is small and breeding activity can be highly variable between years.

The 2018-19 census results indicate that breeding activity is occurring throughout the Muchea North area. Due to the historic large-scale clearing of trees and continuing decline of suitable trees with hollows in the area, all remaining suitable nesting hollows in the study area should be considered of high value to Carnaby's Cockatoo.

Considering the artificial nesting hollows were installed during the current season, the observations of a breeding event and/or evidence of nesting activity in three of these indicate the readiness of Carnaby's Cockatoo to prospect new hollows.

For the purposes of future monitoring, the pre-impact breeding density is defined as:

- the average number of confirmed breeding events over two seasons = five
- the average number of hollows observed with evidence of nesting activity over two seasons = 10.

For future monitoring of the nesting hollows, consistent methodology should be employed to that used in the 2017-18 and 2018-19 breeding census. Where possible, pole cameras should be used to inspect suspected breeding events.

5 REFERENCES

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- Phoenix. 2015. *Flora and fauna assessment for Muchea North and Chittering study area*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup).
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- Phoenix. 2018. *Muchea North Black Cockatoo breeding activity census*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Main Roads Western Australia.

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

Appendix 1 Results for all hollows in 2017-18 and 2018-19 breeding season

HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
HT04059	No evidence of breeding	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT04274	No evidence of breeding	No evidence of breeding	No flush	No flush. Bees in hollow	No flush	No flush. Bees in hollow	No flush	No flush
HT04579	Confirmed breeding event - failed	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT04581	Confirmed breeding event - failed	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT04588	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT05911	No access	Hollow not located						
HT05923	No evidence of breeding	Felled. Further monitoring not required.	No flush	Felled. Further monitoring not required.				
HT05938	No longer suitable hollow. Further monitoring not required							
HT05947	No evidence of breeding	Not located		Not located				
HT05954	No evidence of breeding	No evidence of breeding	No access	No flush. Duck down, bees in lower hollow	No flush	No flush	No flush	No flush
HT06017	No access	No evidence of breeding	No flush	No flush	No flush. Galah in smaller hollow	No flush	No flush	No flush
HT06020	No access	Felled. Further monitoring not required.	No flush	Felled. Further monitoring not required.				
HT06025	No access	No evidence of breeding	No flush. Hollow located has bees	No flush	No flush	No flush	No flush	No flush
HT06046	No access	Felled. Further monitoring not required.	No flush	Felled. Frogmouth				

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
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HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
				flushed, Carnaby's pair nearby reacting to chainsaw. Further monitoring not required.				
HT06148	No longer suitable. Further monitoring not required.							
HT06160	No evidence of breeding	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT06201	No evidence of breeding	No evidence of breeding	No flush. Marri nut carried in by FRTBC at base of tree.	No flush	No flush	No flush	No flush	No flush
HT06216	No evidence of breeding	No evidence of breeding	No flush	No flush. Carnaby's sightings & calls in vicinity	No flush	No flush	No flush	No flush
HT06261	No evidence of breeding	Felled. Further monitoring not required.	No flush	No flush	No flush	Felled. Further monitoring not required.		
HT06278	Evidence of nesting activity	Felled. Further monitoring not required.	No flush	No flush	No flush	No flush	Felled. Further monitoring not required.	
HT06330	Not sampled	No evidence of breeding. Added to breeding census in 2018-19.	No flush	No flush	No flush	No flush	No flush	No flush
HT06348	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT06421	No access. Evidence of nesting activity (from a distance)	No access	No access	No access	No access	No access	No access	
HT06655	No longer suitable. Further monitoring not required.							

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
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HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
HT06678	Evidence of nesting activity (FRTBC)	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT08752	No evidence of breeding	Felled. Further monitoring not required.	No flush	No flush.	No flush	No flush	Felled. Further monitoring not required.	
HT08753	Evidence of nesting activity	No evidence of breeding	No flush	No flush. Fresh scarring from Galahs.	No flush	No flush	No flush	No flush
HT08754	No access	Confirmed breeding event	No access	No flush.	No flush	No flush	No flush	CBC chick photog. prev. week; to be felled when fledged
HT12761	Hollow not located	Hollow not located		Not seen				
HT12762	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT12763	Evidence of nesting activity	No evidence of breeding	No flush	No flush. Duck scat around entrance	No flush	No flush	No flush	No flush
HT12765	Confirmed breeding event - successful	No evidence of breeding. May no longer be suitable	No flush	No flush	No flush	No flush	No flush	No flush. Lopped for powerline clearance
HT13484	No access	No evidence of breeding	No flush	No flush. Corella in other hollow	No flush. Corella in other hollow	No flush	No flush	No flush
HT13497	No access	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT13503	No access	No longer suitable. Further monitoring not required.	Hollow no longer suitable					
HT13505	No access	No longer suitable. Further monitoring not required.	Hollow no longer suitable					
HT13506	No access	No evidence of breeding	Duck down at hollow entrance	No flush	No flush	No flush	No flush	No flush

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
HT13507	No access	Evidence of nesting activity	No flush	No flush	No flush	No flush. Fresh chewing	No flush	No flush
HT13508	No access	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT13511	No access	No longer suitable. Further monitoring not required.	Hollow no longer suitable					
HT13523	No access	No longer suitable. Further monitoring not required.	No flush	Hollow no longer suitable. Further monitoring not required.				
HT13533	No evidence of breeding	No evidence of breeding	No flush	No flush	No flush. Tree martins in hollows	No flush	No flush	No flush
HT13534	Evidence of nesting activity	Felled. Further monitoring not required.	No flush	Felled. Further monitoring not required.				
HT13535	Evidence of nesting activity	Felled. Further monitoring not required.	No flush	Felled. Further monitoring not required.				
HT13585	Not sampled	No evidence of breeding. Added to breeding census in 2018-19, chewing observed at hollow.		No flush		No flush	No flush	No flush
HT14633	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush. CBC calls to south	No flush	No flush	No flush
HT14653	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT14657	No evidence of breeding	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT14670	Collapsed, no longer suitable. Further monitoring not required.							

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
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HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
HT14672	Evidence of nesting activity	Evidence of nesting activity	No flush	No flush. Duck flushed from lower hollow	No flush. Redtail foraging traces	No flush	No flush	No flush
HT14748	Confirmed breeding event - successful	Evidence of nesting activity	No flush	No flush	Flushed CBC female	No flush. Camera check: empty	No flush	No flush
HT14749	Confirmed breeding event - successful	Confirmed breeding event	No flush	Carnaby's: pair prospecting + other female in hollow with 2 entrances, female squabbling calls.	No flush (could be present with chick)	Carnaby's M+F flushed, +F inside ?feeding young	No flush	No flush, no activity all morning
HT14805	No access	No access	No access	No access	No access	No access		
HT14806	No access	No access	No access	No access	No access	No access		
HT14807	No access	No access	No access	No access	No access	No access		
HT14808	No access	No access	No access	No access	No access	No access		
HT14809	Evidence of nesting activity	No evidence of breeding	No flush	No flush	No flush. Ringnecks x4 at tree	No flush	No flush	No flush
HT14810	Confirmed breeding event - failed	No evidence of breeding	No flush	No flush	No flush	No flush	No flush	No flush
HT14811	No evidence of breeding	No evidence of breeding	No flush	No flush. Corella pair in other hollow	No flush	No flush	No flush. CBC calls to E & W	No flush
NB01	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB02	n/a	Confirmed breeding event	n/a	n/a	No flush	CBC Pair flew off and returned, F entered box,	No flush	No flush

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
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HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
						?laying (by sound). Too high for camera.		
NB03	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB04	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB05	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB06	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB08	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB09	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush
NB10	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB11	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush. Marri canker	No flush
NB12	n/a	No evidence of breeding	n/a	n/a	No flush; mob of CBC ~100m S drinking at dam	Not seen	No flush	No flush
NB13	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB14	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB32	n/a	No evidence of breeding/no access	n/a	n/a	Not seen	No access	No access	
NB33	n/a	No evidence of breeding/no access	n/a	n/a	Not seen	No access	No access	
NB46	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB55	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB57	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB58	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
NB59	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB60	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB61	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB62	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush. CBC call to west	No flush
NB63	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB64	n/a	Evidence of nesting activity	n/a	n/a	No flush; CBC pair in upper branches, M feeding F	No flush	No flush	No flush
NB65	n/a	No evidence of breeding	n/a	n/a	No flush; red-tails calling to E	No flush	No flush	No flush
NB66	n/a	Evidence of nesting activity	n/a	n/a	CBC F on box, flushed as vehicle passed	CBC 1F on nest	No flush. Camera check, empty. CBC calls to W	No flush
NB67	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush
NB68	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB69	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB70	n/a	Not surveyed	n/a	n/a	Not seen	Not seen	Not seen	
NB71	n/a	No evidence of breeding	n/a	n/a	No flush	No flush	No flush	No flush
NB76	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush
NB77	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush
NB78	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush
NB79	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush

Black cockatoo breeding activity census 2018-19 assessment for the Muchea North
Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup)

HT ID	Result 2017-18	Result 2018-19	21/08/2018	21/09/2018	19/10/2018	28/11/2018	3/01/2019	5/02/2019
NB99	n/a	No evidence of breeding	n/a	n/a	Not seen	No flush	No flush	No flush





PHOENIX

ENVIRONMENTAL SCIENCES

Black cockatoo breeding activity census 2019-20 for Muchea North
Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project

Prepared for Main Roads WA

April 2020

Final



Black cockatoo breeding activity census 2019-20 for Muchea North.
Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project.
Prepared for Main Roads WA

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[Phoenix Environmental Sciences Pty Ltd](#)

2/3 King Edward Rd Osborne Park WA 6017

P: 08 6323 5410

E: admin@phoenixenv.com.au

Project code: 1272-SR159-MR-VER

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1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Main Roads WA, to undertake a Carnaby's Cockatoo breeding activity census over the 2019-20 breeding season within and surrounding the disturbance footprint for the Muchea North project area (Figure 1). This report presents the results of the census.

1.1 BACKGROUND

Main Roads is currently upgrading the Great Northern Highway (GNH) between Straight Line Kilometre (SLK) 38.60 and 51.40 (referred to as Muchea North Upgrade). The Muchea North Upgrade proposal was referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 1 March 2016 (EPBC 2016/7656), assessed as a controlled action and granted conditional approval in August 2018.

Muchea North Upgrade resulted in the loss of 13 Carnaby's Black Cockatoo nesting hollows. To mitigate and offset the loss of these, Main Roads was required to install 39 artificial nest boxes (Figure 1). In accordance with EPBC 2016/7656 Conditions 4f(i) and (ii) each artificial nesting hollow installed must:

- EPBC 2016/7656 condition f(i): be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify any maintenance requirements
- EPBC 2016/7656 condition f(ii): be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season.

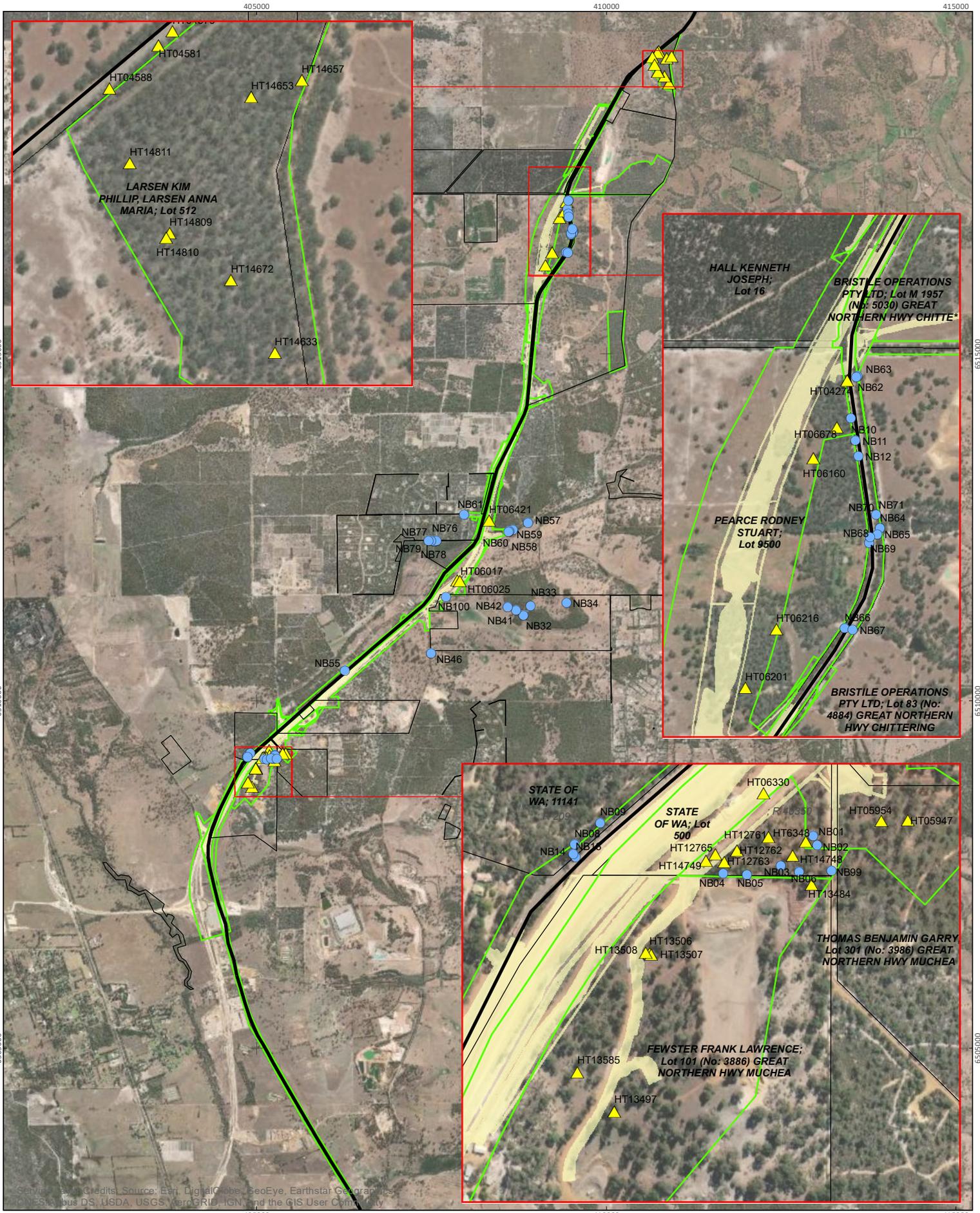
The monitoring campaign will also require monitoring of previously recorded natural hollows suitable for Carnaby's Cockatoo (Figure 1). Monitoring of artificial and natural hollows shall be monitored in accordance with How to Monitor and Maintain Artificial Hollows for Carnaby's Cockatoo (DPaW 2015).

Detailed black cockatoo habitat assessments conducted as part of the baseline assessments for the Muchea North project (Phoenix 2015, 2017a) recorded all potential breeding trees of species known to support black cockatoo breeding and identified suitable nesting hollows and hollows with evidence of use.

A native vegetation clearing permit (NVCP) for Muchea North (Permit no. 7563/2) has been approved by the WA Department of Water and Environmental Regulation (DWER) under the *Environmental Protection Act 1986* (EP Act).

To support Condition 4c of EPBC 2016/7656, Main Roads commissioned Phoenix to undertake monitoring of confirmed and suitable nesting hollows recorded within the Muchea North EPBC Act Approval Boundary and wider baseline survey area (Phoenix 2015, 2017a) (the study area; Figure 1). The initial baseline monitoring program was conducted in the 2017-18 breeding season (August 2017 – February 2018) and assessed hollow usage of suitable nesting hollows and hollows with evidence of use within the study area (Phoenix 2018). A second year of monitoring for hollow usage within the study area in the 2018-19 breeding season was undertaken by Phoenix from August 2018 to February 2019 (Phoenix 2019). The artificial nesting hollows were installed during the 2018-2019 breeding season, therefore the results of these first two surveys collectively represent the pre-impact breeding density.

Phoenix was subsequently commissioned to undertake a third year of monitoring for hollow usage within the study area in the 2019-2020 breeding season. This report incorporates the results of the third monitoring season into the nesting hollow usage dataset for Muchea North.



Main Roads WA Great Northern Highway, M2W Upgrade Project	
Project No	1272
Date	26-Mar-20
Drawn by	AJ
Map author	AJ
	
	
1:70,000 (at A4) GDA 1994 MGA Zone 50	

- Study area
- Disturbance footprint
- Road
- Monitored hollows**
- Artificial nesting hollow
- ▲ Natural nesting hollow

Figure 1
Study area and sampling sites



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1.2 SCOPE OF WORK

The scope of work was as follows:

Six rounds of monitoring of artificial and natural nest hollows to be undertaken between August 2019 and January 2020.

During inspections of artificial and natural hollows, record evidence of use by Carnaby's Cockatoos at each artificial and natural hollow in accordance with (DPaW 2015).

During inspections, identify any artificial nest box maintenance needs in accordance with (DPaW 2015) and whether natural hollows remain suitable for use by Carnaby's Black Cockatoo.

Provide a report that summarises all records required by Conditions 4f(i) and (ii) of EPBC 2016/7656 for all artificial and natural hollows inspected. The draft report shall be provided to Main Roads in electronic PDF and Word version copy format.

2 CENSUS METHODOLOGY

Methods were consistent with the approach undertaken in previous monitoring events for Muchea North (Phoenix 2018, 2019).

Prior to the surveys, site locations (artificial and natural nest hollows) were loaded onto field tablets. Data was collected electronically using a customised data collection template and included:

- site code
- signs of use – birds prospecting hollows, fresh chewings, birds perching, birds entering/existing hollows, birds flushed from hollows, gender of observed birds, chick calls, eggs observed (inc. status if possible – incubated or abandoned), chick/s observed, chick/s fledged
- other indicators, e.g. gender mix of flocks, evidence of nesting at base of trees
- condition of hollow, current suitability for use (natural hollows), maintenance requirements (artificial hollows).

The knocking and scraping method was conducted at the base of trees for all monitored hollows. Other observational methods were also employed, i.e. pole camera inspections of hollows where possible, listening for nest activity, flock and individual bird behaviour.

Consistent with previous methodology the following activities were undertaken:

- evidence of nesting activity was noted where fresh chewing is around the hollow entrance and/or birds are seen prospecting hollows.
- a confirmed breeding event was noted where eggs are seen in hollow and/or other clear evidence observed that a chick is present (i.e. female seen at hollow entrance when during brooding eggs, and/or parents seen preparing to feed chick in the hollow).

Maintenance checks of artificial hollows will assess the following as a minimum:

- condition of chewing posts
- condition of attachment points
- condition of hollow bases
- stability of tree or pole used to mount the artificial hollow.

As per previous surveys, site visits were undertaken every 4-5 weeks between August 2019 and January 2020: 15 August, 17 September, 22 October, 22 November, 21 December and 20 January.

The baseline surveys for Muchea North identified a total of 57 trees in the study area containing suitable nesting hollows for black cockatoos, of which 25 had evidence of nesting activity. In the initial survey 37 of these were monitored as the remaining 20 were unable to be assessed due to access constraints.

In the 2018-19 season, 47 natural nesting hollows and 36 artificial nesting hollows were monitored. This included two new natural hollows added to the census in the current season and 14 trees that were not accessible in the 2017-18 season. Twelve further natural nesting hollows were not monitored; five of these were not able to be accessed, three were not relocated and four hollows were removed from monitoring in the 2017-18 season due to collapse, cracks forming or tree death.

In the current survey a total of 73 hollows were monitored, of which 33 were natural nesting hollows and 40 were artificial nesting hollows (Table 1). Prior to the survey, 13 trees which contained suitable nesting hollows were removed as part of the GNH road upgrades (HT05911, HT05923, HT06020, HT06046, HT06261, HT06278, HT06655, HT08752, HT08753, HT08754, HT13533, HT13534 and HT13535), 12 of these were monitored in the previous two monitoring programs and one was not accessible. These 13 trees were offset by the installation of the 39 artificial nesting hollows of which all were able to be monitored this season. An additional artificial nesting hollow (NB100) was included in the survey which was erected to replace HT04059. Four natural nesting hollows from the baseline dataset that had not been monitored in the previous two years were this year able to be surveyed because landowner access had been granted. Four trees with natural nesting hollows were not surveyed this year because the tree or hollow was no longer considered suitable.

In this report:

- *confirmed breeding event* – means eggs were seen in hollow and/or other clear evidence observed that chick was present (i.e. female seen at hollow entrance when brooding eggs and/or parents seen preparing to feed chick in the hollow)
- *evidence of nesting activity* – means chewing around the hollow entrance and/or bird seen prospecting hollows. It does not necessarily mean that a breeding event took place that year; however, it is evidence that the hollow is suitable and was considered and may have been used in previous years.

Table 1 Monitored hollows

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT04059	Evidence of nesting activity, artificial hollow	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT04274	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT04579	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT04581	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT04588	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus accedens</i>	Yes	Yes	Yes
HT05911	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus accedens</i>	No access	No access	No (tree cleared)
HT05923	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT05938	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No	No (not suitable – hollow has cracked or degraded)
HT05947	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No	Yes
HT05954	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT06017	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT06020	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes	No (tree cleared)
HT06025	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT06046	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	No (tree cleared)
HT06148	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No	No (not suitable – hollow has cracked or degraded)
HT06160	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT06201	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT06216	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	Yes	Yes	Yes
HT06261	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT06278	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT06330	Not suitable	<i>Eucalyptus wandoo</i>	No	Yes	Yes
HT06348	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT06421	Evidence of nesting activity	<i>Corymbia calophylla</i>	No access	No access	No (no access)

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT06655	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No	No (tree cleared)
HT06678	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT08752	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT08753	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT08754	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes	No (tree cleared)
HT12761	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No	No	Yes
HT12762	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT12763	Evidence of nesting activity (FRTBC)	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT12765	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT13484	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT13497	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes	Yes
HT13503	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13505	Suitable, no evidence of breeding	<i>Eucalyptus sp.</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13506	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT13507	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT13508	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes
HT13511	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13523	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13533	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT13534	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT13535	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)
HT13585	Not suitable	<i>Corymbia calophylla</i>	No	Yes	Yes
HT14633	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14653	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14657	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14670	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	No	No (not suitable – hollow collapsed)
HT14672	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14748	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14749	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14805	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14806	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14807	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14808	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14809	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14810	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
HT14811	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes
NB01	n/a	n/a	n/a	Yes	Yes
NB02	n/a	n/a	n/a	Yes	Yes
NB03	n/a	n/a	n/a	Yes	Yes
NB04	n/a	n/a	n/a	Yes	Yes
NB05	n/a	n/a	n/a	Yes	Yes
NB06	n/a	n/a	n/a	Yes	Yes
NB08	n/a	n/a	n/a	Yes	Yes
NB09	n/a	n/a	n/a	Yes	Yes
NB10	n/a	n/a	n/a	Yes	Yes

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
NB11	n/a	n/a	n/a	Yes	Yes
NB12	n/a	n/a	n/a	Yes	Yes
NB13	n/a	n/a	n/a	Yes	Yes
NB14	n/a	n/a	n/a	Yes	Yes
NB32	n/a	n/a	n/a	Yes	Yes
NB33	n/a	n/a	n/a	Yes	Yes
NB34	n/a	n/a	n/a	n/a	Yes
NB41	n/a	n/a	n/a	n/a	Yes
NB42	n/a	n/a	n/a	n/a	Yes
NB46	n/a	n/a	n/a	Yes	Yes
NB55	n/a	n/a	n/a	Yes	Yes
NB57	n/a	n/a	n/a	Yes	Yes
NB58	n/a	n/a	n/a	Yes	Yes
NB59	n/a	n/a	n/a	Yes	Yes
NB60	n/a	n/a	n/a	Yes	Yes
NB61	n/a	n/a	n/a	Yes	Yes
NB62	n/a	n/a	n/a	Yes	Yes
NB63	n/a	n/a	n/a	Yes	Yes
NB64	n/a	n/a	n/a	Yes	Yes
NB65	n/a	n/a	n/a	Yes	Yes
NB66	n/a	n/a	n/a	Yes	Yes
NB67	n/a	n/a	n/a	Yes	Yes
NB68	n/a	n/a	n/a	Yes	Yes
NB69	n/a	n/a	n/a	Yes	Yes
NB71	n/a	n/a	n/a	Yes	Yes
NB76	n/a	n/a	n/a	Yes	Yes
NB77	n/a	n/a	n/a	Yes	Yes
NB78	n/a	n/a	n/a	Yes	Yes
NB79	n/a	n/a	n/a	Yes	Yes
NB99	n/a	n/a	n/a	Yes	Yes
NB100	HT04059 was cleared and this nestbox was installed to replace it in 2019	n/a	n/a	n/a	Yes

* HT = habitat tree (natural); NB = nest box (artificial)

3 RESULTS

3.1 CENSUS RESULTS 2019-20 BREEDING SEASON

Confirmed breeding events were recorded in three artificial nesting hollows and three natural nesting hollows by Phoenix, (Table 2; Figure 2). Evidence of nesting activity was observed in a further ten artificial nesting hollows and four natural nesting hollows (Table 2; Figure 2).

Of the confirmed breeding events:

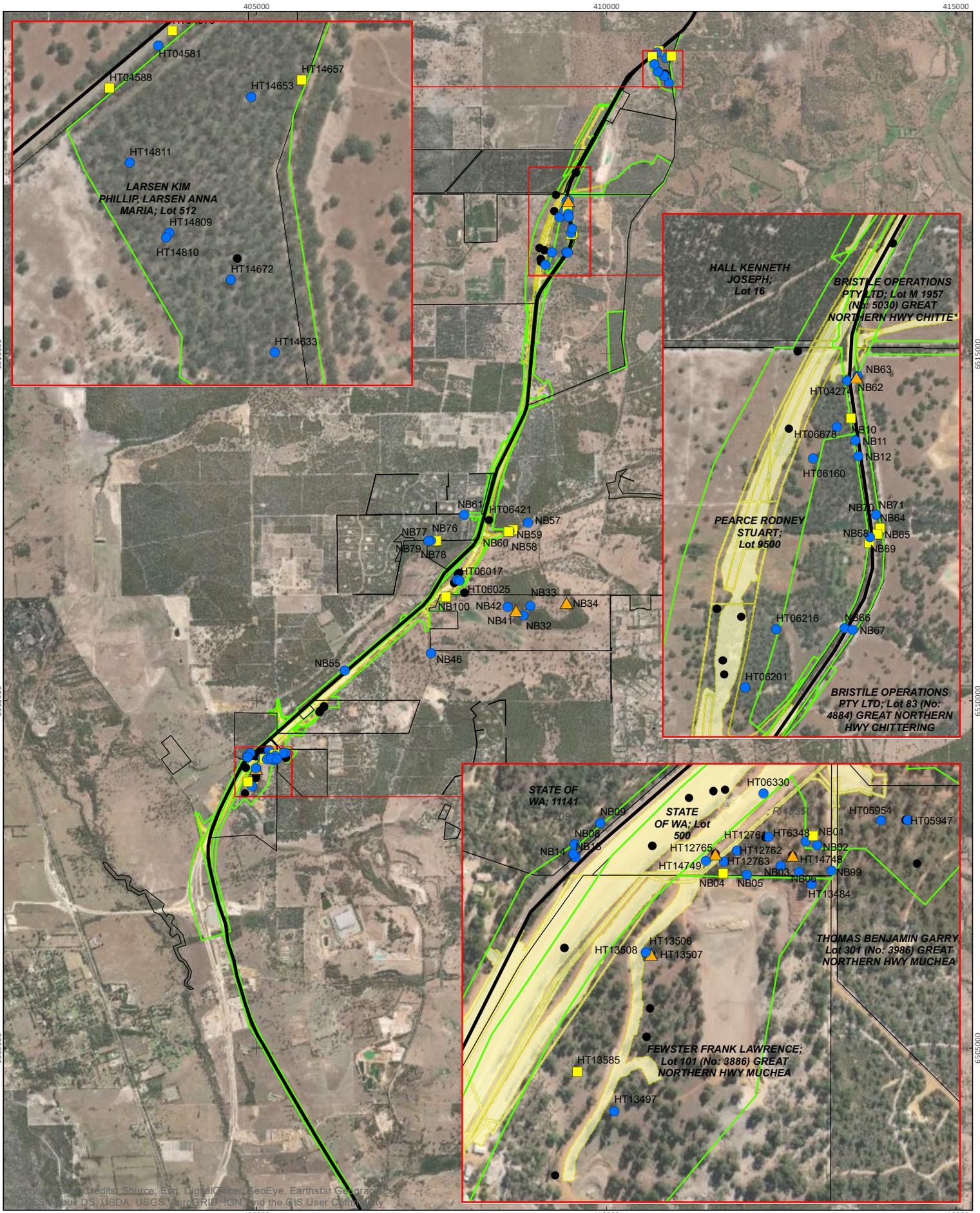
- NB34, NB41 and NB63 – are presumed to have resulted in successful fledging of a chick. Images of large chicks were seen with a camera in all three artificial nest hollows in December 2019 (Figure 3).
- HT12765 and HT13507 – female was flushed from hollow, presumed to be sitting on eggs.
- HT06348 – two eggs were observed with a camera in the hollow in October 2019, however these had been predated by November 2019.

There were several instances where females were flushed from a hollow but a later inspection saw no chicks or eggs and the bird was likely to be prospecting. No evidence of nesting activities were observed in the remaining 27 natural nesting hollows or 26 artificial nesting hollows (Appendix 1).

Table 2 Evidence of breeding records by Phoenix during the 2019-20 census

HT ID	Inspection date						Result
	15/08/2019	17/09/2019	22/10/2019	22/11/2019	21/12/2019	20/01/2020	
NB01	Fresh chewing at post	No flush	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB04	No flush	No flush	No flush	Flushed female CBC, likely to be prospecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB10	No flush	Prospecting pair in tree: female flushed from hollow , likely to be propsecting hollow	No flush, no eggs in hollow	No flush	No flush	No flush	Evidence of nesting activity
NB34	No flush	No flush	No flush	No access	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB41	No flush	No flush	No flush	No access	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB58	No flush	No flush	No flush	Flushed female CBC, possibly prospecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB60	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB63	No flush	Flushed female CBC, likely to be incubating eggs	Flushed female CBC, likely to be incubating eggs	Camera check: small chick in nest	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB64	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity

HT ID	Inspection date						Result
	15/08/2019	17/09/2019	22/10/2019	22/11/2019	21/12/2019	20/01/2020	
NB65	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB68	No flush	No flush	No flush	Flushed female CBC, likely to be prospecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB76	No flush	No flush	No flush	Chewing at post	No flush	No flush	Evidence of nesting activity
NB77	No flush	No flush		Chewing at post	No flush	No flush	Evidence of nesting activity
HT04579	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT04588	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT06348	No flush	No flush	Flushed female CBC, camera check: 2 eggs in nest	Camera check: eggs predated	No flush	No flush	Confirmed breeding event: unsuccessful
HT12765	No flush	No flush	No flush	Flushed female CBC, likely to be incubating eggs	No flush, tree too close to powerlines to inspect with pole camera	No flush	Confirmed breeding event
HT13507	No flush	Flushed female CBC, likely to be incubating eggs	No flush, hollow too high to inspect with pole camera	No flush	No flush	No flush	Confirmed breeding event
HT13585	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT14657	No flush	Flushed female CBC, likely to be prospecting hollow	No flush	No flush, no eggs or chicks seen in hollow	Prospecting pair in tree hollows	No flush	Evidence of nesting activity



Main Roads WA
Great Northern Highway, M2W Upgrade Project

Project No 1272
Date 26-Mar-20
Drawn by AJ
Map author AJ

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
 - Disturbance footprint
 - Road
- Results**
- ▲ Confirmed breeding event
 - Evidence of nesting activity
 - No evidence of breeding
 - Not surveyed (no access/no longer suitable, cleared)

Figure 2

Monitoring results for 2018-19 breeding season

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Figure 3 Female flushed from a nest box (September 2019)



Figure 4 Chick in nest box (December 2019)

3.2 COMPARISON BETWEEN MONITORING SEASONS

The number of confirmed Carnaby's Cockatoo breeding events in the 2019-20 breeding season is about consistent with the pre-impact average, however the nesting activity was significantly higher than the pre-impact average, particularly the 2018-2019 breeding season which surveyed a comparable number of artificial and natural nesting hollows (Table 3).

Breeding events and evidence of nesting activity in the 2019-20 season were identified in the same general areas as in the previous seasons, including the two areas that were identified as having a higher rate of breeding activity, Reserve 40350 and Lot 512 (Figure 3). An additional cluster where there was evidence of nesting or breeding activity was on a property where several artificial nesting hollows were installed after it was observed that Carnaby's Cockatoos were present in higher numbers, indicating the area could be a favourable breeding area (Nesci Estate and surrounding road reserve) (Phoenix 2017b).

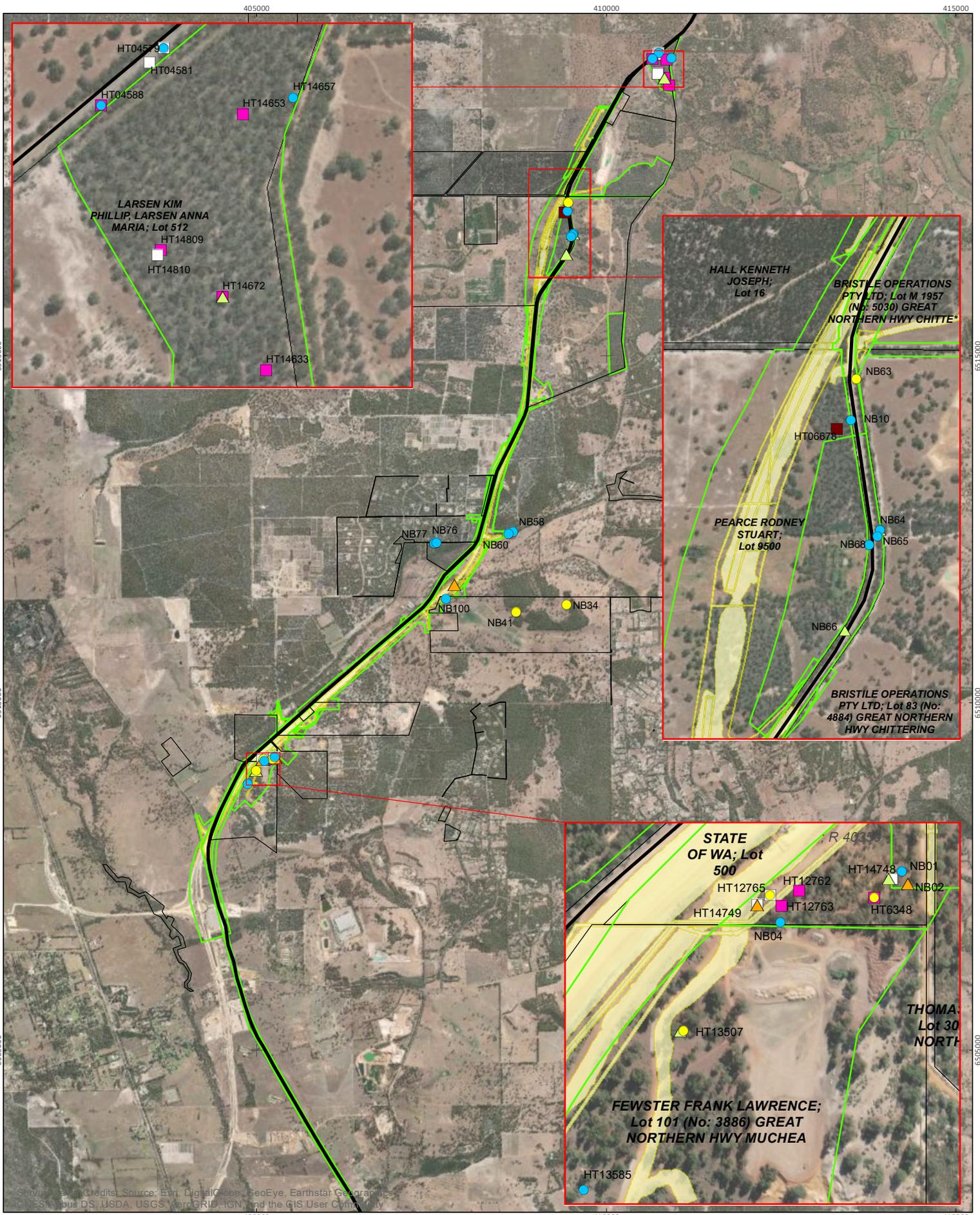
The natural nesting hollows which recorded a confirmed breeding event also had evidence of use in the previous breeding seasons, one had a successful breeding event in the 2017-2018 season. Of the four natural nesting hollows which recorded evidence of nesting activity, two had previous evidence, and of these, one had a confirmed breeding event.

The artificial nesting hollows were installed during the 2018-2019 breeding season so there are a few records of use by Carnaby's Cockatoo. However, the 2019-2020 breeding season recorded a higher number of artificial nesting hollows with both confirmed breeding events and evidence of nesting activity other than in the natural nesting hollows. Three of the four confirmed breeding events were observed in the artificial nesting hollows, and these were also the three that had successful outcome (a chick that hatched and had fledged). An additional 10 artificial nesting hollows had evidence of nesting which was also higher than the natural nesting hollows of which six hollows had evidence of nesting activities. This is a good indication that the artificial nesting hollows are providing a suitable alternative to natural nesting hollows in the Muchea area.

Table 3 Summary of results for 2017-18 and 2018-19 breeding seasons

Result type	Baseline records pre 2017-18¹ Natural hollows and existing artificial hollows	2017-18 breeding season Natural hollows and existing artificial hollows	2018-19 breeding season All hollows (natural & existing artificial hollows/new artificial hollows)	Pre-impact average (2017-18 and 2018-19) All hollows	2019-20 breeding season All hollows (natural & existing artificial hollows/new artificial hollows)
Confirmed breeding event	n/a	6	3 (2/1)	5	6 (3/3)
Evidence of nesting activity	24	14	5 (3/2)	10	15 (4/11)
No evidence of breeding	35	13	63 (30/33)	38	52 (26/26)
No longer suitable, not accessible, cleared	n/a	26	25 (24/1)	23	17 (17/0)

¹ Evidence of nesting activity recorded at some point. Not annual census data and cannot be compared with annual census results.



Main Roads WA Great Northern Highway, M2W Upgrade Project	
Project No	1272
Date	01-Apr-20
Drawn by	AJ
Map author	AJ
1:70,000 (at A4) GDA 1994 MGA Zone 50	

- Study area
- Disturbance footprint
- Road
- 2019-2020 breeding season**
- Confirmed breeding event
- Evidence of nesting activity
- 2018-2019 breeding season**
- ▲ Confirmed breeding event
- ▲ Evidence of nesting activity
- 2017-2018 breeding season**
- Confirmed breeding event
- Evidence of nesting activity
- Evidence of nesting activity (FRTBC)

Figure 5
Confirmed breeding events and Evidence of nesting activity across breeding seasons



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4 CONCLUSION

Four confirmed Carnaby's Cockatoo breeding events were observed in the 2019-20 season and evidence of nesting was observed in a further 16 hollows, with both natural and artificial nesting hollows showing activity.

The difference in nesting activity recorded between the breeding seasons is not unexpected as the sample size for this monitoring program is small and breeding activity can be highly variable between years.

The 2019-2020 census results indicate that breeding activity is occurring throughout the Muchea North area. Due to the historic large-scale clearing of trees and continuing decline of suitable trees with hollows in the area, all remaining suitable nesting hollows in the study area should be considered of high value to Carnaby's Cockatoo.

Considering the artificial nesting hollows were installed during the previous season, the uptake of many of these for breeding events and several more with evidence of nesting activity indicate the willingness of Carnaby's Cockatoo to utilise these as an alternative to natural nest hollows.

All of the artificial nesting hollows were in good condition and none required any maintenance.

For future monitoring of the nesting hollows, consistent methodology should be employed to that used in the 2019-2020 breeding census. Where possible, pole cameras should be used to inspect suspected breeding events.

5 REFERENCES

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- Phoenix. 2018. *Muchea North Black Cockatoo breeding activity census*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Main Roads Western Australia.
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Appendix 1 Results for all hollows in in the 2019-20 breeding season

HT ID	15-Aug-19	17-Sep-19	22-Oct-19	22-Nov-19	21-Dec-19	20-01-2020
HT04274	No flush	No flush	No flush	No flush	No flush	no flush
HT04579	No flush	No flush	Chewing at entrance	No flush	No flush	no flush
HT04581	No flush	No flush	No flush	No flush	No flush	no flush
HT04588	No flush	No flush	Slight chewing at entrance	No flush	No flush	no flush
HT05947	No flush	No flush	No flush	No flush	No flush	no flush
HT05954	No flush	No flush	No flush	No flush	No flush	no flush
HT06017	No flush	No flush	No flush	No flush	No flush	no flush
HT06025	No flush	No flush	No flush	No flush	No flush	no flush
HT06160	No flush	No flush	No flush	No flush	No flush	no flush
HT06201	No flush	No flush	No flush	No flush	No flush	no flush
HT06216	No flush	No flush	No flush	No flush	No flush	no flush
HT06330	No flush	No flush	No flush	No flush	No flush	no flush
HT06348	No flush	No flush	Carnaby flushed. 2 eggs	Eggs predated	No flush	no flush
HT06678	No flush	No flush	No flush	No flush	No flush	no flush
HT12761	No flush	No flush	No flush	No flush	No flush	no flush
HT12762	No flush	No flush	No flush	No flush	No flush	no flush
HT12763	No flush	No flush	No flush	No flush	No flush	no flush
HT12765	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
HT13484	No flush	No flush	No flush	No flush	No flush	no flush

HT13497	No flush	No flush	No flush	No flush	No flush	no flush
HT13506	No flush	No flush	No flush	No flush	No flush	no flush
HT13507	No flush	Carnaby flushed	No flush	No flush	No flush	no flush
HT13508	No flush	No flush	No flush	No flush	No flush	no flush
HT13585	No flush	No flush	Slight chewing at entrance	No flush	No flush	no flush
HT14633	No flush	No flush	No flush	No flush	No flush	no flush
HT14653	No flush	No flush	No flush	No flush	No flush	no flush
HT14657	No flush	Carnaby flushed	No flush	No flush	Pair prospecting hollows	no flush
HT14672	No flush	No flush	No flush	No flush	No flush	no flush
HT14748	No flush	No flush	No flush	No flush	No flush	no flush
HT14749	No flush	No flush	No flush	No flush	No flush	no flush
HT14809	No flush	No flush	No flush	No flush	No flush	no flush
HT14810	No flush	No flush	No flush	No flush	No flush	no flush
HT14811	No flush	No flush	No flush	No flush	No flush	no flush
NB01	Chewing at post	Chewing at post	No flush	No flush	No flush	no flush
NB02	No flush	No flush	No flush	No flush	No flush	no flush
NB03	No flush	No flush	No flush	No flush	No flush	no flush
NB04	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
NB05	No flush	No flush	No flush	No flush	No flush	no flush
NB06	No flush	No flush	No flush	No flush	No flush	no flush

NB08	No flush	No flush	No flush	No flush	No flush	no flush
NB09	No flush	No flush	No flush	No flush	No flush	no flush
NB10	No flush	Prospecting: female Carnaby flushed then leaves with male. Probably prospecting	No flush	No flush	No flush	no flush
NB11	No flush	No flush	No flush	No flush	No flush	no flush
NB12	No flush	No flush	No flush	No flush	No flush	no flush
NB13	No flush	No flush	No flush	No flush	No flush	no flush
NB14	No flush	No flush	No flush	No flush	No flush	no flush
NB32	No flush	No flush	No flush	No flush	No flush	no flush
NB33	No flush	No flush	No flush	No flush	No flush	no flush
NB34	no flush	no flush	no flush	No flush	Large chick in nest	Chick fledged
NB41	no flush	No flush	No flush	No flush	Large chick in nest - still has down on neck	Chick fledged
NB42	no flush	No flush	No flush	No flush	No flush	no flush
NB46	No flush	No flush	No flush	No flush	No flush	no flush
NB55	No flush	No flush	No flush	No flush	No flush	no flush
NB57	No flush	No flush	No flush	No flush	No flush	no flush
NB58	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
NB59	No flush	No flush	No flush	No flush	No flush	no flush
NB60	No flush	No flush	Post chewed	No flush	No flush	no flush
NB61	No flush	No flush	No flush	No flush	No flush	no flush

NB62	No flush	No flush	No flush	No flush	No flush	no flush
NB63	No flush	Carnaby's flushed	Carnaby's flushed	Pin feathered chick in nest	Large chick in nest	Chick fledged
NB64	No flush	Post chewed	No flush	No flush - empty	No flush	no flush
NB65	No flush	Post chewed	No flush	No flush	No flush	no flush
NB66	No flush	No flush	No flush	No flush	No flush	no flush
NB67	No flush	No flush	No flush	No flush	No flush	no flush
NB68	No flush	No flush	No flush	Carnaby flushed	No flush	no flush
NB69	No flush	No flush	No flush	No flush	No flush	no flush
NB71	No flush	No flush	No flush	No flush	No flush	no flush
NB76	No flush	No flush	No flush	Post chewed but nest empty	No flush	no flush
NB77	No flush	No flush	No flush	Post chewed but nest empty	No flush	no flush
NB78	no flush	No flush	No flush	No flush. Pair of Carnaby's nearby. Male making mating call	No flush	no flush
NB79	No flush	No flush	No flush	No flush	No flush	no flush
NB99	No flush	no flush	no flush	No flush	No flush	no flush
NB100	no flush	no flush	no flush	No flush	No flush - very old Carnaby's tail feather in nest	no flush

Appendix 2 Results for all hollows in 2017-18 and 2018-19 breeding season

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT04059	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required
HT04274	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT04579	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT04581	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT04588	Evidence of nesting activity	No evidence of breeding	Evidence of nesting activity
HT05911	No access	Hollow not located	Tree cleared. Further monitoring not required
HT05923	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT05938	No longer suitable hollow. Further monitoring not required	n/a	n/a
HT05947	No evidence of breeding	Not located	No evidence of breeding
HT05954	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06017	No access	No evidence of breeding	No evidence of breeding
HT06020	No access	Tree cleared. Further monitoring not required	n/a
HT06025	No access	No evidence of breeding	No evidence of breeding
HT06046	No access	Tree cleared. Further monitoring not required	n/a
HT06148	No longer suitable. Further monitoring not required	n/a	n/a
HT06160	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06201	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06216	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06261	No evidence of breeding	Tree cleared. Further monitoring not required.	n/a

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT06278	Evidence of nesting activity	Tree cleared. Further monitoring not required.	n/a
HT06330	Not sampled	No evidence of breeding. Added to breeding census in 2018-19	No evidence of breeding
HT06348	Evidence of nesting activity	No evidence of breeding	Confirmed breeding event - failed
HT06421	No access. Evidence of nesting activity (from a distance)	No access	n/a
HT06655	No longer suitable. Further monitoring not required	Tree cleared. Further monitoring not required	n/a
HT06678	Evidence of nesting activity (FRTBC)	No evidence of breeding	No evidence of breeding
HT08752	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT08753	Evidence of nesting activity	No evidence of breeding	Tree cleared. Further monitoring not required
HT08754	No access	Confirmed breeding event	Tree cleared. Further monitoring not required
HT12761	Hollow not located	Hollow not located	No evidence of breeding
HT12762	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT12763	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT12765	Confirmed breeding event - successful	No evidence of breeding	Confirmed breeding event
HT13484	No access	No evidence of breeding	No evidence of breeding
HT13497	No access	No evidence of breeding	No evidence of breeding
HT13503	No access	No longer suitable. Further monitoring not required	n/a
HT13505	No access	No longer suitable. Further monitoring not required	n/a
HT13506	No access	No evidence of breeding	No evidence of breeding
HT13507	No access	Evidence of nesting activity	

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT13508	No access	No evidence of breeding	No evidence of breeding
HT13511	No access	No longer suitable. Further monitoring not required	n/a
HT13523	No access	No longer suitable. Further monitoring not required	n/a
HT13533	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required
HT13534	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a
HT13535	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a
HT13585	Not sampled	No evidence of breeding. Added to breeding census in 2018-19, chewing observed at hollow	Evidence of nesting activity
HT14633	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14653	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14657	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
HT14670	Collapsed, no longer suitable. Further monitoring not required	n/a	n/a
HT14672	Evidence of nesting activity	Evidence of nesting activity	No evidence of breeding
HT14748	Confirmed breeding event - successful	Evidence of nesting activity	No evidence of breeding
HT14749	Confirmed breeding event - successful	Confirmed breeding event	No evidence of breeding
HT14805	No access	No access	No longer suitable. Further monitoring not required
HT14806	No access	No access	No longer suitable. Further monitoring not required
HT14807	No access	No access	No longer suitable. Further monitoring not required
HT14808	No access	No access	No longer suitable. Further monitoring not required
HT14809	Evidence of nesting activity	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT14810	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT14811	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB01	n/a	No evidence of breeding	Evidence of nesting activity
NB02	n/a	Confirmed breeding event	No evidence of breeding
NB03	n/a	No evidence of breeding	No evidence of breeding
NB04	n/a	No evidence of breeding	Evidence of nesting activity
NB05	n/a	No evidence of breeding	No evidence of breeding
NB06	n/a	No evidence of breeding	No evidence of breeding
NB08	n/a	No evidence of breeding	No evidence of breeding
NB09	n/a	No evidence of breeding	No evidence of breeding
NB10	n/a	No evidence of breeding	Evidence of nesting activity
NB11	n/a	No evidence of breeding	No evidence of breeding
NB12	n/a	No evidence of breeding	No evidence of breeding
NB13	n/a	No evidence of breeding	No evidence of breeding
NB14	n/a	No evidence of breeding	No evidence of breeding
NB32	n/a	No evidence of breeding/no access	No evidence of breeding
NB33	n/a	No evidence of breeding/no access	No evidence of breeding
NB34	n/a	n/a	Confirmed breeding event
NB41	n/a	n/a	Confirmed breeding event
NB42	n/a	n/a	No evidence of breeding
NB46	n/a	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
NB55	n/a	No evidence of breeding	No evidence of breeding
NB57	n/a	No evidence of breeding	No evidence of breeding
NB58	n/a	No evidence of breeding	Evidence of nesting activity
NB59	n/a	No evidence of breeding	No evidence of breeding
NB60	n/a	No evidence of breeding	Evidence of nesting activity
NB61	n/a	No evidence of breeding	No evidence of breeding
NB62	n/a	No evidence of breeding	No evidence of breeding
NB63	n/a	No evidence of breeding	Confirmed breeding event
NB64	n/a	Evidence of nesting activity	Evidence of nesting activity
NB65	n/a	No evidence of breeding	Evidence of nesting activity
NB66	n/a	Evidence of nesting activity	No evidence of breeding
NB67	n/a	No evidence of breeding	No evidence of breeding
NB68	n/a	No evidence of breeding	Evidence of nesting activity
NB69	n/a	No evidence of breeding	No evidence of breeding
NB71	n/a	No evidence of breeding	No evidence of breeding
NB76	n/a	No evidence of breeding	Evidence of nesting activity
NB77	n/a	No evidence of breeding	Evidence of nesting activity
NB78	n/a	No evidence of breeding	No evidence of breeding
NB79	n/a	No evidence of breeding	No evidence of breeding
NB99	n/a	No evidence of breeding	No evidence of breeding
NB100	n/a	n/a	Evidence of nesting activity





PHOENIX

ENVIRONMENTAL SCIENCES

Black cockatoo breeding activity census 2020-21 for Muceha North Great Northern Highway, Muceha to Wubin Upgrade Stage 2 Project

Prepared for Main Roads WA

June 2021

Final



Black cockatoo breeding activity census 2020-21 for Muchea North.
Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project.
Prepared for Main Roads WA

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
A. Jacks	K. Crews	Draft for client comments	0.1	17-Mar-21	L. Zimmermann
A. Jacks		Final	1.0	01-Jun-21	L. Zimmerman

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[Phoenix Environmental Sciences Pty Ltd](#)

2/3 King Edward Rd Osborne Park WA 6017

P: 08 6323 5410

E: admin@phoenixenv.com.au

Project code: 1333-SR342-MR-VER

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Appendix 1	Results for all hollows in in the 2019-20 breeding season
Appendix 2	Results for all hollows in all breeding seasons

1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Main Roads WA, to undertake a Carnaby's Cockatoo breeding activity census over the 2020-21 breeding season within and surrounding the disturbance footprint for the Muchea North Upgrade project area (Figure 1). This report presents the results of the census.

1.1 BACKGROUND

Main Roads has recently upgraded the Great Northern Highway (GNH) between Straight Line Kilometre (SLK) 38.60 and 51.40, referred to as Muchea North Upgrade (Muchea North in this report). The Muchea North proposal was referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 1 March 2016 (EPBC 2016/7656), assessed as a controlled action and granted conditional approval in August 2018 (DotEE 2018).

Muchea North resulted in the loss of 13 Carnaby's Black Cockatoo nesting hollows. To mitigate and offset the loss of these, Main Roads was required to install 39 artificial nest boxes (Figure 1). In accordance with EPBC 2016/7656 Conditions 4f(i) and (ii) each artificial nesting hollow installed must:

- EPBC 2016/7656 condition f(i): be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify any maintenance requirements.
- EPBC 2016/7656 condition f(ii): be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season.

The monitoring program also required monitoring of previously recorded natural hollows suitable for Carnaby's Cockatoo (Figure 1). Monitoring of artificial and natural hollows is required to be monitored in accordance with How to Monitor and Maintain Artificial Hollows for Carnaby's Cockatoo (DPaW 2015).

Detailed black cockatoo habitat assessments conducted as part of the baseline assessments for the Muchea North (Phoenix 2015, 2017a) recorded all potential breeding trees of species known to support black cockatoo breeding and identified suitable nesting hollows and hollows with evidence of use.

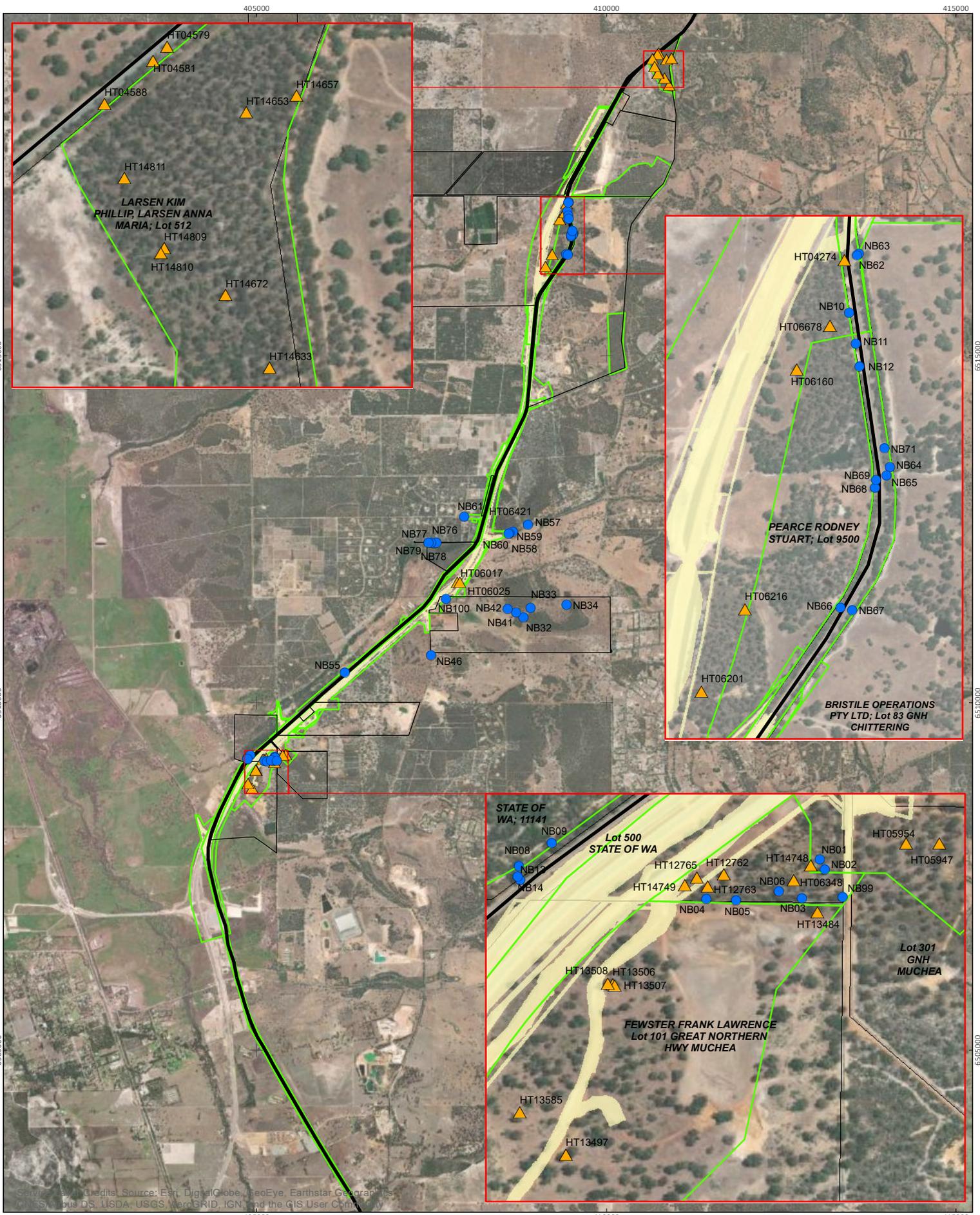
A native vegetation clearing permit (NVCP) for Muchea North (Permit no. 7563/2) has been approved by the WA Department of Water and Environmental Regulation (DWER) under the *Environmental Protection Act 1986* (EP Act).

To support Condition 4c of EPBC 2016/7656, Main Roads commissioned Phoenix to undertake monitoring of confirmed and suitable nesting hollows recorded within the EPBC Act Approval Boundary and wider baseline survey area (Phoenix 2015, 2017a) (the study area; Figure 1). A series of monitoring events have taken place to support this condition (Table 1). The initial baseline monitoring program was conducted in the 2017-18 breeding season (August 2017 – February 2018) and assessed hollow usage of suitable nesting hollows and hollows with evidence of use within the study area (Phoenix 2018). A second year of monitoring for hollow usage within the study area in the 2018-19 breeding season was undertaken by Phoenix from August 2018 to February 2019 (Phoenix 2019). The artificial nesting hollows were installed during the 2018-2019 breeding season, therefore the results of these first two surveys collectively represent the pre-impact breeding density.

Impact monitoring was subsequently conducted in the 2019-2020 breeding season (Phoenix 2020) and the 2020-2021 season. This report incorporates the results of the 2020-2021 monitoring season into the nesting hollow usage dataset for Muchea North.

Table 1 Summary of black cockatoo monitoring activity

Year	Activity
2014-2016 Various times	Habitat assessment including recording all potential breeding trees and suitability for nesting.
2017-2018 August to January	Baseline assessment: Assessment of nest hollows for evidence of breeding.
2018-2019 August to February	Baseline assessment: Assessment of nest hollows for evidence of breeding. <i>Road works commenced and artificial nesting hollows were installed during this breeding season.</i>
2019-2020 August to January	Assessment of both natural nest hollows and artificial neststing hollows for evidence of breeding
2020-2021 August to February	Assessment of both natural nest hollows and artificial neststing hollows for evidence of breeding



Main Roads WA
Great Northern Highway, M2W Upgrade Project

Project No 1333
Date 09-Mar-21
Drawn by AJ
Map author AJ

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Disturbance footprint
- Road
- Artificial nesting hollow
- ▲ Natural nesting hollow

Figure 1
Study area and sampling sites



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1.2 SCOPE OF WORK

The scope of work was as follows:

- Six rounds of monitoring of artificial and natural nest hollows to be undertaken between August 2020 and January 2021.
- During inspections of artificial and natural hollows, record evidence of use by Carnaby's Cockatoos at each artificial and natural hollow in accordance with (DPaW 2015).
- During inspections, identify any artificial nest box maintenance needs in accordance with (DPaW 2015) and whether natural hollows remain suitable for use by Carnaby's Black Cockatoo.
- Provide a report that summarises all records required by Conditions 4f(i) and (ii) of EPBC 2016/7656 for all artificial and natural hollows inspected. The draft report shall be provided to Main Roads in electronic PDF and Word version copy format.

2 CENSUS METHODOLOGY (DPAW 2015)

Methods were consistent with the approach undertaken in previous monitoring events for Muchea North (Phoenix 2018, 2019, 2020).

Prior to the surveys, site locations (artificial and natural nest hollows) were loaded onto field tablets. Data was collected electronically using a customised data collection template and included:

- site code
- signs of use – birds prospecting hollows, fresh chewings, birds perching, birds entering/existing hollows, birds flushed from hollows, gender of observed birds, chick calls, eggs observed (inc. status if possible – incubated or abandoned), chick/s observed, chick/s fledged
- other indicators, e.g. gender mix of flocks, evidence of nesting at base of trees
- condition of hollow, current suitability for use (natural hollows), maintenance requirements (artificial hollows).

The knocking and scraping method was conducted at the base of trees for all monitored hollows. Other observational methods were also employed, i.e. pole camera inspections of hollows where possible, listening for nest activity, flock and individual bird behaviour.

Consistent with previous methodology the following activities were undertaken:

- evidence of nesting activity was noted where fresh chewing is around the hollow entrance and/or birds are seen prospecting hollows.
- a confirmed breeding event was noted where eggs are seen in hollow and/or other clear evidence observed that a chick is present (i.e. female seen at hollow entrance when during brooding eggs, and/or parents seen preparing to feed chick in the hollow).

Maintenance checks of artificial hollows will assess the following as a minimum:

- condition of chewing posts
- condition of attachment points
- condition of hollow bases
- stability of tree or pole used to mount the artificial hollow.

As per previous surveys, site visits were undertaken every 4-5 weeks between August 2020 and January 2021: 24 August, 22 September, 26 October, 27 November, 31 December and 07 February.

The baseline surveys for Muchea North identified a total of 57 trees in the study area containing suitable nesting hollows for black cockatoos, of which 25 had evidence of nesting activity (Table 2). In the initial survey, 37 of these were monitored as the remaining 20 were unable to be assessed due to access constraints.

In the 2018-19 season, 47 natural nesting hollows and 36 artificial nesting hollows were monitored (Table 2). This included two new natural hollows added to the census in the current season and 14 trees that were not accessible in the 2017-18 season. Twelve further natural nesting hollows were not monitored; five of these were not able to be accessed, three were not relocated and four hollows were removed from monitoring in the 2017-18 season due to collapse, cracks forming or tree death.

In the 2019-2020 season, 73 hollows were monitored, of which 33 were natural nesting hollows and 40 were artificial nesting hollows (Table 2). Prior to that survey, 13 trees which contained suitable nesting hollows were removed as part of the GNH road upgrades (HT05911, HT05923, HT06020, HT06046, HT06261, HT06278, HT06655, HT08752, HT08753, HT08754, HT13533, HT13534 and HT13535), 12 of these were monitored in the previous two monitoring programs and one was not accessible. These 13 trees were offset by the installation of the 39 artificial nesting hollows of which all were able to be monitored in the 2019-2020 season. An additional artificial nesting hollow (NB100) was included in the survey which was erected to replace HT04059. Four natural nesting hollows from the baseline dataset that had not been monitored in the previous two years were able to be surveyed in the 2019-2020 season because landowner access had been granted. Four trees with natural nesting hollows were not surveyed in the 2019-2020 season because the tree or hollow was no longer considered suitable.

In the current 2020-2021 survey, the same trees and artificial nesting hollows from the 2019-2020 season were monitored.

In this report:

- *confirmed breeding event* – means eggs were seen in hollow and/or other clear evidence observed that chick was present (i.e. female seen at hollow entrance when brooding eggs and/or parents seen preparing to feed chick in the hollow)
- *evidence of nesting activity* – means chewing around the hollow entrance and/or bird seen prospecting hollows. It does not necessarily mean that a breeding event took place that year; however, it is evidence that the hollow is suitable and was considered and may have been used in previous years.

Table 2 Monitored hollows

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20	2020-21
HT04059	Evidence of nesting activity, artificial hollow	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT04274	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT04579 (NB)	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT04581 (NB)	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT04588 (NB)	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus accedens</i>	Yes	Yes	Yes	Yes
HT05911	Suitable, artificial hollow, no evidence of breeding	<i>Eucalyptus accedens</i>	No access	No access	No (tree cleared)	n/a
HT05923	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT05938	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No	No (not suitable – hollow has cracked or degraded)	n/a
HT05947	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	No	Yes	Yes
HT05954	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT06017	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT06020	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes	No (tree cleared)	
HT06025	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT06046	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	No (tree cleared)	n/a
HT06148	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No	No (not suitable – hollow has cracked or degraded)	n/a
HT06160	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT06201	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT06216	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	Yes	Yes	Yes	Yes
HT06261	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20	2020-21
HT06278	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT06330	Not currently suitable	<i>Eucalyptus wandoo</i>	No	Yes	No (tree cleared)	n/a
HT06348	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT06421	Evidence of nesting activity	<i>Corymbia calophylla</i>	No access	No access	No (no access)	n/a
HT06655	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	Yes	No	No (tree cleared)	n/a
HT06678	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT08752	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT08753	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT08754	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	Yes	No (tree cleared)	n/a
HT12761	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No	No	Yes	No (not suitable – hollow has cracked or degraded)
HT12762	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT12763	Evidence of nesting activity (FRTBC)	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT12765	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT13484	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT13497	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes	Yes	Yes
HT13503	Suitable, no evidence of breeding	<i>Eucalyptus marginata</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)	n/a
HT13505	Suitable, no evidence of breeding	<i>Eucalyptus sp.</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)	n/a
HT13506	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT13507	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT13508	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	Yes	Yes
HT13511	Suitable, no evidence of breeding	<i>Corymbia calophylla</i>	No access	Yes	No (not suitable –	n/a

Black cockatoo breeding activity census 2020-21 for Muchea North

Prepared for Main Roads WA

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20	2020-21
					hollow has cracked or degraded)	
HT13523	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	Yes	No (not suitable – hollow has cracked or degraded)	n/a
HT13533	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT13534	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT13535	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	No (tree cleared)	n/a
HT13585	Not currently suitable	<i>Corymbia calophylla</i>	No	Yes	Yes	Yes
HT14633	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14653	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14657	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14670	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	No	No (not suitable – hollow collapsed)	n/a
HT14672	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14748	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14749	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14805	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)	n/a
HT14806	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)	n/a
HT14807	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has cracked or degraded)	n/a
HT14808	Suitable, no evidence of breeding	<i>Eucalyptus wandoo</i>	No access	No access	No (not suitable – hollow has	n/a

Black cockatoo breeding activity census 2020-21 for Muchea North

Prepared for Main Roads WA

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20	2020-21
					cracked or degraded)	
HT14809	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14810	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
HT14811	Evidence of nesting activity	<i>Eucalyptus wandoo</i>	Yes	Yes	Yes	Yes
NB01	n/a	n/a	n/a	Yes	Yes	Yes
NB02	n/a	n/a	n/a	Yes	Yes	Yes
NB03	n/a	n/a	n/a	Yes	Yes	Yes
NB04	n/a	n/a	n/a	Yes	Yes	Yes
NB05	n/a	n/a	n/a	Yes	Yes	Yes
NB06	n/a	n/a	n/a	Yes	Yes	Yes
NB08	n/a	n/a	n/a	Yes	Yes	Yes
NB09	n/a	n/a	n/a	Yes	Yes	Yes
NB10	n/a	n/a	n/a	Yes	Yes	Yes
NB11	n/a	n/a	n/a	Yes	Yes	Yes
NB12	n/a	n/a	n/a	Yes	Yes	Yes
NB13	n/a	n/a	n/a	Yes	Yes	Yes
NB14	n/a	n/a	n/a	Yes	Yes	Yes
NB32	n/a	n/a	n/a	Yes	Yes	Yes
NB33	n/a	n/a	n/a	Yes	Yes	Yes
NB34	n/a	n/a	n/a	n/a	Yes	Yes
NB41	n/a	n/a	n/a	n/a	Yes	Yes
NB42	n/a	n/a	n/a	n/a	Yes	Yes
NB46	n/a	n/a	n/a	Yes	Yes	Yes
NB55	n/a	n/a	n/a	Yes	Yes	Yes
NB57	n/a	n/a	n/a	Yes	Yes	Yes
NB58	n/a	n/a	n/a	Yes	Yes	Yes
NB59	n/a	n/a	n/a	Yes	Yes	Yes
NB60	n/a	n/a	n/a	Yes	Yes	Yes
NB61	n/a	n/a	n/a	Yes	Yes	Yes
NB62	n/a	n/a	n/a	Yes	Yes	Yes
NB63	n/a	n/a	n/a	Yes	Yes	Yes
NB64	n/a	n/a	n/a	Yes	Yes	Yes
NB65	n/a	n/a	n/a	Yes	Yes	Yes
NB66	n/a	n/a	n/a	Yes	Yes	Yes
NB67	n/a	n/a	n/a	Yes	Yes	Yes
NB68	n/a	n/a	n/a	Yes	Yes	Yes
NB69	n/a	n/a	n/a	Yes	Yes	Yes

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20	2020-21
NB71	n/a	n/a	n/a	Yes	Yes	Yes
NB76	n/a	n/a	n/a	Yes	Yes	Yes
NB77	n/a	n/a	n/a	Yes	Yes	Yes
NB78	n/a	n/a	n/a	Yes	Yes	Yes
NB79	n/a	n/a	n/a	Yes	Yes	Yes
NB99	n/a	n/a	n/a	Yes	Yes	Yes
NB100	HT04059 was cleared and this nestbox was installed to replace it in 2019	n/a	n/a	n/a	Yes	Yes

* HT = habitat tree (natural); NB = nest box (artificial); HT (NB) = this tree had an artificial nest box installed prior to the baseline records (pre-2017) and has been counted as a natural habitat tree for the pre- and post- baseline analysis.

3 RESULTS

3.1 CENSUS RESULTS 2020-21 BREEDING SEASON

Confirmed breeding events were recorded in 12 artificial nesting hollows and one natural nesting hollow during the 2020-2021 monitoring season (Table 3; Figure 2). Evidence of nesting activity was observed in a further seven artificial nesting hollows and six natural nesting hollows (Table 3; Figure 2).

Of the confirmed breeding events:

- HT14809, NB01, NB03, NB32, NB34, NB41, NB62, NB71 and NB78 – are presumed to have resulted in successful fledging of a chick. Images of chicks were seen with a camera in all three artificial nest hollows between October and February 2020 (Figure 3).
- NB10 – a single egg was seen in the nest in October but the nest was empty in December. The nest could not be accessed in November so unsure if this chick fledged or was predated.
- NB12, NB63 and NB99 – two addled or broken eggs were observed with a camera in the hollow in October and November 2020.

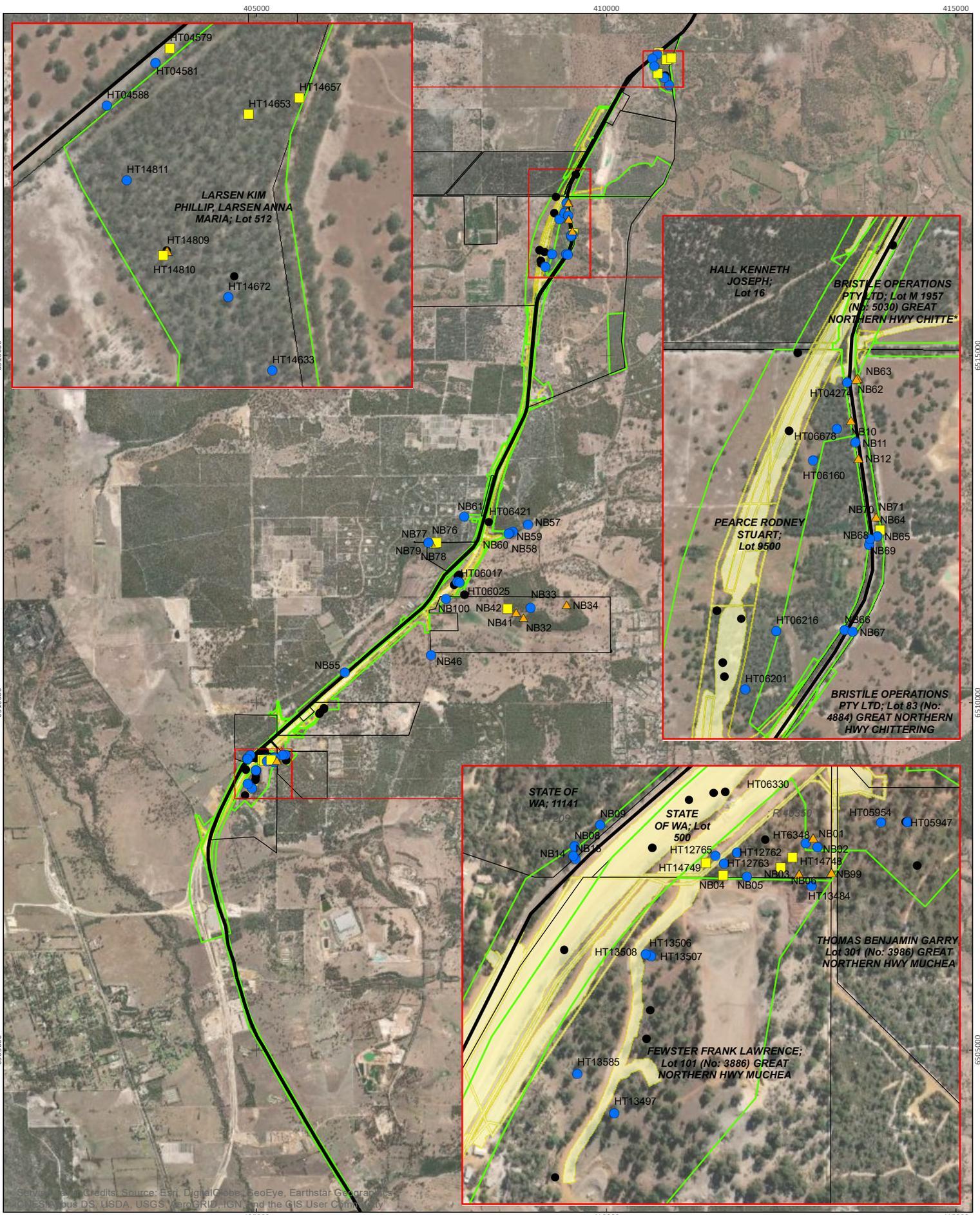
There were eight instances where females were flushed from a hollow but a later inspection saw no chicks or eggs and the bird was likely to be prospecting. A further five had observations of prospecting birds or recent chewing around the hollow or on the post. No evidence of nesting activities were observed in the remaining natural nesting hollows or artificial nesting hollows (Appendix 1).

Table 3 Evidence of breeding records by Phoenix during the 2020-21 census

HT ID	Inspection date						Result
	24/08/2020	22/09/2020	26/10/2020	27/11/2020	31/12/2020	07/02/2021	
HT04579 (NB)^				Post chewed			Evidence of nesting activity
HT06348			Carnaby flushed				Evidence of nesting activity
HT14653				Chewed entrance, pair prospecting			Evidence of nesting activity
HT12657		Female prospecting		Pair prospecting			Evidence of nesting activity
HT14749			Carnaby flushed				Evidence of nesting activity
HT14809			Carnaby flushed	Pin feathered chick	Large- feathered chick	Chick fledged	Confirmed breeding event: assumed successful
HT14810		Carnaby flushed					Evidence of nesting activity
NB01			Carnaby flushed	Pin feathered chick in nest	Large- feathered chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB03				Small chick and addled egg	Chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB04				Flushed female Carnaby, likely to be prospecting hollow	No flush, no eggs in hollow		Evidence of nesting activity
NB06		Carnaby flushed					Evidence of nesting activity
NB10		Carnaby flushed	Single egg in nest	No access			Confirmed breeding event: uncertain outcome
NB12			Carnaby flushed	2 broken eggs			Confirmed breeding event: unsuccessful

HT ID	Inspection date						Result
	24/08/2020	22/09/2020	26/10/2020	27/11/2020	31/12/2020	07/02/2021	
NB32			Carnaby flushed	Check in nest	Chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB34			Prospecting female	Single egg in nest	Chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB41		Carnaby flushed	Chick in nest				Confirmed breeding event: assumed successful
NB42					Pair of Carnaby prospecting		Evidence of nesting activity
NB62	Carnaby flushed	Carnaby flushed	Downy chick in nest	Large-feathered chick in nest	Chick fledged		Confirmed breeding event: assumed successful
NB63	Carnaby flushed	Carnaby flushed	Cracked egg in nest				Confirmed breeding event: unsuccessful
NB64	Carnaby flushed			<i>Chick in natural hollow underneath NB64</i>			Evidence of nesting activity (Confirmed breeding event: assumed successful - in a natural hollow under the box in the same tree)
NB71			Carnaby flushed	Nestling in hollow	Feathered chick in hollow	Chick fledged	Confirmed breeding event: assumed successful
NB76		Heavily chewed post					Evidence of nesting activity
NB77			Carnaby flushed				Evidence of nesting activity
NB78		Carnaby flushed		Pin-feathered chick	Chick fledged		Confirmed breeding event: assumed successful
NB79			Post chewed				Evidence of nesting activity
NB99		Pair at nest, female stays		Two addled or broken eggs			Confirmed breeding event: unsuccessful

^ this tree had an artificial nest box installed prior to the baseline records (pre-2017).



Main Roads WA
Great Northern Highway, M2W Upgrade Project

Project No 1333
Date 19-Feb-21
Drawn by AJ
Map author AJ

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

Study area
 Disturbance footprint
 Road

Results

- ▲ Confirmed breeding event
- Evidence of nesting activity
- No evidence of breeding
- Not surveyed (no access/no longer suitable, cleared)

Figure 2
Monitoring results for 2020-21 breeding season



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Figure 3 Pin-feathered chick a nest box (November 2020)



Figure 4 Almost ready to fledge (December 2020)

3.2 COMPARISON BETWEEN BREEDING SEASONS

The number of hollows which had either confirmed Carnaby's Cockatoo breeding events in the 2020-21 breeding season is significantly higher than both the pre-impact average and the previous year's (2019-2020) post-impact survey. Overall, the number of confirmed breeding events in 2020-2021 (13) was more than double that of the pre-impact average of five (Table 4). Evidence of nesting activity has also been higher in the two post impact monitoring events than the pre-impact average (Table 4). The current breeding season was slightly lower than the previous year, but this was offset but a much higher number of confirmed breeding events.

Most significantly, the results of the monitoring program clearly show a trend toward increased usage of the artificial nesting hollows installed under the Muchea North offset. The nest boxes were installed during the 2018-2019 breeding season so there were few records of use of these during that season, with only one confirmed breeding event and two records of evidence of nesting activity (Table 4). This increased in the 2019-2020 breeding season to three confirmed breeding events and 11 records of nesting activity in the artificial nesting hollows. In 2020-2021, the number of confirmed breeding events in the artificial nesting hollows increased by 400% to 12, with the majority assumed to have had a successful outcome i.e., a chick hatched and fledged (Table 4).

In contrast, the number of confirmed breeding events in natural nest hollows declined from three in 2020-2021 to one in the current breeding season. The results suggest the birds are preferentially choosing the artificial hollows over the natural hollows.

Repeated use of the same hollows for breeding was also apparent from the 2020-2021 season. All of the natural nesting hollows which had evidence of nesting or a confirmed breeding event in the current season also had evidence of use or a confirmed breeding in previous breeding seasons.

Of the 19 new artificial nesting hollows which recorded evidence of nesting activity or a confirmed breeding event in the current breeding season, six had evidence of nesting activity in the previous (2019-20) season and three had a successful breeding event. The three artificial nesting boxes that recorded a confirmed breeding event in 2019-2020 also had confirmed breeding in 2020-2021.

Breeding events and evidence of nesting activity in the 2020-21 season were identified in the same general areas as in the previous seasons, including the three areas that were identified as having a higher rate of breeding activity, Reserve 40350 and Lot 512, and the old GNH adjacent to Lot 9500. An additional cluster of activity was identified at Nesci Estate and the surrounding road reserve; this was a location where several artificial nesting hollows were installed after it was observed that Carnaby's Cockatoos were present in higher numbers, indicating the area could be a favourable breeding area (Phoenix 2017b).

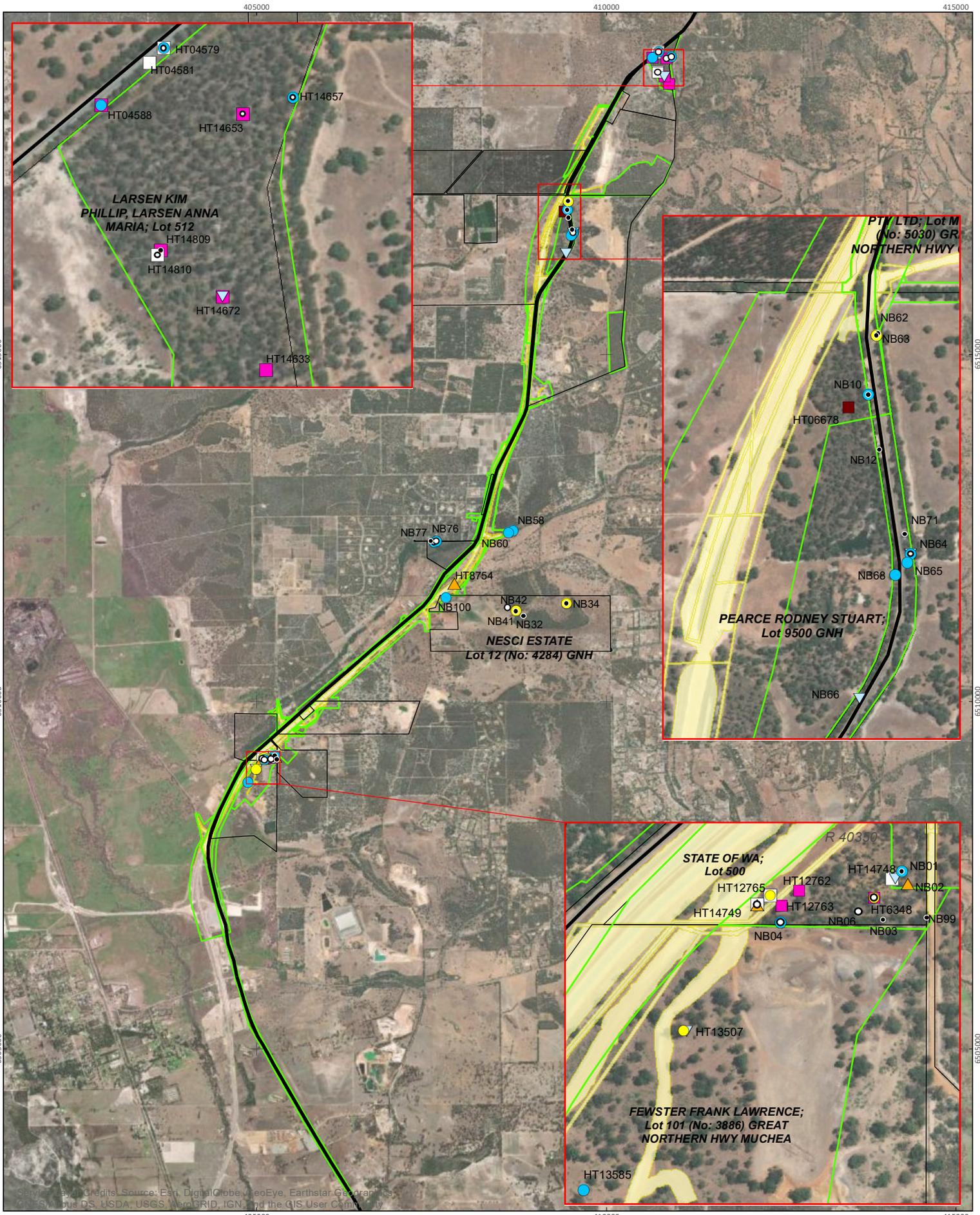
3.1 CONDITION OF ARTIFICIAL NESTING HOLLOWES

All of the artificial nesting hollows surveyed were observed to be in good condition.

Table 4 Summary of results for each breeding season

Result type	Baseline records pre 2017-18¹ Natural hollows and existing artificial hollows	2017-18 breeding season Natural hollows and existing artificial hollows	2018-19 breeding season All hollows (natural & existing artificial hollows/new artificial hollows)	Pre-impact average (2017-18 and 2018-19) All hollows	2019-20 breeding season All hollows (natural & existing artificial hollows/new artificial hollows)	2020-21 breeding season All hollows (natural & existing artificial hollows/new artificial hollows)	Post-impact average (2019-20 and 2020-21) All hollows
Confirmed breeding event	n/a	6	3 (2/1)	5	6 (3/3)	13 (1/12)	10 (2/8)
Evidence of nesting activity	24	14	5 (3/2)	10	15 (4/11)	13 (6/7)	14 (5/9)
No evidence of breeding	35	13	63 (30/33)	38	52 (26/26)	45 (24/21)	49 (25/23)
Total no. hollows surveyed	59	33	71	53	73	71	72
Trees not surveyed: no longer suitable, not accessible, cleared	n/a	26	25 (24/1)	23	17 (17/0)	19 (19/0)	18

¹ Evidence of nesting activity recorded at some point. Not annual census data and cannot be compared with annual census results.



Main Roads WA
Great Northern Highway, M2W Upgrade Project

Project No 1333
Date 19-Mar-21
Drawn by AJ
Map author AJ

0 1 2
Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Disturbance
- 2020-2021 breeding**
 - Confirmed breeding
 - Evidence of nesting activity
- 2019-2020 breeding**
 - Confirmed breeding
 - Evidence of nesting activity

- 2018-2019 breeding**
 - ▲ Confirmed breeding
 - ▼ Evidence of nesting activity
- 2017-2018 breeding**
 - Confirmed breeding
 - Evidence of nesting activity

Figure 5
Confirmed breeding events and evidence of nesting activity across breeding seasons



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4 CONCLUSION AND RECOMMENDATIONS

The 2020-2021 breeding season results indicate that breeding activity is occurring throughout the Muchea North area and that it is an important breeding area for Carnabys Cockatoo. This breeding season was remarkably more successful than previous seasons, with more than double the number of confirmed breeding events recorded compared to last breeding season and also the pre-impact average. Thirteen confirmed Carnaby's Cockatoo breeding events were observed in the 2020-21 season and evidence of nesting was observed in a further 13 hollows. Both natural and artificial nesting hollows showed activity but there was a clear trend towards confirmed breeding in the artificial nesting hollows.

The difference in nesting activity recorded between the breeding seasons is not unexpected as the sample size for this monitoring program is small and breeding activity can be highly variable between years; however, the increased rate of post-impact breeding observed over the past three years is promising for mitigating population decline.

The willingness of Carnabys Cockatoo to utilise the artificial nesting hollows as an alternative to natural nest hollows is evident from the 2020-2021 breeding data. Considering the artificial nesting hollows were installed during the 2018-2019 season, the uptake of many of these for breeding and several more with evidence of nesting activity in the first two years post-installation is encouraging, particularly this breeding season where the rate of confirmed breeding events is much higher in artificial nesting hollows than natural nesting hollows.

Of the 13 hollows with evidence of breeding, eight were from artificial nesting hollows (seven from the new and one from an existing artificial nesting hollows), and five from natural nesting hollows. This is a good indication that the artificial nesting hollows are providing a suitable alternative to natural nesting hollows and may even be preferred in the Muchea area.

The repeated use of the same hollows suggests that Carnaby's Cockatoo have preferred locations, either in the landscape, breeding areas or within the tree itself. Additional years of monitoring are required to confirm this notion.

The rate of unsuccessful breeding events is standard across the monitoring project so far.

All of the artificial nesting hollows were in good condition and none required any maintenance.

Due to the historic large-scale clearing of trees and continuing decline of suitable trees with hollows in the area, all remaining suitable nesting hollows in the study area should be considered of high value to Carnaby's Cockatoo.

Under EPBC 2016/7656 (DotEE 2018), condition 4d states: "*Adaptive management may cease when at least one artificial nesting hollow for each known nesting hollow cleared has shown evidence of use by the Carnaby's Black Cockatoo, as verified by the suitable qualified person, for three consecutive years; the artificial nesting hollow in use for three consecutive years need not be the same artificial nesting hollow each year*". At least one more year of monitoring is therefore required to demonstrate that condition 4d has been met.

For future monitoring of the nesting hollows, consistent methodology should be employed to that used in the 2019-2020 and 2020-2021 breeding censuses, including continuing the use of pole cameras to inspect suspected breeding events where possible.

5 REFERENCES

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Appendix 1 Results for all hollows in in the 2019-20 breeding season

HT ID	24/08/20	22/09/20	26/10/ 20	27/11/20	31/12/20	07/02/2021
HT04274	No flush	No flush	No flush	No flush	No flush	No flush
HT04579	No flush	No flush	No flush	Post chewed	No flush	No flush
HT04581	No flush	No flush	No flush	No flush	No flush	No flush
HT04588	No flush	No flush	No flush	No flush	No flush	No flush
HT05947	No flush	No flush	No flush	No flush	No flush	No flush
HT05954	No flush	No flush	No flush	No flush	No flush	No flush
HT06017	No flush	No flush	No flush	No flush	No flush	No flush
HT06025	No flush	No flush	No flush	No flush	No flush	No flush
HT06160	No flush	No flush	No flush	No flush	No flush	No flush
HT06201	No flush	No flush	No flush	No flush	No flush	No flush
HT06216	No flush	No flush	No flush	No flush	No flush	No flush
HT06330	No flush	No flush	No flush	No flush	No flush	No flush
HT06348	No flush	No flush	Carnaby flushed	No flush	No flush	No flush
HT06678	No flush	No flush	No flush	No flush	No flush	No flush
HT12761	No flush	No flush	No flush	No flush	No flush	No flush
HT12762	No flush	No flush	No flush	No flush	No flush	No flush
HT12763	No flush	No flush	No flush	No flush	No flush	No flush
HT12765	No flush	No flush	No flush	No flush	No flush	No flush
HT13484	No flush	No flush	No flush	No flush	No flush	No flush

HT ID	24/08/20	22/09/20	26/10/ 20	27/11/20	31/12/20	07/02/2021
HT13497	No flush	No flush	No flush	No flush	No flush	No flush
HT13506	No flush	No flush	No flush	No flush	No flush	No flush
HT13507	No flush	No flush	No flush	No flush	No flush	No flush
HT13508	No flush	No flush	No flush	No flush	No flush	No flush
HT13585	No flush	No flush	No flush	No flush	No flush	No flush
HT14633	No flush	No flush	No flush	No flush	No flush	No flush
HT14653	No flush	No flush	No flush	Chewed entrance, pair prospecting	No flush	No flush
HT14657	No flush	Female prospecting	No flush	Pair prospecting	No flush	No flush
HT14672	No flush	No flush	No flush	No flush	No flush	No flush
HT14748	No flush	No flush	No flush	No flush	No flush	No flush
HT14749	No flush	No flush	Carnaby flushed	No flush	No flush	No flush
HT14809	No flush	No flush	Carnaby flushed	Pin-feathered chick	Large-feathered chick	Chick fledged
HT14810	No flush	Carnaby flushed	No flush	No flush	No flush	No flush
HT14811	No flush	No flush	No flush	No flush	No flush	No flush
NB01	No flush	No flush	Carnaby flushed	Pin feathered chick in nest	Large-feathered chick in nest	Chick fledged
NB02	No flush	No flush	No flush	No flush	No flush	No flush
NB03	No flush	No flush	No flush	Small chick in nest	Chick in nest	Chick fledged
NB04	No flush	No flush	No flush	Flushed female CBC, likely to be prospecting	No flush, no eggs in hollow	No flush

HT ID	24/08/20	22/09/20	26/10/ 20	27/11/20	31/12/20	07/02/2021
NB05	No flush	No flush	No flush	No flush	No flush	No flush
NB06	No flush	Carnaby flushed	No flush	No flush	No flush	No flush
NB08	No flush	No flush	No flush	No flush	No flush	No flush
NB09	No flush	No flush	No flush	No flush	No flush	No flush
NB10	No flush	Carnaby flushed	Single egg in nest	No access	No flush	No flush
NB11	No flush	No flush	No flush	No flush	No flush	No flush
NB12	No flush	No flush	Carnaby flushed	2 broken eggs	No flush	No flush
NB13	No flush	No flush	No flush	No flush	No flush	No flush
NB14	No flush	No flush	No flush	No flush	No flush	No flush
NB32	No flush	No flush	Carnaby flushed	Check in nest	Chick in nest	Chick fledged
NB33	No flush	No flush	No flush	No flush	No flush	No flush
NB34	No flush	No flush	Prospecting female	Single egg in nest	Chick in nest	Chick fledged
NB41	No flush	Carnaby flushed	Chick in nest	No flush	No flush	No flush
NB42	No flush	No flush	No flush	No flush	Pair of Carnaby's prospecting	No flush
NB46	No flush	No flush	No flush	No flush	No flush	No flush
NB55	No flush	No flush	No flush	No flush	No flush	No flush
NB57	No flush	No flush	No flush	No flush	No flush	No flush
NB58	No flush	No flush	No flush	No flush	No flush	No flush
NB59	No flush	No flush	No flush	No flush	No flush	No flush
NB60	No flush	No flush	No flush	No flush	No flush	No flush

HT ID	24/08/20	22/09/20	26/10/ 20	27/11/20	31/12/20	07/02/2021
NB61	No flush	No flush	No flush	No flush	No flush	No flush
NB62	Carnaby flushed	Carnaby flushed	Downy chick in nest	Large-feathered chick in nest	No flush	No flush
NB63	Carnaby flushed	Carnaby flushed	Cracked egg in nest	No flush	No flush	No flush
NB64	Carnaby flushed	No flush	No flush	<i>Chick in natural hollow underneath NB64</i>	No flush	No flush
NB65	No flush	No flush	No flush	No flush	No flush	No flush
NB66	No flush	No flush	No flush	No flush	No flush	No flush
NB67	No flush	No flush	No flush	No flush	No flush	No flush
NB68	No flush	No flush	No flush	No flush	No flush	No flush
NB69	No flush	No flush	No flush	No flush	No flush	No flush
NB71	No flush	No flush	Carnaby flushed	Nestling in hollow	Feathered chick in hollow	Chick fledged
NB76	No flush	Heavily chewed post	No flush	No flush	No flush	No flush
NB77	No flush	No flush	Carnaby flushed	No flush	No flush	No flush
NB78	No flush	Carnaby flushed	No flush	Pin-feathered chick	Chick fledged	No flush
NB79	No flush	No flush	Post chewed	No flush	No flush	No flush
NB99	No flush	Pair prosecting	No flush	Two old eggs	No flush	No flush
NB100	No flush	No flush	No flush	No flush	No flush	No flush

Appendix 2 Results for all hollows in all breeding seasons

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
HT04059	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT04274	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT04579	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
HT04581	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT04588	Evidence of nesting activity	No evidence of breeding	Evidence of nesting activity	No evidence of breeding
HT05911	No access	Hollow not located	Tree cleared. Further monitoring not required	n/a
HT05923	No evidence of breeding	Tree cleared. Further monitoring not required	n/a	n/a
HT05938	No longer suitable hollow. Further monitoring not required	n/a	n/a	n/a
HT05947	No evidence of breeding	Not located	No evidence of breeding	No evidence of breeding
HT05954	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06017	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06020	No access	Tree cleared. Further monitoring not required	n/a	n/a
HT06025	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06046	No access	Tree cleared. Further monitoring not required	n/a	n/a
HT06148	No longer suitable. Further monitoring not required	n/a	n/a	n/a
HT06160	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06201	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06216	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
HT06261	No evidence of breeding	Tree cleared. Further monitoring not required.	n/a	No evidence of breeding
HT06278	Evidence of nesting activity	Tree cleared. Further monitoring not required.	n/a	No evidence of breeding
HT06330	Not sampled	No evidence of breeding. Added to breeding census in 2018-19	No evidence of breeding	No evidence of breeding
HT06348	Evidence of nesting activity	No evidence of breeding	Confirmed breeding event - failed	Evidence of nesting activity
HT06421	No access. Evidence of nesting activity (from a distance)	No access	n/a	n/a
HT06655	No longer suitable. Further monitoring not required	Tree cleared. Further monitoring not required	n/a	n/a
HT06678	Evidence of nesting activity (FRTBC)	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT08752	No evidence of breeding	Tree cleared. Further monitoring not required	n/a	n/a
HT08753	Evidence of nesting activity	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT08754	No access	Confirmed breeding event	Tree cleared. Further monitoring not required	n/a
HT12761	Hollow not located	Hollow not located	No evidence of breeding	n/a
HT12762	Evidence of nesting activity	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT12763	Evidence of nesting activity	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT12765	Confirmed breeding event - successful	No evidence of breeding	Confirmed breeding event	No evidence of breeding
HT13484	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT13497	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT13503	No access	No longer suitable. Further monitoring not required	n/a	n/a
HT13505	No access	No longer suitable. Further monitoring not required	n/a	n/a

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
HT13506	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT13507	No access	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT13508	No access	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT13511	No access	No longer suitable. Further monitoring not required	n/a	n/a
HT13523	No access	No longer suitable. Further monitoring not required	n/a	n/a
HT13533	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT13534	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a	n/a
HT13535	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a	n/a
HT13585	Not sampled	No evidence of breeding. Added to breeding census in 2018-19, chewing observed at hollow	Evidence of nesting activity	No evidence of breeding
HT14633	Evidence of nesting activity	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT14653	Evidence of nesting activity	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
HT14657	No evidence of breeding	No evidence of breeding	Evidence of nesting activity	Evidence of nesting activity
HT14670	Collapsed, no longer suitable. Further monitoring not required	n/a	n/a	n/a
HT14672	Evidence of nesting activity	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14748	Confirmed breeding event - successful	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14749	Confirmed breeding event - successful	Confirmed breeding event	No evidence of breeding	Evidence of nesting activity
HT14805	No access	No access	No longer suitable. Further monitoring not required	n/a
HT14806	No access	No access	No longer suitable. Further monitoring not required	n/a

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
HT14807	No access	No access	No longer suitable. Further monitoring not required	n/a
HT14808	No access	No access	No longer suitable. Further monitoring not required	n/a
HT14809	Evidence of nesting activity	No evidence of breeding	No evidence of breeding	Confirmed breeding event
HT14810	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
HT14811	No evidence of breeding	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB01	n/a	No evidence of breeding	Evidence of nesting activity	Confirmed breeding event
NB02	n/a	Confirmed breeding event	No evidence of breeding	No evidence of breeding
NB03	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB04	n/a	No evidence of breeding	Evidence of nesting activity	Evidence of nesting activity
NB05	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB06	n/a	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
NB08	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB09	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB10	n/a	No evidence of breeding	Evidence of nesting activity	Confirmed breeding event
NB11	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB12	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB13	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB14	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB32	n/a	No evidence of breeding/no access	No evidence of breeding	Confirmed breeding event
NB33	n/a	No evidence of breeding/no access	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
NB34	n/a	n/a	Confirmed breeding event	Confirmed breeding event
NB41	n/a	n/a	Confirmed breeding event	Confirmed breeding event
NB42	n/a	n/a	No evidence of breeding	Evidence of nesting activity
NB46	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB55	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB57	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB58	n/a	No evidence of breeding	Evidence of nesting activity	No evidence of breeding
NB59	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB60	n/a	No evidence of breeding	Evidence of nesting activity	No evidence of breeding
NB61	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB62	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB63	n/a	No evidence of breeding	Confirmed breeding event	Confirmed breeding event
NB64	n/a	Evidence of nesting activity	Evidence of nesting activity	Evidence of nesting activity
NB65	n/a	No evidence of breeding	Evidence of nesting activity	No evidence of breeding
NB66	n/a	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
NB67	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB68	n/a	No evidence of breeding	Evidence of nesting activity	No evidence of breeding
NB69	n/a	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB71	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB76	n/a	No evidence of breeding	Evidence of nesting activity	Evidence of nesting activity

HT ID	Result 2017-18	Result 2018-19	Result 2019-20	Result 2020-2021
NB77	n/a	No evidence of breeding	Evidence of nesting activity	Evidence of nesting activity
NB78	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB79	n/a	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
NB99	n/a	No evidence of breeding	No evidence of breeding	Confirmed breeding event
NB100	n/a	n/a	Evidence of nesting activity	No evidence of breeding

