Hornsby Shire Council
Hornsby Quarry Rehabilitation

Vegetation Management Plan
and
Habitat Creation and Enhancement Plan

Report prepared by Hornsby Shire Council
and
Gecko Environment Management

2020

Revision	Date	Details
A	17/07/2020	Final draft issued for exhibition
B	11/05/2021	Amendments as per conditions of consent
C	30/07/2021	Correction to amendments

Title Page Photo: Powerful Owl Breeding Pair © Birdlife Australia

Executive Summary

The former Hornsby Quarry is located entirely in the Hornsby diatreme. A diatreme is a relatively rare volcanic intrusion which is believed to be formed during the Jurassic period. The material sought after from the diatreme was used primarily for road base. Quarrying activities continued from 1902 and throughout the 1990's under a range of ownerships. Hornsby Shire Council (Council) acquired the Quarry in 2002. Since acquisition, the area has been closed to the public for safety reasons as the Quarry and surrounds were deemed unstable. During that time, Council has undertaken extensive investigations, planning and design to rehabilitate and make the site safe so the highly modified but unique surrounding landscape can be protected and used by the community for a mixture of open space and recreational uses within a bushland setting.

Being of volcanic origin, soils derived from the weathering of the Diatreme are generally deep, clayey soils with high nutrient levels and as such, support a Blue Gum Diatreme Forest (BGDF), a forest listed as a Critically Endangered Ecological Community under both the *Environment Protection and Biodiversity Conservation Act 1999* and the *NSW Biodiversity Conservation Act 2016*. Previous studies and Council investigations have mapped the extent and condition of the remaining BGDF. Additional geotechnical studies have been undertaken to determine the best way to stabilise the site for future use while preserving the BGDF. It is necessary however, to remove a part of the regrowth BGDF on the degraded and unstable north spoil mound to make the area safe. As part of the geotechnical studies the area to be removed has been limited as much as possible and will be compensated as 'offset' areas on the site through the Biodiversity Offset Strategy prepared for the Hornsby Quarry Rehabilitation project.

The rehabilitation project relates primarily to earthworks necessary to stabilise and reshape the Quarry site to ensure the area is safe and usable for future community recreational use. The Development Application required an Environmental Impact Statement (EIS) be prepared. This EIS included a Biodiversity Impact Assessment in accordance with the requirements of the Secretary's Environmental Assessment Requirements (EAR) issued by the NSW Office of Environment and Heritage (OEH) (EAR 1167, dated 31/8/17).

This Vegetation Management Plan (VMP) and Habitat Creation and Enhancement Plan (HCEP) has been prepared to provide direction for ongoing native vegetation and habitat management in accordance with the EAR's and any conditions of approval. The VMP also supports Council's Biodiversity Offset Strategy and associated Voluntary Conservation Agreement (VCA) for the Hornsby Quarry Rehabilitation. The Biodiversity Offset Strategy identifies the steps taken to avoid and mitigate the impacts from earthworks pertaining to the DA and recommends that the residual offsetting requirements resulting from the works are undertaken locally, on the Site.

Council plans to open the Quarry for the public, hence the highly modified area within the extent of works (hereafter 'the Impact Area') will be made available for recreation, balanced with conserving, re-establishing and enhancing the surrounding bushland (hereafter 'the Site') in-perpetuity. Through the implementation of this VMP and HCEP, Council will be able to ensure the following:

- protection of the native vegetation onsite with specific reference to the unique Blue Gum Diatreme Forest and connection with the Berowra Valley National Park
- protection of existing fauna known and predicted to occupy the area prior, during and post the proposed earthworks
- restoration and conservation of the connectivity of native vegetation and habitat corridors in-perpetuity

- sustainably establish native vegetation and associated ecological processes to a condition representative of the surrounding plant communities, with particular emphasis in areas where there has been major disturbance or areas that require stabilisation works
- establishment of an adaptive management program for the natural areas of the Site to ensure ecological condition is maintained and improved
- improved integration of ecological management and habitat protection with the objectives of appropriate recreation pursuits such as walking and riding

The northern spoil mound is a critical area requiring stabilisation to ensure public safety and prevent the potential loss of existing high value vegetation through localised landslip. Much of this area is steep, unstable and covered with weeds that are currently the source of weed seed threatening the surrounding bushland areas. Of significance is *Cortaderia selloana* Pampas Grass, a weed listed as a Priority Weed under the NSW *Biosecurity Act 2016*. Following stabilisation earthworks, the north spoil mound will be restored with specifically engineered soils, re-used natural elements and revegetation using densely planted native endemic species. The intention is to revegetate with species representative of the surrounding bushland plant community types, specifically the BGDF. Any vegetation clearing, and habitat protection required as part of the stabilisation process will be undertaken in accordance with the VMP and associated Construction and Environmental Management Plan.

Important in the restoration of the Quarry is the development of and implementation of actions which aim to protect, enhance and conserve a high level of ecological function within the Site now and in-perpetuity. To achieve the aim, the current site description and condition have been provided. It is evident that the bushland areas have been highly modified through the impacts of historic mining activities. Yet, despite the modifications, a high level of habitat value exists. The Impact Area, the Site and adjacent bushland provides roosting, nesting, sheltering and foraging sites for arboreal, herpetofauna, mammals, microbats and birds who can move freely between these areas. Of significance is the inclusion of a breeding pair of *Ninox strenua* Powerful Owl successfully breeding in recent years within the Site.

Mitigating potential direct, indirect and cumulative impacts from the earthworks associated with the DA have been identified and mitigation management actions have been provided that are reflective of the planning and design done to date. Mitigation relies heavily upon ongoing vegetation management because of its importance in supporting the existing fauna on-site. A strong emphasis has also been placed on the importance of riparian areas as wildlife corridors and the weed species, *Ligustrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet, as roosting areas. The staging and location of weed treatment has been itemised in management action tables and the performance criteria specified relates to baseline data collated. All works will be assessed and incorporated in ongoing adaptive management through a detailed and prescribed annual monitoring program.

Recommendations are provided regarding the staging of earthworks with consideration to the breeding cycle of the *Ninox strenua* Powerful Owl and consultation with Birdlife Australia. Works will not be undertaken within the recommended exclusion zones if a breeding pair are occupying a nest on Site. Through the implementation of this plan site management activities will facilitate the return of the Powerful Owls at the completion of the north spoil mound stabilisation and restoration works.

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Abbreviations

Abbreviation	Description
AS	Australian Standard
BBAM	BioBanking Assessment Methodology
BBGF	Blackbutt Gully Forest
BC Act	*Biodiversity Conservation Act* 2016
BGDF	Blue Gum Diatreme Forest
BVNP	Berowra Valley National Park
CBD	Central Business District
CEEC	Critically Endangered Ecological Community
DA	Development Application
DBH	Diameter at Breast Height
EAR	Environmental Assessment Requirements
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
FM Act	*Fisheries Management Act*
GBD	General Biosecurity Duty
HCEP	Habitat Creation and Enhancement Plan
KTP	Key Threatening Process
LGA	Local Government Area
MZ	Management Zone
PPE	Personal Protective Equipment
PCT	Plant Community Type
SDT	Standing Dead Trees
SEAR	Secretary's Environmental Assessment Requirements
SWM	South West Mound
VCA	Voluntary Conservation Agreement
VMP	Vegetation Management Plan

1. Introduction

1.1 Purpose

The rehabilitation and development of the former Hornsby Quarry as a new recreational parkland, Hornsby Park, has been proposed under DA/101/2019. The Secretary's Environmental Assessment Requirements (EAR No 1167) dated 6 September 2017 notes that the EIS, in determining a Biodiversity offsets package, must *identify the conservation mechanisms to be used to ensure the in-perpetuity protection and management of proposed offset sites.*

A Preliminary Vegetation Management Plan (VMP) was submitted as part of the Application that provided a general description of the ongoing conservation mechanisms for an offsets package in accordance with the EAR's and any conditions of approval. Following the Sydney North Planning Panel public meeting held via teleconference on 6 May 2020, the Panel deferred the Application to enable several key issues of significant public interest be resolved with certainty for both the Panel and the Public.

Key relevant issues to be resolved are the completion of the Biodiversity Offset Package following the finalisation of a VMP and an associated Habitat Creation and Enhancement Plan (HCEP). The purpose of this document is to cover the VMP and HECP. It will provide the mechanisms for ongoing ecosystem management within the extent of works (hereafter 'the Impact Area') as part of the DA and within the surrounding area (hereafter 'the Site') (Figure 1.1) as per the Biodiversity Offset Package and Voluntary Conservation Agreement (VCA). Additional focus will to be on a staged plan of works with reference to natural rehabilitation, habitat protection and the breeding pair of Powerful Owls, as keystone species, for 'the Site's' ecosystem processes.

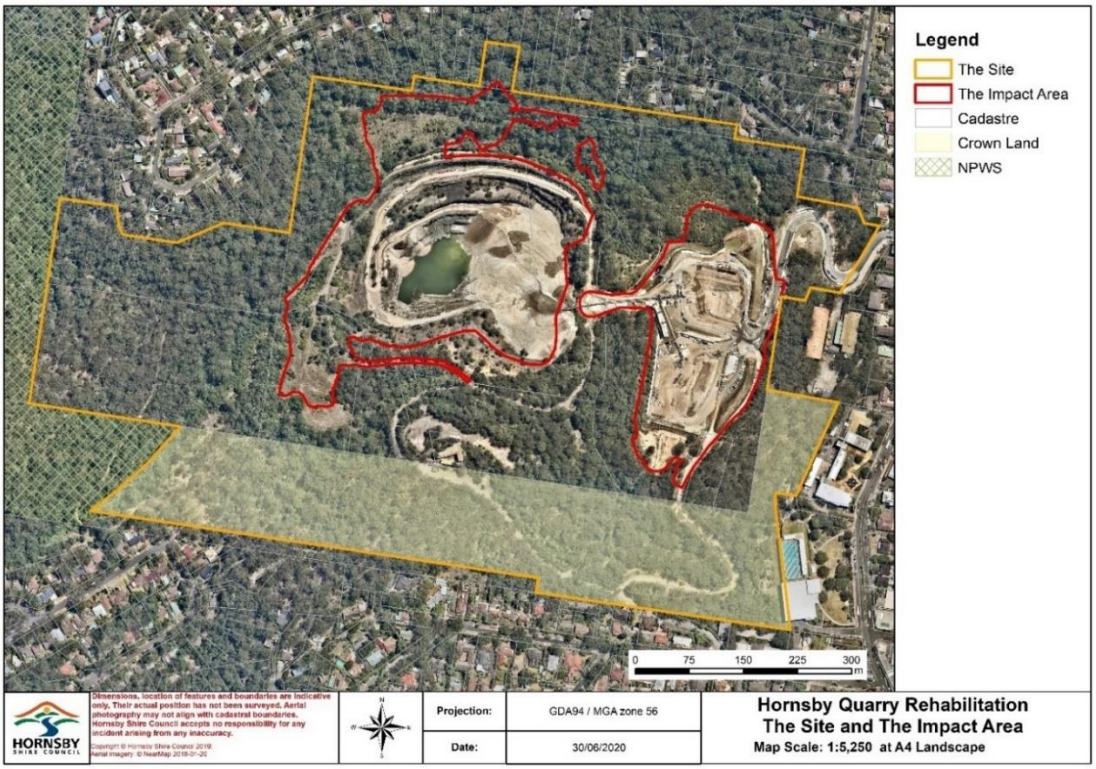

Figure 1. 1 The Site and Impact Area

1.2 Background

The northern portion of the Hornsby Diatreme was mined for blue metal aggregate since the early 1900's in an area that is now known as the Hornsby Quarry. The Quarry was decommissioned and then acquired by Hornsby Council in 2002. Since acquisition, the Quarry and surrounds have been closed to the public for safety reasons and Council has undertaken extensive studies with the aim to rehabilitate the area. Plans have now been prepared to stabilise the Quarry and provide a landform for future embellishment as a place to be enjoyed as a public recreational parkland surrounded by a landscape of high ecological integrity. Initial stabilisation works involved partial filling of the void. Roads and Maritime Services were given approval to undertake the filling operations with material extracted from the NorthConnex tunnel works.

The rehabilitation details pertaining to DA/101/2019 relate primarily to earthworks necessary to complete stabilisation requirements and reshape the Quarry precinct to ensure the area is safe and usable for the public. Landscaping and embellishment will be determined through a future approval process. This VMP, the HCEP and the Biodiversity Offsets Strategy discuss the works proposed under DA/101/2019 and together, will act as a directive to ongoing ecological management in-perpetuity.

Stabilisation works of relevance to this Development Application are needed to stabilise the north spoil mound, an area on the northern slope above the void used as an overburden site. Since the rehabilitation project's inception, many reiterations of how the north spoil mound could be stabilised, with the least possible disturbance, have been explored by a team of Engineers, Landscape Architects and Natural Resource Managers. Water entering the site along the drainage line from Manor Road Hornsby is of high importance and its management is critical to the structural integrity of the north spoil mound. There is an existing trapped low point behind the overburden. Water is no longer able to drain due to the failure of a drainage pipe that was installed during the mining operations. The proposed design will remove steep and unconsolidated fill profiles that are at risk of landslide resulting in additional significant tree loss, promote improved management of overland flows and reinstate collection of low flows, managed by a stormwater drainage system. The design will also provide for managed overflow in high rainfall and flood events. In the process, the north spoil mound can be reshaped to incorporate a topography more conducive to safe access, the weeds can be treated, the soil improved, and the area can be revegetated with plants of local provenance representative of the surrounding native vegetation. Vegetation removal is necessary as part of the required works to ensure the area is stabilised and as such, a small part of the Blue Gum Diatreme Forest of poor quality requires removal. The area to be removed has been limited to the fullest extent possible and will be offset as per Council's Biodiversity Offset Strategy.

The landscape within the Impact Area of the DA and the Site, is currently complex and physically difficult to manage because of the steep and unstable topography that occupies most of the area. The soils are varied and disturbed. Opportunistic woody weeds have established as the dominant midstorey under a canopy of native vegetation regrowth on these disturbed areas.

The Site currently supports a diverse range of native fauna. Of note has been the recent confirmation of a breeding pair of *Ninox strenua* Powerful Owl. It is inevitable that the proposed project will be disruptive in the short term, but it is Council's plan to aim for best practice ecologically sustainable development to ensure the natural longevity of the remnant forest including the areas subject to rehabilitation. The stringent and accountable processes accepted through this document, will enable a much more sustainable long-term outcome for the Site's biodiversity, the connectivity to adjacent natural areas and as an education platform for

the broader community. Confidence is to be gained from the resilience currently observed of native vegetation regrowth over the Site despite historic disturbances (Figures 2.3 to 2.9).

1.3 Aims and Objectives

This VMP and HCEP describes the ecological processes currently functioning within the Impact Area and the Site (Figure 1.1), with reference to fauna and flora present, the Site condition, the proposed impact and proposed mitigation mechanisms. The aim of this report is to formulate mechanisms and management actions to protect, enhance and conserve a high level of ecological function within the Site now and in-perpetuity through building ecosystem resilience (Gleeson 2012).

The objectives are to:

- protect the native vegetation onsite including the Blue Gum Diatreme Forest and surrounding natural areas
- protect existing fauna known and predicted to occupy the Impact Area and the Site prior, during and post the proposed earthworks
- restore and conserve connectivity of native vegetation and habitat corridors in-perpetuity
- sustainably establish native vegetation and associated ecological functions and processes to a condition representative of the surrounding Plant Community Types (PCTs) in areas of major disturbance including areas requiring stabilisation works
- establish a mechanism to provide succinct flora and fauna baseline data for future reference
- set up a monitoring and evaluation program for adaptive management of flora and fauna
- improve integration of habitat with appropriate recreation provision

1.4 Methodology

The following has been undertaken in the process of preparing this report:

- Review of previous reports: Soils - SESL Australia (2018), Tree Survey - Arterra (2019), EIS - GHD (2019), Vegetation Survey and Mapping - Kleinfelder (2017), EcoLogical (2015), Dragonfly MBT REF (2011), Preliminary Construction Environmental Management Plan – GHD (2019), Preliminary VMP (2019)
- On-ground field investigations
- Discussions with relevant stakeholders
- Consideration to the final earthwork requirements for stabilisation, vegetation condition and future surrounding land use design

1.5 Plan Tenure

The VMP and HCEP is to cover a period of twenty years and then in-perpetuity under the guise of adaptive management. Levels and types of input and resources required to ensure processes endure will need to be reviewed annually to assess if any alterations to ecological functionality are apparent due to disturbance: unforeseen, naturally occurring or through deviations from the original plan by others. It is advised that this document is reviewed in 5 years.

1.6 Legislation and Planning Controls

Table 1. 1 Relevant Legislation

Government Level	Relevant Policy/Legislation	Relevance to the Site
Local	• Hornsby Local Environmental Plan 2013	• RE1 Public Recreation (public open space or recreation; protect and enhance the natural environment for recreation; protect and maintain areas of bushland with ecological value) Note: A small section of R2 Low Density Residential Land is also incorporated into the Site.
State	• *Biodiversity Conservation Act 2016* • *NSW Biosecurity Act 2015*	• CEEC present. • Secretary's Environment Assessment Requirements (SEARs) published 28.08.17 (assess significance of impact including residual impacts to determine if Offsets are required.
Commonwealth	• *Environment Protection and Biodiversity Conservation Act 1999*	• CEEC present.

2. Existing Environment

2.1 Location

Hornsby is a suburb of Sydney located approximately 21 kilometres north west from the CBD. The Hornsby Quarry is located within Old Mans Valley and adjacent to Hornsby Park. Old Mans Valley and Hornsby Park are located on the west side of the Hornsby CBD. The Hornsby Railway Station is a major transport link to the city. Both the Railway Station and the CBD are within walking distance to Old Mans Valley and Hornsby Park (Figure 2.1 and Table 2.1).

Native vegetation surrounds the Quarry. The native vegetation on the northern, southern and eastern boundaries of the Quarry in Old Mans Valley creates a buffer to the Quarry from the built environment of the Hornsby CBD and the Hornsby residential zones. The native vegetation on the western boundary borders the Berowra Valley National Park and as such, the Impact Area and the Site have linkages to protected natural areas along Dog Pound Creek to the Blue Gum Creek Reserve and the Dog Pound Creek BioBanking site. This BioBanking site is also a Blue Gum Diatreme Forest and protected in-perpetuity under the State's BioBanking Agreement Number 142**.**

Table 2. 1 The Site Definition

Land Title	Lot A, B, C, D and E in DP 318676, Lot 1 DP 926103, Lot 1 DP 926449, Lot 1 DP 114323, Lots 1 and 2 in DP 169188, Lot 7306 DP 1157797, Lot 1 DP 859646, Lot 13 DP 734459, Lot 114 DP 749606, Lot 213 DP 713249
Location	Old Mans Valley and Hornsby Park, HORNSBY
Grid Reference	151.090704 E, -33.69740 S
Ownership	Hornsby Shire Council, Crown
Zoning	RE1 Public Recreation
Current Land Use	Decommissioned Quarry, Mountain Bike Track, Walking Tracks, Native Bushland

2.2 Topography

The original topography of the Site would have been representative of a river system imbedded in gently undulating low hills within a steep valley. The Site now forms an amphitheatre sloping away from the higher elevation of the built environment of Quarry, Old Peats Ferry, Manor and Summers Roads to the south, east and north respectively. Joe's Mountain, within the Berowra Valley National Park, is to the west (Figure 2.2). The void is at the centre of the amphitheatre, a large hole surrounded by exposed rockfaces. The eastern rockface exposes an impressive geological representation of the diatreme formation. The northern, southern and western rockfaces of the Quarry rim are a combination of steep exposed slopes comprising of a mixture of spoil from quarrying activities, bedrock and eroded soil (Figure 2.8).

The most recent LiDAR image provides a detailed representation of the current topography including the modified landforms due to mining activities and the complexity of the challenges these present (Figure 2.9).

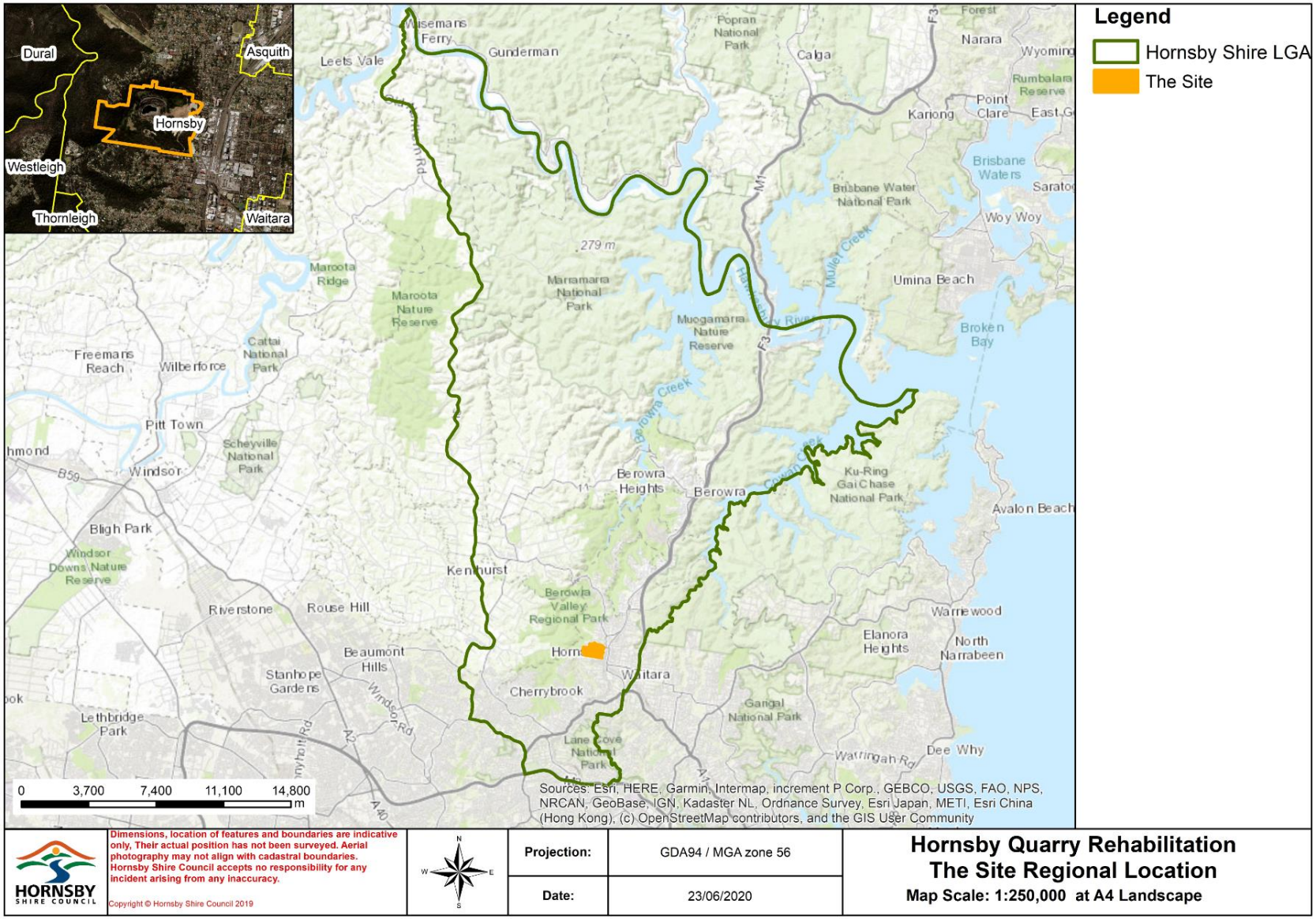

Figure 2. 1 The Site Regional Location

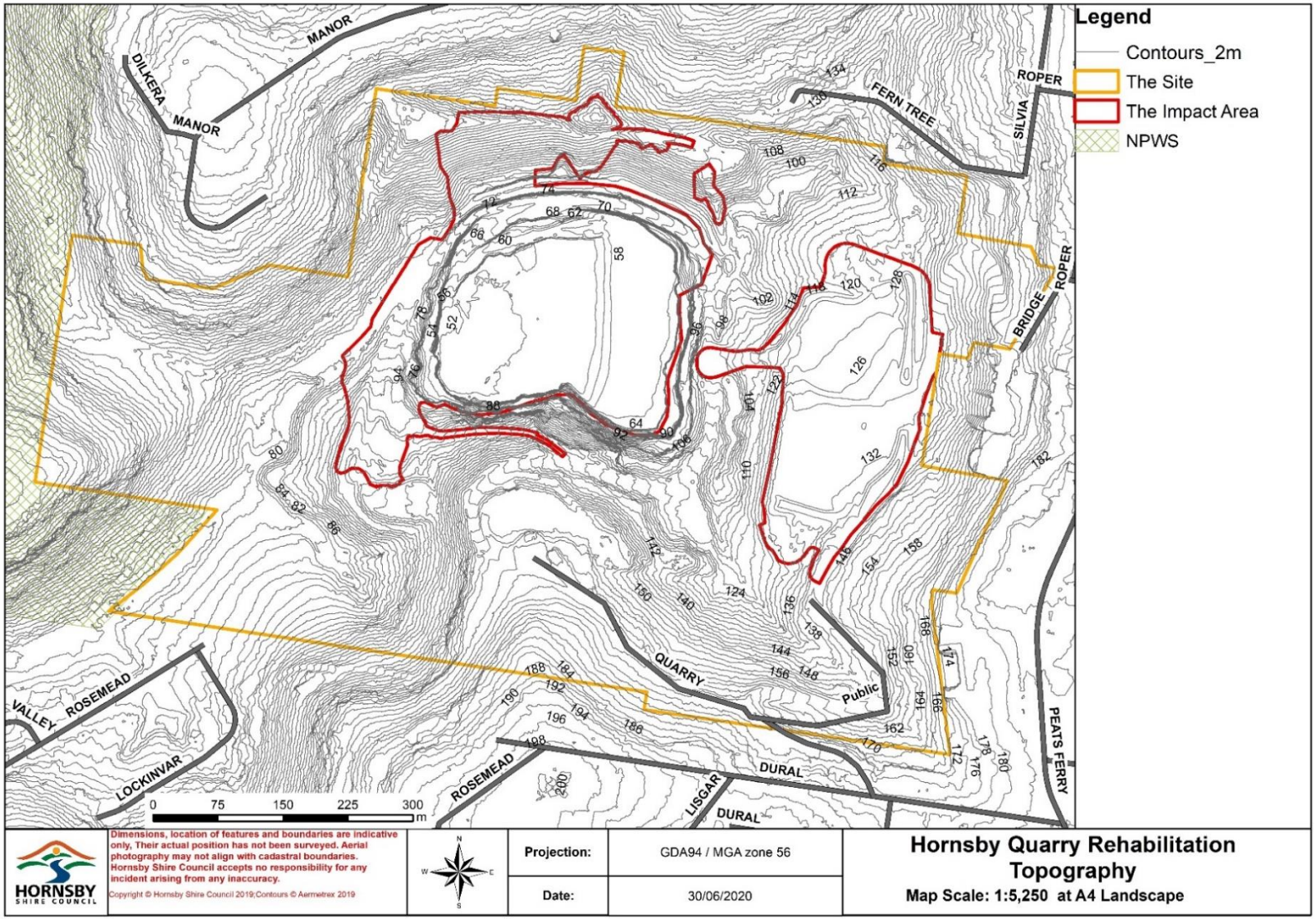

Figure 2. 2 Topography

2.3 Geology and Soil

The Quarry is at the northern end of the Hornsby diatreme, a rare volcanic structure formed within the joint system and horizontal layers of sedimentary rocks. Formed millions of years ago, the soil was a mixture of basaltic breccia, sedimentary breccia and metamorphosed Hawkesbury sandstone. The surrounding areas are Hawkesbury Sandstone (PSM 2007). The intrinsic qualities of the Hornsby Diatreme's soil have resulted in its value to development and the mining of its properties. Based on Chapman and Murphy (1989) soil type descriptions, Hornsby (ho), Hawkesbury (ha) and Lucas Heights (lh) soils have been mapped on site in the *Soil Landscapes of the Sydney 1:100,00 Sheet.*

Previous studies of the Site soils have been undertaken by Coffeys and Partners Investigations (1990), Parsons Brickenhoff Investigations (2004), PSM Investigations (2007) and SESL (2019). These studies indicate that little, if any, of the remaining A horizon exists in the Impact Area and B horizons have been heavily modified. Excavated material associated with mining activities, have been deposited around the Impact Area and the Site. These deposits are a mixture of varying development stages of breccia and sandstone overburden. The Quarry void has been half filled with crushed sandstone excavated during the construction of the North Connex tunnel.

Historic aerial photos provide a good temporal and spatial story reflecting the historic land clearing and soil disturbance that has occurred prior to this project (Figures 2.3 to 2.8).

Figure 2. 3 View from Old Mans Valley looking West South-West pre-mining

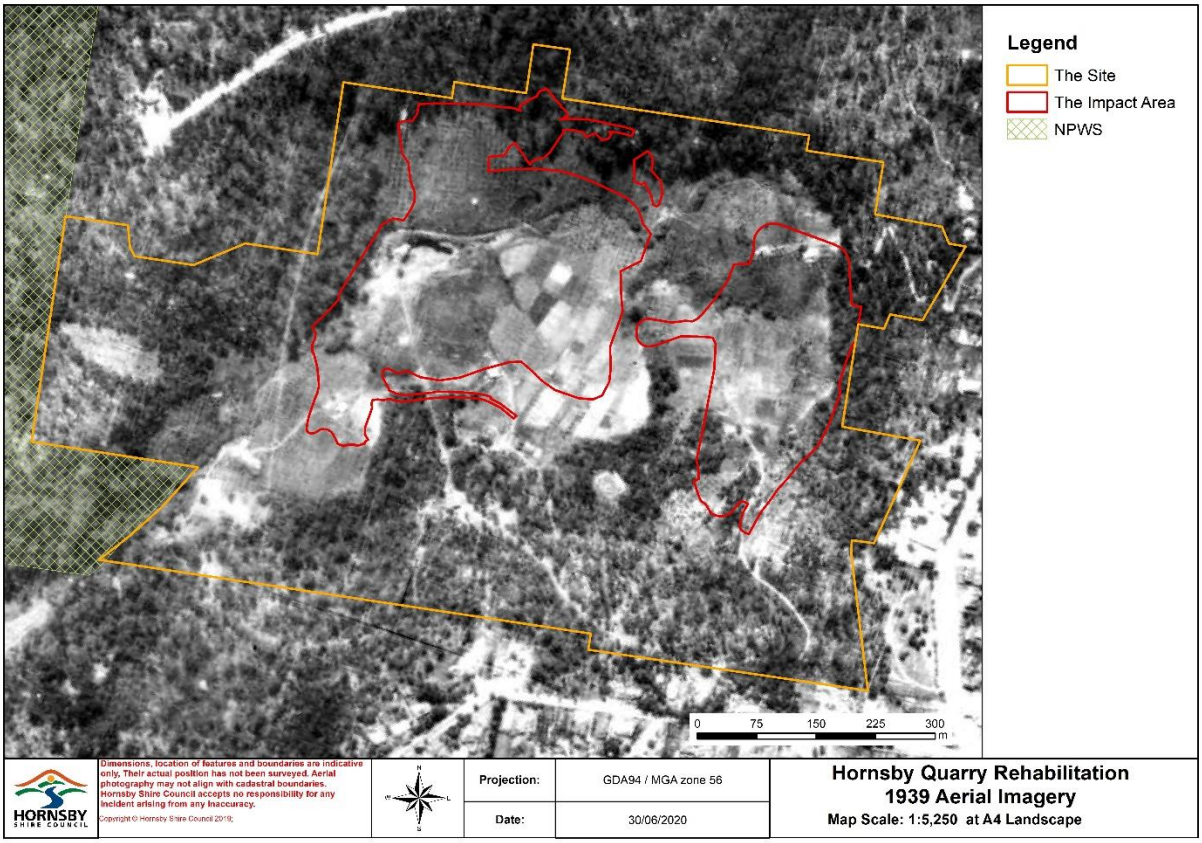

Figure 2. 4 Quarry Aerial Imagery 1939

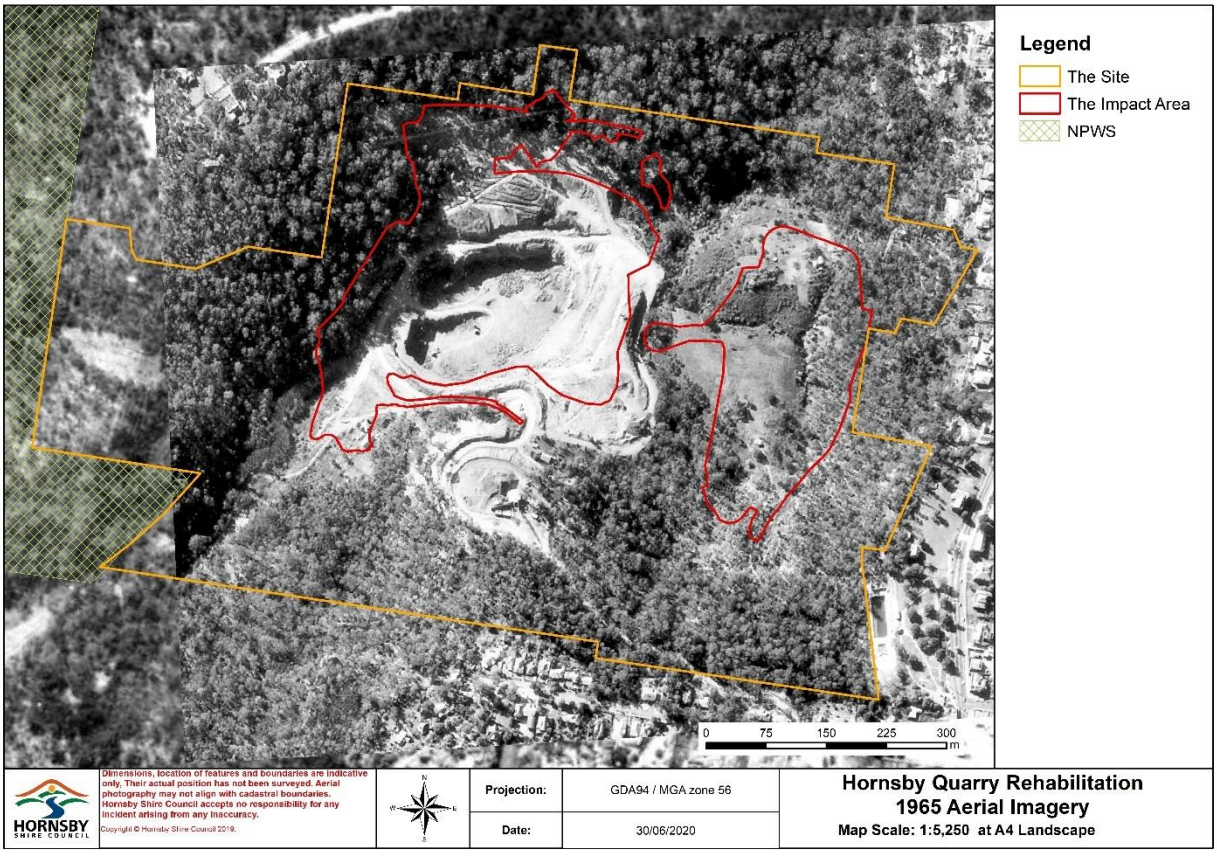

Figure 2. 5 Quarry Aerial Imagery 1965

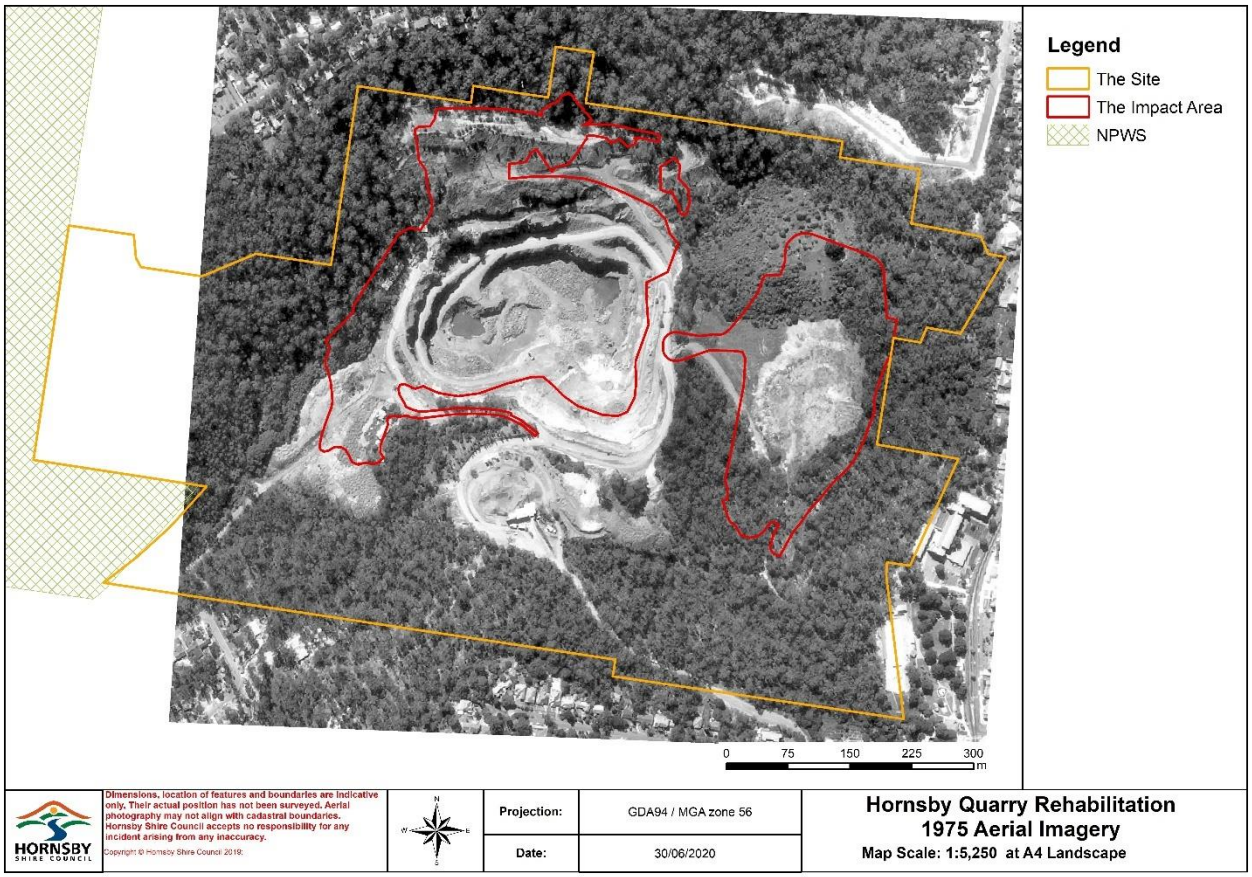

Figure 2. 6 Quarry Aerial Imagery 1975

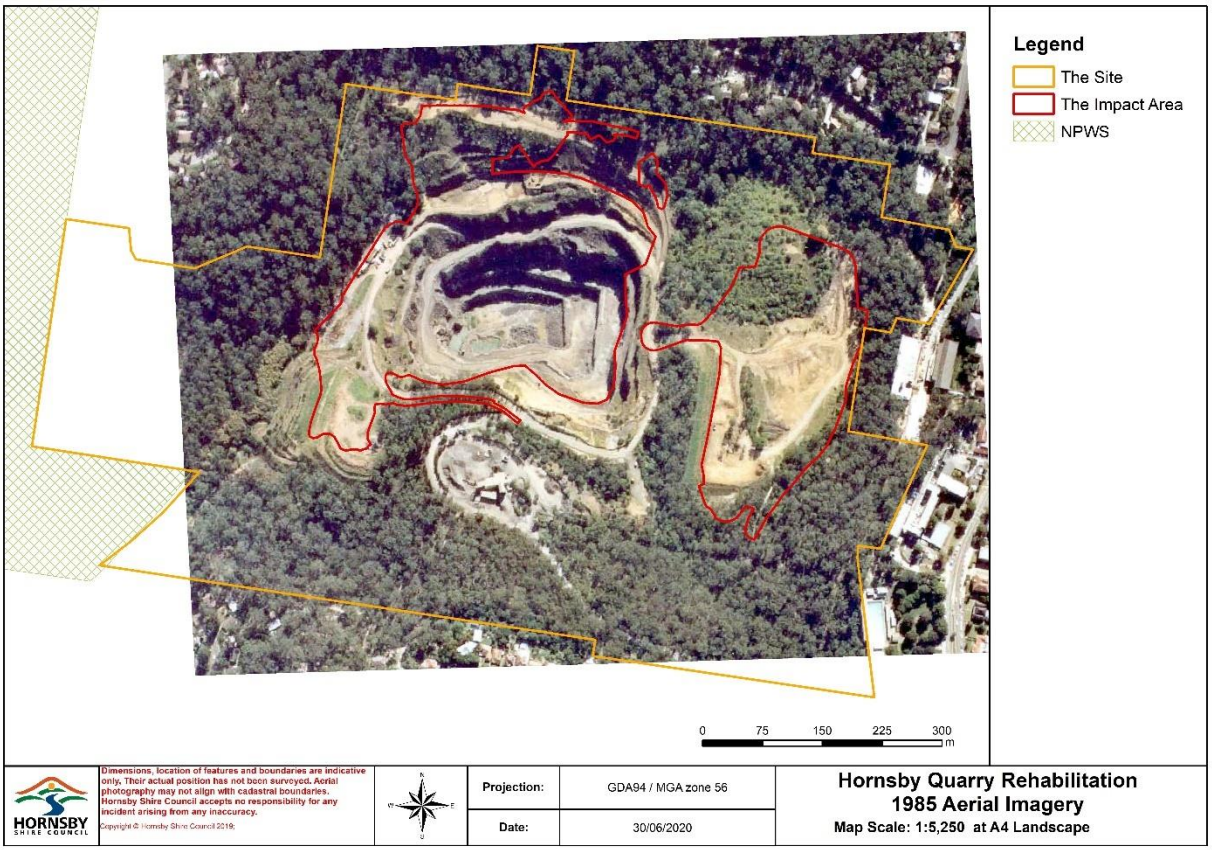

Figure 2. 7 Quarry Aerial Imagery 1985

Figure 2. 8 Aerial view looking South towards Crusher Plant early 1960s

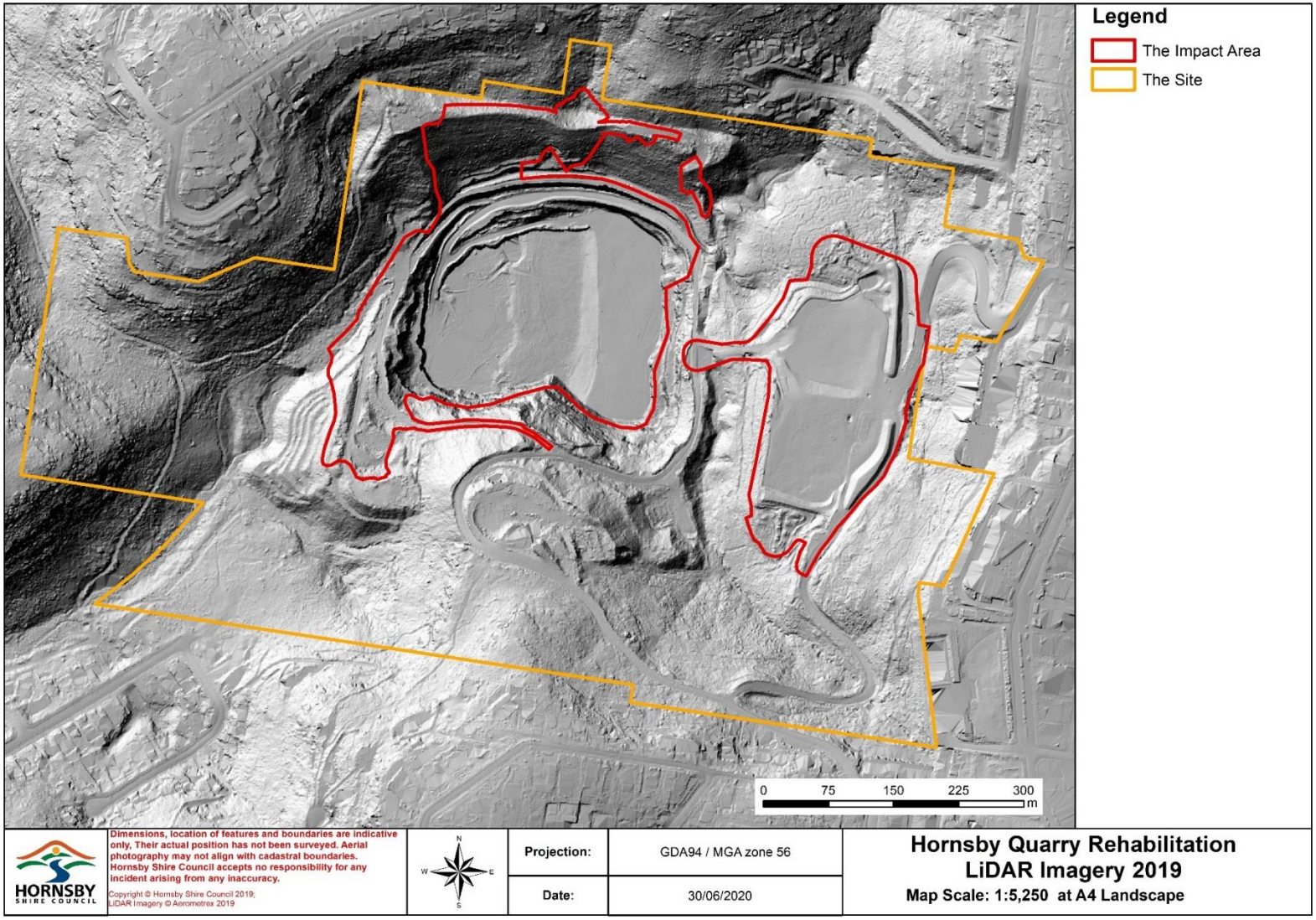

Figure 2. 9 LiDAR Imagery

2.4 Hydrology

Old Mans Valley is within the Hawkesbury Nepean River Catchment, the largest river/estuary system in the Sydney Region and one of the most important river systems in NSW. The land use of Old Mans Valley has changed over time, and as such, so has the integrity of the natural water flows. Following thousands of years of Aboriginal occupation and use, the natural landforms were subjected to land clearing, then orcharding and finally mining activities. Water now flows into the valley from neighbouring urban and natural areas via ephemeral drainage lines. All surface water flows have been diverted around the quarry void via a series of pipes, constructed channels and culverts to Old Mans Creek, a tributary of Berowra Creek within the Hawkesbury River Catchment (Figure 2.10). Groundwater inflow has historically filled the base of the void with water requiring pumping out by Council under a *Water Management Act 2000,* dewatering licence with an allocation of 370 ML/year.

2.5 Conservation Significance

The Blue Gum Diatreme Forest (BGDF) as described by Smith and Smith (2008) is part of the complex vegetation community that is Blue Gum High Forest (BGHF) in the Sydney basin and is listed as critically endangered under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the NSW *Biodiversity Conservation Act 2016.* A critically endangered ecological community classification, as per the Scientific Committee, is one facing an extremely high risk of extinction in New South Wales in the immediate future.

The BGHF and BGDF ecological communities are defined by the geology and soils that support them. The BGHF grows on soils derived from Wianamatta Shale and the BGDF grows on soils derived from volcanic diatremes. The original distribution of the BGHF complex occupied an area of 2000 hectares in northern Sydney. Less than 4.5% of the original distribution remains and these are in small remnants. The Hornsby Local Government Area (LGA) contains approximately 25% or the remaining remnants and possibly all of the remaining BGDF (Smith & Smith 2008). The existing condition of the BGDF within the Impact Area and the Site is variable and is highly modified due to past mining activities.

The Hornsby Diatreme in Hornsby's LGA is one of six priority Blue Gum High Forest management sites identified in NSW to be included in the Saving our Species program, a targeted strategy for managing threatened species. The conservation strategy of the program aims to secure the ecological community in the long term. The status of the Hornsby Diatreme in the program is 'Proposed'. Ten conservation management actions are proposed for this site and these have been addressed as part of the DA, the Biodiversity Offset Strategy as well as through mechanisms provided by this VMP and HCEP. The following objectives of the proposed management actions that have been addressed are:

- Minimise spread of disease within the site
- Minimise impacts of commercial activities
- Minimise impacts of recreational activities
- Maintain appropriate fire regime for the species/community
- Reduce and maintain weed densities at low levels
- Minimise impacts of development

Two threatened plant species have been recorded near the Site boundary but not within the Impact Area, *Galium australe* Tangled Bedstraw and *Darwinia peduncularis.*

Four threatened fauna species have been positively recorded within the Site boundary:

- Eastern Bentwing Bat *Miniopterus schreibersii oceanensis,* listed as vulnerable under the BC Act
- Grey-headed Flying-Fox *Pteropus poliocephalus,* listed as vulnerable under the BC Act and the EPBC Act
- Powerful Owl *Ninox strenua,* listed as vulnerable under the BC Act
- Varied Sittela *Daphoenositta chrysoptera,* listed as vulnerable under the BC Act and the EPBC Act

The Site and the Impact Area provide significant roosting, nesting, sheltering and foraging sites for arboreal herpetofauna, mammals, microbats and birds who can move freely between the native vegetation within these areas and the neighbouring bushland.

The core area of bushland in the Site has a significant connection to largely undisturbed bushland. On the western boundary is the Berowra Valley National Park (BVNP). Connected to the BVNP are Council Bushland Reserves including the Rosemead Road Bushland as well as both the Dog Pound Creek and Galston Park BioBanking sites to the south and west respectively, and the Pyes Creek/NewFarm Road BioBanking site to the South. To the north, Council's reserves Turner Road Bushland, Woolwash Bay and Furber Park connects the BVNP to Muogamarra Nature Reserve and the Marramarra National Park, all on the banks of Berowra Creek flowing into the Hawkesbury River (Figure 2.11). In developing the recreational parkland, opportunities exist here for sensitively and passively connecting the urban interface with significant bushland experiences.

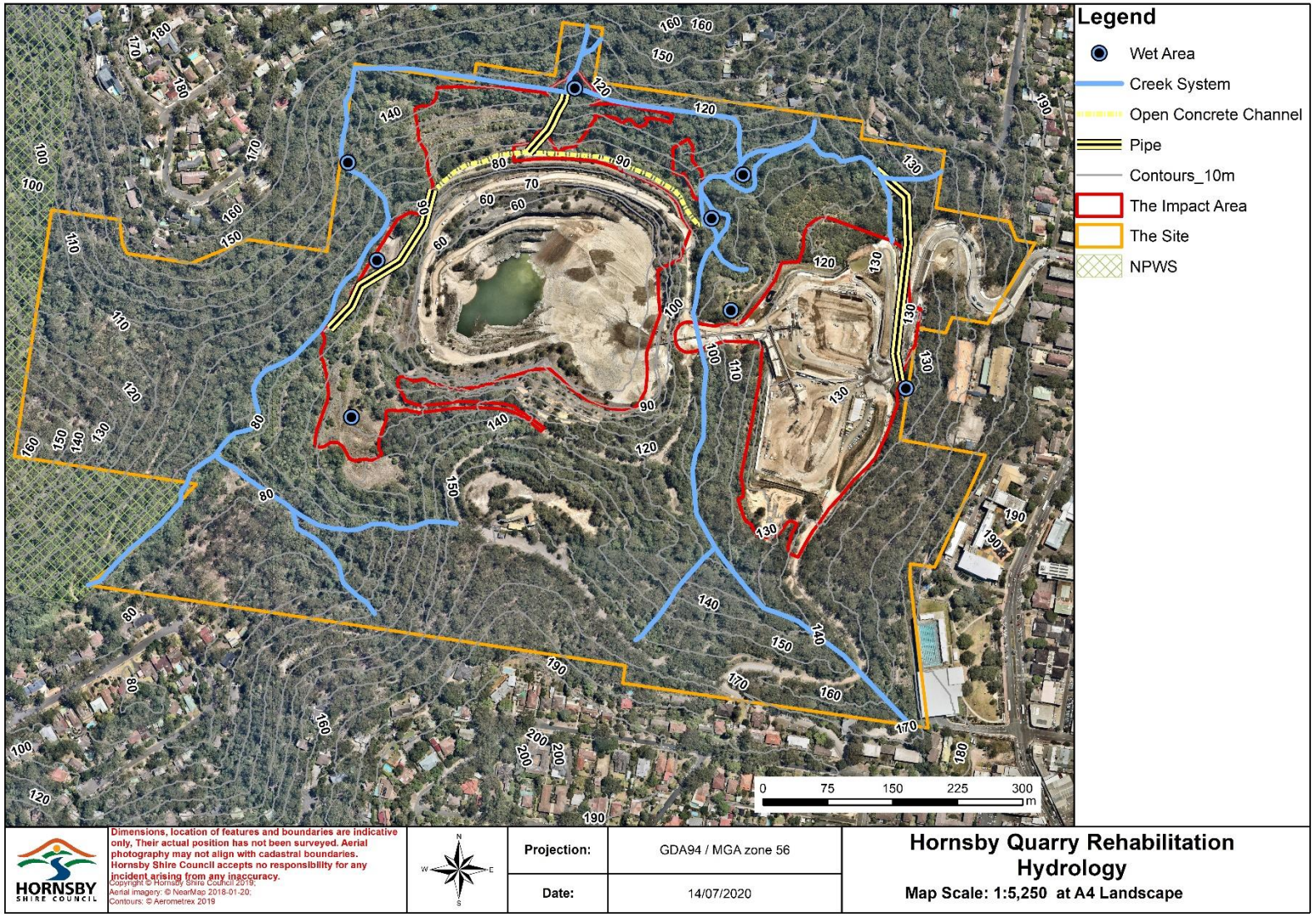

Figure 2. 10: Hydrology

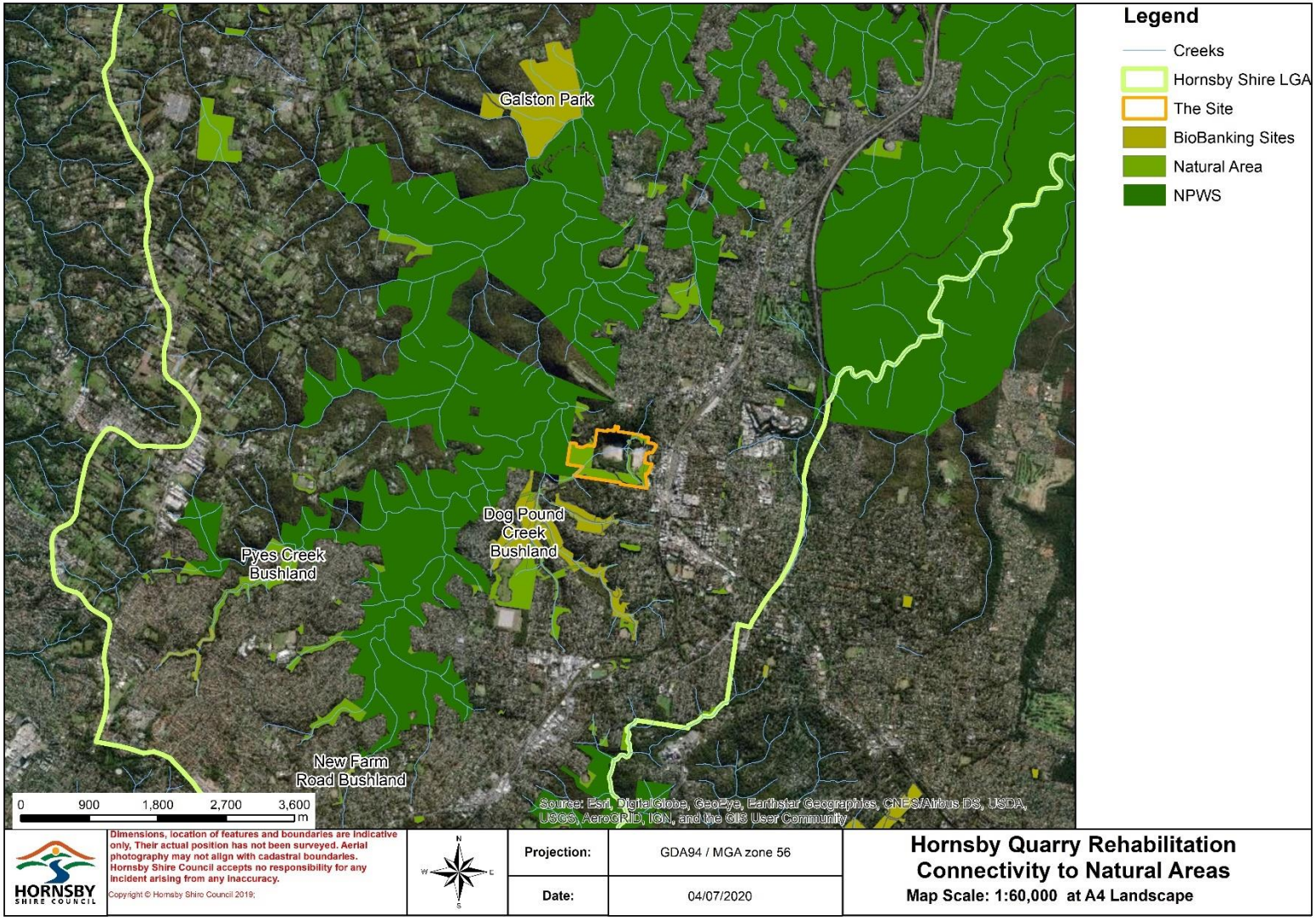

Figure 2. 11 Conservation Significance

2.6 Native Vegetation

2.6.1 Vegetation Communities – Plant Community Types

Both Kleinfelder (2017) and GHD (2019) used the BioBanking Assessment Methodology (BBAM) to assess the vegetation on Site. BBAM was the methodology used by the BioBanking Scheme established under Part 7A of the NSW *Threatened Species Conservation Act 1995* (TSC Act). While both reports used the same methodology, the presentation of their results were for different purposes. Kleinfelder used the BBAM to describe plant community type and condition (Figure 2.12). Whereas, GHD used the BBAM for the purposes of calculating the number and type of credits that could be generated for retirement as part of an Offset Package for development (Figure 2.13). The presentations differ because credit calculation requires vegetation mapping to represent a Plant Community Type (PCT) irrespective of the extent of exotic presence.

Both Kleinfelder and GHD's assessments concluded the same PCTs exist on Site from their results. The BioBanking Scheme has since been replaced by the Biodiversity Offsets Scheme and the Biodiversity Assessment Methodology (BAM) under the *Biodiversity Conservation Act 2016*. The replacement does not alter the PCT classification by Kleinfelder or GHD and its relevance to the VMP and HCEP.

For the purposes of this VMP and HCEP, GDH's mapping data has been used to display the vegetation communities (Figure 2.13). In addition, Kleinfelder's mapping data has been used to map vegetation condition (Figure 2.12) and to determine appropriate Management Zones (Figure 6.1). The Smith and Smith (2008) naming classification has been used to describe both plant communities Blue Gum Diatreme Forest (BGDF) and Blackbutt Gully Forest (BBGF) in this document (Table 2.2, Table 2.3). The Blue Gum Diatreme Forest is listed as a critically endangered ecological community (CEEC) under the *NSW Biodiversity Conservation Act 2016* and critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Blue Gum Shale Forest. The community is very restricted and may now be confined to the Hornsby Local Government Area (Smith & Smith 2008).

Table 2. 2 Hornsby Shire Vegetation Communities and other Vegetation Classifications

Hornsby vegetation community (Smith & Smith 2008)	Australian endangered ecological community (EPBC Act)	NSW endangered ecological community (BCT Act)	BioMetric Vegetation Type (NSW BioBanking Scheme)	NSW Plant community Type (VIS Classification 2.1) PCTID
Blue Gum Diatreme Forest (BGDF)	Blue Gum High Forest in the Sydney Basin Bioregion (CE)	Blue Gum High Forest in the Sydney Basin Bioregion (CE)	HN596/ME001. Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	1237. Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin Bioregion
Blackbutt Gully Forest (BBGF)	Not Listed	Not Listed	HN648 Smooth-barked Apple – Turpentine – Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region.	1841. Smooth-barked Apple – Turpentine – Blackbutt tall open forest on enriched sandstone slopes and gullies of Sydney region.

The area of each plant community within the Site and the Impact Area is as follows:

Table 2. 3 Plant Community Areas

Plant Community Type (PCT) (GHD 2019)	Area of PCT within the Site (Ha)	Area of PCT within the Impact Area (Ha)	Condition of PCT within Impact Area (Kleinfelder 2017)
Blue Gum Diatreme Forest	15.75	0.68	Moderate-good_poor
Blackbutt Gully Forest	20.46	0.86	Native Rehabilitation/Regen
Blackbutt Gully Forest Regrowth	6.95	2.31	Exotic
Total	**43.16**	**3.85**	

Of note is the mapped location of BBGF located on the south west mound (SWM). With reference to the site geology, this location is likely to have been BGDF. This can be a consideration when planning a planting schedule for revegetation of the SWM (Appendix B).

2.6.2 Vegetation Condition

The soil structure and composition within the Site and the Impact Area have been highly modified due to mining activities and as a result the native vegetation has been compromised. The current bushland condition directly reflects the amount and type of soil disturbance that has occurred. Kleinfelder (2017) and GHD (2019) mapped and described the PCTs and condition in line with BBAM methodology (OEH 20014) (2.6.1 Vegetation Communities – Plant Community Types). This document has incorporated the bushland condition mapping method from The National Trust of Australia (NSW) Bush Regenerator's Handbook 3rd Edition (2010) with the previous condition mapping results for both PCTs. The National Trust method classifies the native vegetation condition by assessing the description (structure, species composition, diversity, response to disturbance i.e. native resilience and density of weeds present). It provides a guideline for appropriate management actions and the ability to establish baseline data that can quickly and easily be assessed in a monitoring regime. (Tables 2.4, Appendices A and F).

The results of the National Trust bushland assessment methodology have been overlain with the Kleinfelder condition mapping polygons for consistency and comparison (Figure 2.13).

2.6.1 Native Species List

A list of native species recorded on the Site can be found in Appendix C.

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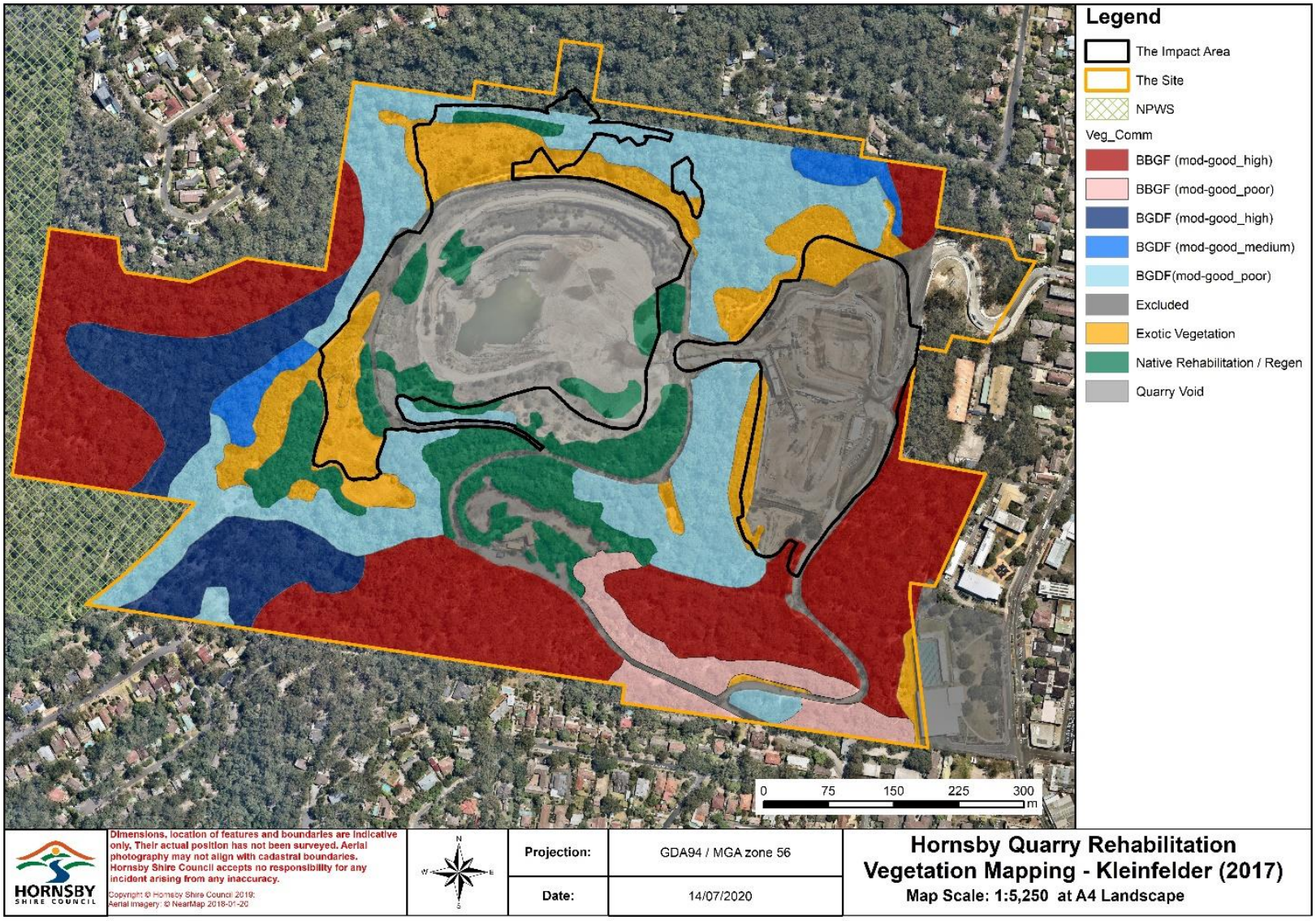

Figure 2. 12: **Vegetation Condition – Kleinfelder 2017**

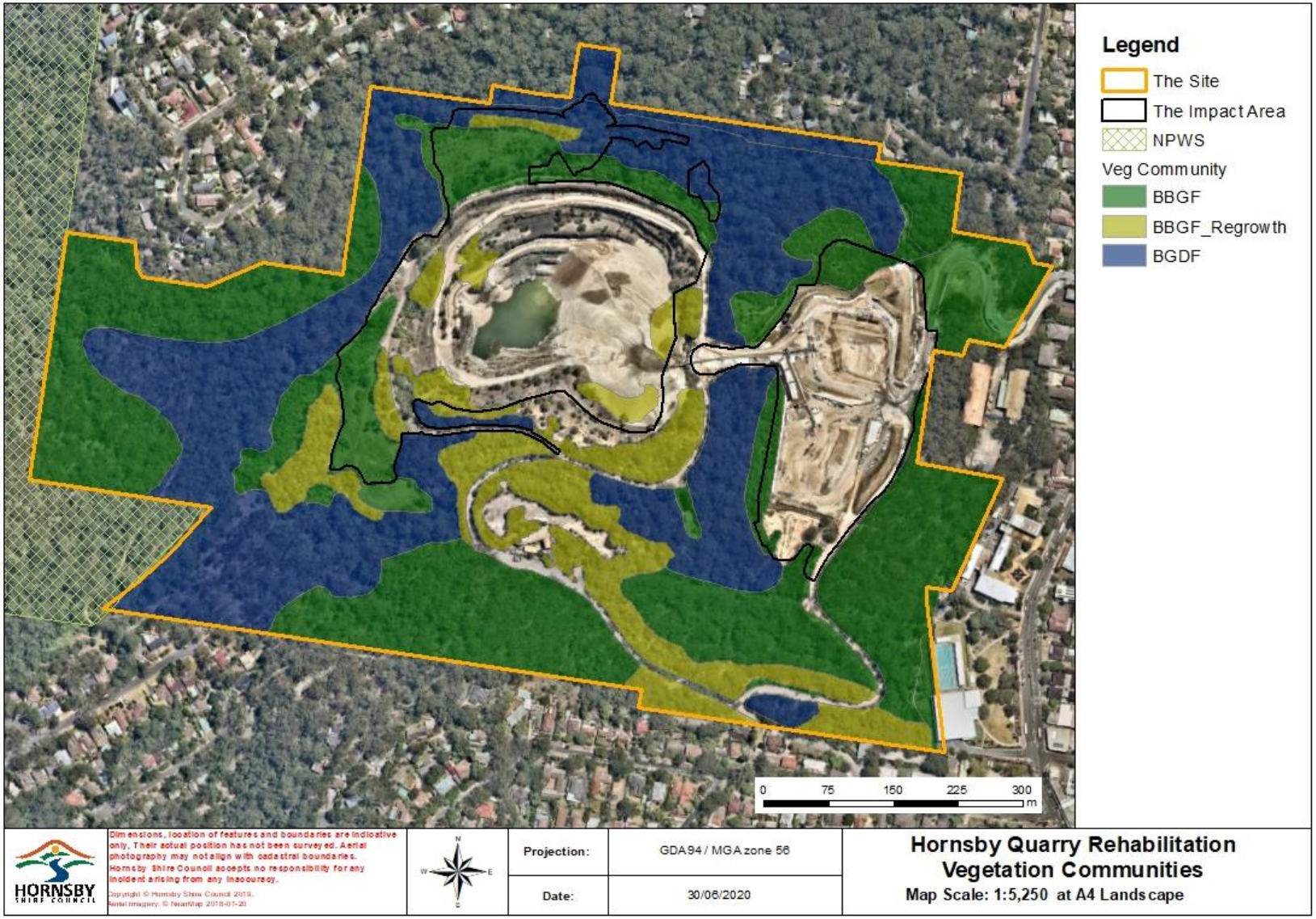

Figure 2. 13 Vegetation Communities – GHD 2019

Table 2. 4 Bushland condition mapping adapted from The National Trust of Australia (NSW)

Colour Code	Condition of Bushland	Weed Density	Description	Management Actions
Green	**Good**	<5%	High level of native vegetation structure, species composition and diversity. Virtually weed/exotic plant free. Soil intact. High Level of resilience.	**Low (Regeneration)** Maintain connectivity to bushland of similar condition. Prevent impacts from bushland of lesser condition. Monitor for possible wind or bird dispersed weed/exotic plants.
Blue	**Fair**	6-20%	Plant community slightly compromised but native species dominate the site. Minor infestations of weed/exotic plants. Soil relatively intact. Good level of resilience.	**Medium (Regeneration)** Assess cause of infestation and address where possible (e.g. neighbouring property source, over clearing, overuse). Remove weed/exotic plants with best practice bush regeneration techniques.
Orange	**Poor**	21-60%	Dominant native species highly suppressed, one or more strata layers missing. Severe infestations of weed/exotic plants. Soil integrity low. Poor level of resilience.	**High (Regeneration and Revegetation)** Assess cause of infestation and address where possible (e.g. modified soils, neighbouring property source, over clearing, overuse). Remove weed/exotic plants with best practice bush regeneration techniques. 'Assisted regeneration' e.g. revegetation, physical disturbance, fire.
Red	**Very Poor**	>61%	Only mature specimens of the dominant highest stratum of the PCT remain. Recruitment absent due to modified soils and heavy infestation of weeds/exotic plants. Bushland has been completely replaced by exotics.	**Extremely High (Revegetation)** Ability of the PCT to recover is extremely low, at times non-existent. 'Assisted regeneration' will require soil reconstruction, revegetation and ongoing weed/exotic plant treatment.

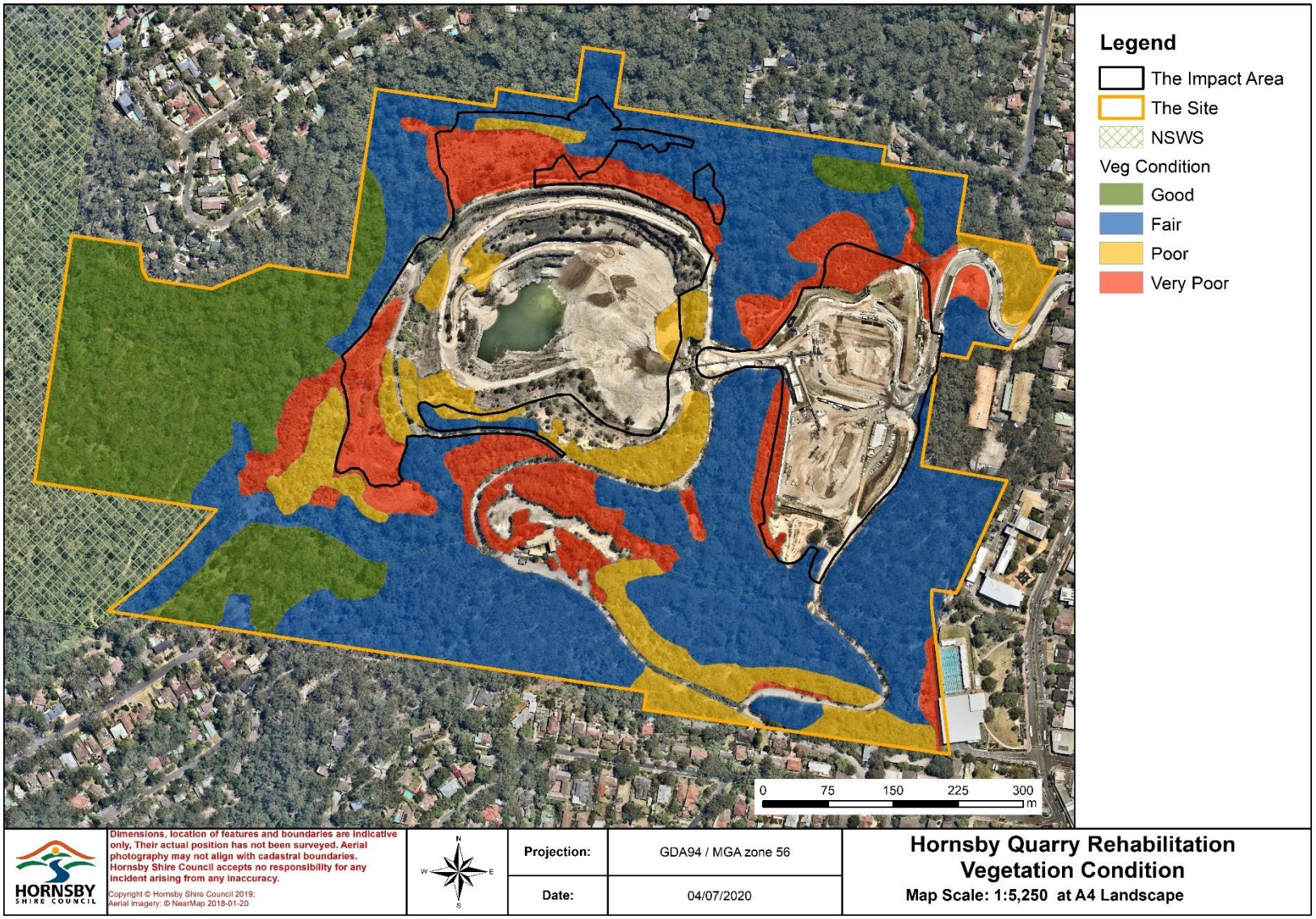

Figure 2. 14 Vegetation Condition – The National Trust of Australia (NSW)

2.7 Weed Species

A weed is a plant growing in the wrong location, dominating the landscape and suppressing plants which would normally exist. Weeds are known to be opportunistic in a disturbed area with adaptations of rapid growth and effective dispersal mechanisms. They have the capacity to dominate an environment to the extent that they alter microclimates and ecosystems. This in turn improves conditions for their survival and the level of ongoing disturbance. With reference to bushland, weeds are plants which do not grow within the classified Plant Community Type (PCT). Whilst undesirable, the value of weeds as habitat for fauna must be considered in a treatment plan.

2.7.1 Priority Weeds

The *Biosecurity Act 2016* and regulations provide a list of priority weeds and high-risk activities at a State level. The Biosecurity Act prioritises weeds based upon management objectives. Prevention is the highest followed by Eradication, Containment and Asset Protection. Table 2.5 lists priority weeds recorded on the Site, their status at State and Greater Sydney Local Land Services Regional scale, and the outcomes to demonstrate compliance with the General Biosecurity Duty (GBD).

Table 2. 5 Priority Weeds

Botanical Name	Common Name	State level Category	Regional Level Category	*Biosecurity Act 2015* requirements and Strategic response in region for GBD
Anredera cordifolia	Madeira vine	Asset Protection		No movement import or sale
Asparagus aethiopicus	Asparagus weed	Asset Protection		No movement import or sale
Cortaderia selloana	Pampas grass		Asset Protection	Fully and continuously suppressed and destroyed
Genista monspessulana	Cape/Montpellier broom	Asset Protection		No movement import or sale
Lantana camara	Lantana	Asset Protection		No movement import or sale
Ligustrum lucidum	Privet – broad-leaf	Asset Protection		No movement import or sale
Ligustrum sinense	Privet – narrow leaf	Asset Protection		No movement import or sale
Olea europaea subsp. *cuspidata*	African olive		Containment	Prevent spread, reduce impact on assets, identify assets for targeted mgmt
Rubus fruticosus	Blackberry	Asset Protection		No movement import or sale
Senecio madagascariensis	Fire Weed	Asset Protection		No movement import or sale

Biosecurity duty definitions

General Biosecurity Duty: *All plants are regulated with a **general biosecurity duty** to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.*

Asset Protection: *These weeds are widely distributed in some areas of the State. As Weeds of National Significance, their spread must be minimised to protect priority assets.*

Containment: *These weeds are widely distributed in the region. While broad scale elimination is not practicable, minimisation of the biosecurity risk posed by these weeds is reasonably practicable.*

2.7.2 Weeds of Regional Concern

Weeds recorded on the Site of regional concern because, by definition, they present a risk to biodiversity due to the likelihood of them spreading throughout the Site and into the surrounding areas, are listed below. Despite appearing in separate lists within the *Biosecurity Act 2016,* they will also be treated as a priority due to the impact they will have on the success of rehabilitation (Table 2.6).

Table 2. 6 Weeds of Regional Concern

Botanical Name	Common Name	Asset/value at risk
Agapanthus praecox subsp orientalis	Agapanthus	Environment
Ageratina adenophora	Crofton weed	Environment
Ageratina riparia	Mistflower	Environment, Agriculture
Andropogon virginicus	Whiskey Grass	Environment
Araujia sericifera	Moth vine	Environment
Bidens pilosa	Farmers Friend	Environment, Agriculture
Cardiospermum grandiflorum	Balloon vine	Environment
Chlorophytum comosum	Spider Plant	Environment
Cinnamumum campphora	Camphor laurel	Environment, Agriculture, Human health
Cotoneaster spp	Cotoneaster	Environment
Cyperus eragrostis	Umbrella Sedge	Environment, Agriculture
Delairea odorata	Cape Ivy	Environment
Eragrostis curvula	African lovegrass	Environment
Hedychium gardnerianum	Ginger Lily	Environment
Ilex aqifolium	English Holly	Environment
Lonicera japonica	Japanese Honeysuckle	Environment
Nephrolepis cordifolia	Fishbone Fern	Environment
Ochna serrulata	Ochna	Environment
Pennisetum clandestinum	Kikuyu	Environment
Senna pendula	Cassia, Senna	Environment
Solanum mauritianum	Wild tobacco bush	Environment, Agriculture
Tradescantia fluminensis	Trad	Environment

2.8 Fauna

A total of four surveys have been undertaken at the project site and adjacent areas by GHD (2019), Kleinfelder (2017), Ecological Australia (2015) and PB (2004) with some surveys building on previous data sets. Gecko Environment Management undertook two observational surveys in June 2020. A total number of sixty-seven (67) fauna species were recorded including fifty-three (53) bird species, four terrestrial or arboreal mammal species, five bat species, three reptile species, and two frog species. Additionally, the introduced species *Vulpes vulpes* European Red Fox and *Pycnonotus jocosus* Red-whiskered Bulbul were also recorded.

All survey results to date have been collated in Appendix D.

2.8.1 Survey Effort

Fauna surveys included call recordings, call playback and a targeted *Daphoenositta chrysoptera* Varied Sitella survey. A significant portion of the survey effort primarily utilised incidental or opportunistic fauna sightings.

General habitat assessments were conducted to ascertain suitable habitat from condition and structural parameters.

Across all four surveys, temporal effort was focussed over a summer period. An ongoing fauna monitoring program incorporating increased spatial and temporal sampling is required to enhance the current fauna baseline data and representation across the site and adjacent areas.

2.9 Existing Habitat and Value

The key terrestrial habitats identified here recently by GHD (2019), Kleinfelder (2017), Ecological Australia (2015) and PB (2004) include BBGF, BGDF and disturbed landscapes. Habitat attributes afforded by structural vegetation layers have been positively associated with major fauna groups in temperate eucalypt forests (Table 2.7).

The significance of fauna habitat attributes extant within a site are relevant in their:

- resource type and quality
- specific breeding, nesting, feeding and roosting resources to existing species
- functional redundancy within the landscape
- temporal sustainability
- role in sustaining trophic interactions/food webs

Some of the resources recently surveyed include:

- hollow-bearing trees
- specific feed trees
- rock outcrops (potential den sites for the *Dasyurus maculatus* Spotted-tailed Quoll)
- water bodies
- rocks, logs, peeling bark and leaf litter for small reptiles
- winter-flowering eucalypts (important for the *Lathamus discolor* Swift Parrot and *Pteropus poliocephalus* Greyheaded Flying-fox)
- food trees of the *Phascolarctos cinereus* Koala and *Calyptorhynchus lathami* Glossy Black-cockatoo
- hollow-bearing trees and logs which provide refuge, nest and den sites for a range of threatened fauna species
- stags and other roost sites for raptors and owls
- termite mounds comprising potential habitat for *Varanus rosenbergi* Rosenberg's Goanna
- wetlands, moist grassland and other foraging habitat for waterbirds (including migratory birds) and frogs

Within the VMP, some finer scale structural vegetation / habitat zones have been identified as important in taking a precautionary approach to avoiding critical localised impacts for several protected and threatened species. Key habitat zones within the VMP are:

- Blue Gum Diatreme forest
- Blackbutt Gully Forest
- Open Rocky Faces
- Riparian Corridors
- Disturbed Areas
- Privet
- Grasslands
- Wet Areas

Table 2. 7 Habitat Attributes Associated with Major Fauna Groups in Temperate Eucalypt Forests

Stratum	Attribute	Birds	Arboreal Mammals	Ground Mammals	Bats	Reptiles	Amphibians	Invertebrates
Overstorey	Number of overstorey stems	■						■
	Number/basal area of large trees		■					
	Increased larger DBH distribution				■			
	Basal area of overstorey stems	■	■	■				
	Species richness and diversity	■	■					
	Floral resources	■	■					
	Decorticating bark	■	■					■
	% canopy cover	■	■	■				■
	Canopy height/volume	■	■		■			
	Number of hollow bearing trees	■	■					
	Distribution of hollow bearing trees		■					
	Number and DBH of large dead trees					■		
Mid-storey	Mid storey height				■			
	Canopy-mid storey gaps				■			
	% cover	■		■	■			■
Ground layer	Shrub diversity	■		■		■		
	% cover shrubs and herbs	■	■	■	■	■	■	■
	% cover debris (litter, rocks, logs)	■		■	■	■	■	■
	% cover bare ground					■	■	■
	Permanent water and proximity				■		■	

McElhinny et al. (2006) conducted a literature review that identified fifty-five studies from south-east and south-west Australian temperate forests. These studies demonstrated the presence and abundance of different fauna were significantly ($p<0.05$ associated with structural vegetation attributes. The habitat requirements for different fauna types included birds, arboreal mammals, ground mammals, reptiles, bats, amphibians and invertebrates were reviewed, and thirty-four key structural attributes were identified. These attributes function as a comprehensive set with a demonstrated associations with biodiversity values.

2.9.1 Blue Gum Diatreme Forest

Blue Gum Diatreme Forest (BGDF) consists of tall open forest to over 30 metres height over a sparse to dense mid-storey of mesophilic species and a ground layer of ferns, grasses vines and herbs. Structurally this community contains attributes consistent with supporting a diverse variety of fauna demonstrated in Table 2.7. The canopy provides a range of foraging floral resources accessed throughout the year at different flowering times by a range of birds, bats, arboreal mammals and invertebrates. Important habitat corridors exist within this community to the north, east and west surrounding the quarry site, supporting mesic vegetation of varying condition. These corridors form vital habitat for arboreal mammal possum species and in turn hunting flyways for the *Ninox strenua* Powerful Owl. The northern corridor provides essential structural and functional vegetation for extant Powerful Owls. Significant nesting and roosting trees are present. It is estimated that Eucalypts forming suitable hollows for Powerful Owl in this community may be >150 years old, older trees and

ongoing recruitment specimens in this community must be regarded as an irreplaceable resource. The northern BGDF links directly into the western and eastern corridors extending available habitat for this keystone species. These corridors are important to a host of species. Swamp Wallaby *Wallabia bicolor* are commonly observed within this community on site (Figures 2.13 and 2.14).

2.9.2 Blackbutt Gully Forest

Blackbutt Gully Forest (BBGF) is a tall open forest occurring on enriched sandstone slopes and gullies. Typical species that occur within the community include *Eucalyptus pilularis* Blackbutt, *Angophora costata* Sydney Red Gum and *Syncarpia glomulifera* Turpentine. The structural attributes afforded from this community are in line with eucalypt forest fauna habitat requirements of in Table 2.7.

Eucalyptus pilularis Blackbutt are known to begin forming hollows beyond the DBH of 85cm (Todarello and Chalmers 2007). Over twenty trees exhibiting a DBH greater than 85cm were identified by GHD's survey, the vast majority occurring in the southern extent of the site. Senescent or standing dead trees (SDT) are also scattered throughout this community providing significant nesting hollows to many species. Additionally, *Eucalyptus pilularis* Blackbutt provide important browse trees for the threatened *Daphoenositta chrysoptera* Varied Sittella that exploits the often-overlooked bark resources of eucalypt trees which can support rich invertebrate communities of up to 300 species for a single tree (Recher et al 1996). Several bat species utilise bark resources and tree hollows for roosting, hibernation and maternity sites (Brown et al 1997). Bats prefer a diverse range of tree hollows often occupying small hollows when roosting individually or large hollows when roosting communally (Tideman and Flavel 1987) whilst some bat species preferred trees with a DBH greater than 120cm (Taylor and Savva 1988). Attributes associated with increased bark resources are a function of increased bark surface area and therefore, tree basal area and DBH.

Ground layer fauna values such as litter, logs and rocky areas provide important habitat values for several fauna species. Logs, woody debris and litter are a critical resource for small ground mammals such as the *Tachyglossus aculeatus* Short-beaked Echidna and *Antechinus stuartii* Brown Antechinus (Smith et al 1989). Several studies (Bauer et al 2000; Smith et al 1994; Andrews et al 1994) have correlated the richness of small ground mammals with the abundance of large logs. The *Wallabia bicolor* Swamp Wallaby are commonly observed within this community on site.

2.9.3 Open Rocky Faces

Open rocky areas to the north and south of the quarry have been difficult to access for survey for fauna and this will need to be addressed by future management recommendations. These open rocky faces and rock screes can provide important shelter and refuge sites for ground mammals such as the Short-beaked Echidna, wallabies and *Dasyurus maculatus* Spotted Tailed Quoll (Paull and Date 1999). Reptiles utilise rocky faces for refuge, nesting and basking sites and Fanning (1995) found that reptile species richness was significantly higher when these features were present.

2.9.4 Riparian Corridors

The riparian corridors onsite predominantly have their origins in minimally disturbed upper catchments and transect several vegetation communities creating significant ecotones along their extent (Figure 2.15). Within the riparian corridors, canopy eucalypt species such as *Eucalyptus saligna* Sydney Blue Gum include a large tree 30-50 metres high with DBH up to 2 meters. Hollows range from small branch stubs to large hollows

suitable for forest owls in both mature and senescent trees. Approximately eighteen trees of potential small hollow forming DBH (greater than 85cm DBH) are distributed within the western riparian corridor. This increased structural complexity allows for greater diversity of fauna. Amphibians such as the *Crinia signifera* Common Eastern Froglet utilise boggy seepages and water sources for reproduction and development for their young (Smith et al 1994). Retention of canopy and understorey vegetation cover here is important in maintaining a moist microclimate (Parris 2002) with the additional benefits of ground debris for refuge and shelter from predation (Ferraro and Burgin 1993).

Many bat species require easy access to permanent water sources to satisfy their feeding and roosting requirements McElhinny et al. (2006). Proximity to water allows bats to expend minimal energy to access feeding grounds and Riparian areas are important for many insectivorous bat species as insects congregate the open spaces above water sources.

2.9.5 Disturbed Areas

The Site exhibits significant disturbed areas of vegetation around the perimeter of the quarry. Exotic vegetation dominates these disturbed areas consisting of dense Privet forests within mesic riparian corridors. Similar levels of dominant exotic vegetation is found in open grasslands of perennial grass species, on more exposed and drier aspects (2.9.7) or in wet areas containing collected water. Connective vegetation present in the disturbed areas plays a valuable structural and functional role as habitat regardless of whether it is exotic or native.

2.9.6 Large and Small-leaved Privet

Ligustrum lucidum and *Ligustrum sinense* Large and Small-leaved Privet is a highly invasive weed capable of transforming native vegetation communities by dominating the mid and lower strata. Although damaging to native floral diversity, these stands induce a mesic microclimate and provide structural and functional resources conducive to favourable habitat for frugivorous birds, bats and arboreal mammals including *Pseudocheirus peregrinus* Common Ringtail Possum, the *Trichosurus vulpecula* Common Brushtail Possum and, as in this Site, the *Ninox strenua* Powerful Owl. Because of its attributes and important value as habitat, the control of *Ligustrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet will require careful observation prior to any works. Strong consideration will need to be given to seasonal timing and sequencing of mosaic removal and replacement via regeneration or revegetation with native species to maintain canopy connectivity, the current moist and cool microclimate and the riparian wildlife corridor (Figure 2.15).

2.9.7 Grasslands

Perennial grass species dominate the ground layer on exposed aspects. The structure and function afforded by this exotic vegetation provides foraging opportunities for many reptiles, ground mammal and some bat species. The dense understorey allows refuge and shelter opportunities for reptiles, small mammals and invertebrates. This in turn provides predatory species with food sources and hunting advantages with large canopy gaps present.

2.9.8 Wet Areas

Low areas of contained impeded clean drainage on the Site currently form wet areas which retain an environment suitable for the highly sensitive Vulnerable species *Pseudophryne australis* Red Crowned

Toadlet, which has been located just outside the site previously and near the fuel tanks during the June 2020 fauna survey. Wet areas are typically biodiverse zones providing good habitat for a range species. Invertebrate populations are typically high in these areas, as are generalist and insectivorous bird species. Common reptiles to this habitat in the local area include *Eulamprus quoyii* Eastern Water Skink *Pseudechis porphyriacus* Red Belly Black Snake and *Physignathus lesueurii* Eastern Water Dragon. Within the largely exotic grassland area to the very south west of the Impact Area, a wet area on disturbed ground currently support the *Crinia signifera* Common Eastern Froglet. The preservation or creation of wet areas on the Site with revegetation or inclusion in landscape design will provide great opportunities for improving habitat and allowing for passive activity such as bird watching (Figure 2.10).

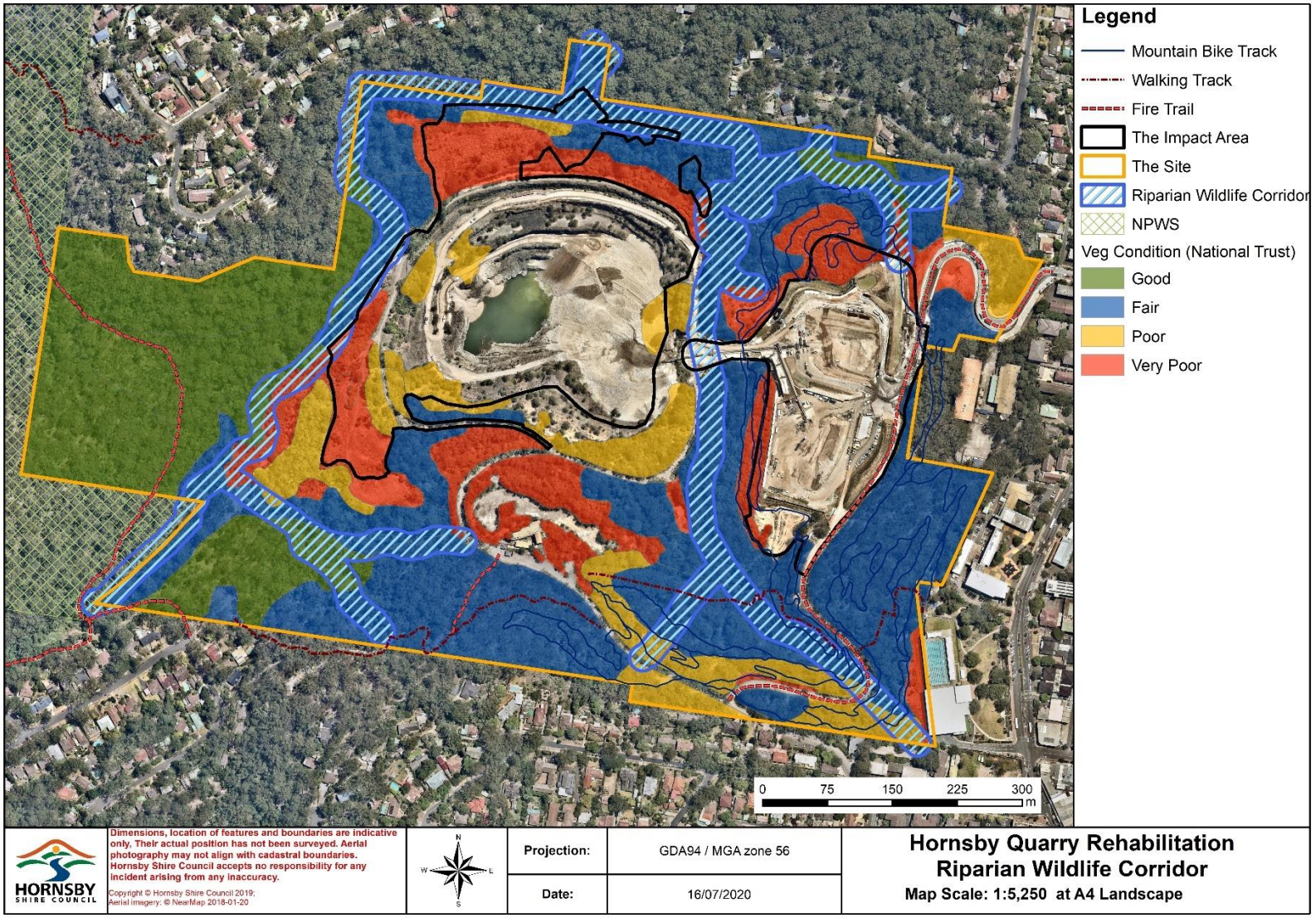

Figure 2. 15 Riparian Corridors as Wildlife Habitat

3. Impacts

The impacts of DA/101/2019 on the ecological functional relationship between vegetation as habitat and fauna are of relevance to this VMP and HCEP. The potential direct, indirect and cumulative impacts of the Site and their relevance to the key threatening processes have been identified. The mitigation of these will be discussed to support the proposed Biodiversity Offset Strategy and necessary actions to achieve the aims (1.3 Aims and Objectives). Mitigation measures to limit the impacts are discussed in Chapter 6 Habitat Management.

Whilst the Site has been historically impacted by mining activities and the areas of high condition have been avoided wherever possible, the proposed development will have an impact on the current environment. It is to be noted here that the impacted vegetation has predominately been mapped as exotic (Kleinfelder 2017) and in poor condition (The National Trust of Australia NSW) (Figures 2.12 and 2.14) due to vegetation consisting mainly of weed growth. The value of the weed growth as habitat has been considered in this plan because of its use by existing fauna for shelter, foraging and breeding. It is also important to note here the inclusion of a breeding pair of *Ninox strenua* Powerful Owl nesting within the Site, and its role as a 'keystone species', when identifying and discussing the impacts.

3.1 Key Threatening Processes and Keystone Species

The roles fauna and flora have on maintaining 'ecosystem function' relates to the processes and interactions (or roles) they both have within their environment. Some of these functions include nutrient cycling, water filtration and cycling, energy flow (production, consumption and decomposition), soil formation, pollination, carbon cycling and gene flow. Table 3.1 below groups the species that together perform an ecosystem function (Department Natural Resources 2011). A 'keystone species' is described as one that has a '*disproportionately important role in maintaining ecosystem function*' (Department Natural Resources 2011) and in this report, it is considered as a 'restoration target'. Species specific mitigation measures to avoid disturbance to the *Ninox strenua* Powerful Owl's life cycle habitat requirements are identified Chapter 6 Habitat Management.

A key threatening process (KTP) is defined under the NSW *Biodiversity Conservation Act 2016* Act (Table 3.2) as an action, activity or proposal that:

- adversely affects two or more threatened species, populations or ecological communities
- could cause species, populations or ecological communities that are not currently threatened to become threatened

Discussion of the KTP serves to inform prioritised prevention, containment, modification or mitigation actions of processes and associated impacts on the Impact Area and the Site, in all activities including future planning and design.

Table 3. 1 Interactive roles of fauna groups in ecosystem function

Functional group	Key processes	Example of functional group members
Primary producers	Energy flow, carbon cycling, nutrient cycling, water filtration and cycling	Plants
Pollinators	Pollination	Birds, insects and small mammals
Seed dispersers	Gene flow	Bird, ants
Decomposers	Nutrient cycling, energy flow carbon cycling	Fungi, bacteria, insects
Nitrogen fixers	Nutrient cycling	Plants hosting rhizobial bacteria
Consumers	Nutrient cycling, energy flow, gene flow	Herbivores, (many mammals such as kangaroos, wallabies and wombats
		Carnivores (birds of prey, snakes, spiders)
		Insectivores (some birds, bats)
		Frugivores (some birds)
		Nectarivores (some birds, small mammals, insects)
		Omnivores (some generalist birds)

Table 3. 2 Key threatening process listed on the EIS from the Schedules of the *BC Act 2016*

EIS Key Threatening Process List
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
Anthropogenic climate change climate change
Loss of hollow-bearing trees
Clearing of native vegetation
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis
Infection of native plants by *Phytophthora cinnamomic*
Introduction and establishment of Exotic Rust Fungi of the order *Pucciniales* pathogenci on plants of the Myrtaceae family
Invasion of plant communities by perennial exotic grasses
Removal of dead wood and dead trees
Additional KTPs identified through this VMP and HCEP
Bush rock removal
Invasion and establishment of exotic vines and scrambles
Invasion of native plant communities by African olive, *Olea europaea* supsp. *Cuspidata*
Invasion, establishment and spread of Lantana, *Lantana camara*
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Predation by the European red fox, *Vulpes vulpes*
Predation by the feral cat, *Felis catus*

3.2 Direct and Indirect Impacts from the Earthworks within the Impact Area

As detailed within the EIS and previously in this document, most of the project area comprises highly modified landforms, soil profiles and vegetation types. The extent of earthworks and vegetation being cleared as part of this DA is within modified land containing exotic species with some native regrowth. Engineering and landscaping plans have considered potential impacts with numerous design modifications being made to protect native vegetation, fauna habitat and the BGDF with the least possible impact on flora and fauna. All revegetation following the earthworks is aimed at mitigating impacts to provide improved long-term outcomes for the Site including the degraded north spoil mound. Revegetation is to occur immediately after earthwork stabilisation (Appendices A and F).

3.2.1 North Spoil Mound Stabilisation and Vegetation Clearing

To ensure public safety and remove the risk of embankment failure resulting in additional significant tree loss, geotechnical recommendations require stabilisation work be undertaken on the north spoil mound. The stabilisation work plans to lower ground levels and remove established exotic vegetation on the mound itself including the area directly adjoining the north slope of the riparian corridor. Until the planned revegetation has established, the act of vegetation clearing will:

- remove existing weeds present on the north mound which are currently providing habitat to all functional groups (Table 3.1)
- fragment the riparian corridor and isolate critical habitat resources
- increase risk of predation
- provide an environment conducive to opportunistic weed establishment as has happened in the past (pampas, privet)
- expose and alter the microclimate of the north riparian wildlife corridor through the removal of vegetation
- alter growing conditions in the corridor with increased evaporation, temperature and light hence decreased levels of available moisture and humidity

3.2.2 Earthworks Disturbance and the *Ninox strenua* Powerful Owl

Since the preparation of the EIS, it has been confirmed that a breeding pair of *Ninox strenua* Powerful Owl has, and continues to, roost, forage, nest in tree hollows and successfully raise young on site. The north, east and western area of the Site currently constitutes key habitat for this threatened species. The *Ninox strenua* Powerful Owl is known to be highly sensitive to disturbance and vegetation clearing. It has been known to be affected by the removal of vegetation, vibration, dust and loud noise associated with earthworks. Any clearing or earthworks between April and October within 100m of known nesting trees will increase the risk of the owls abandoning the nest site and potential their chicks. Clearing the vegetation adjacent to the riparian wildlife corridor behind the mound will remove a key roosting area in the mesic corridor (See 4.2 Protection of the *Ninox strenua* Powerful Owl).

3.2.3 Wildlife Buffers

The term ‘wildlife buffer’ is used to describe the interface between a natural area (Gleeson 2012) and a ‘hostile matrix’ of land uses unsuitable for sustaining Biodiversity (Franklin and Lindenmayer 2009). Wildlife buffers

exist on the Site and despite weed species dominating, they are performing key interactive roles in the Site's ecosystem functions (Table 3.1 and Figure 4.1).

The role and effectiveness of a wildlife buffer varies in relation to the level and type of disturbance as well as the impact the disturbance will have on the ecology of the natural area. A buffer structure and width depend on its position along a hostile matrix, the distance to core good bushland and it's intended use. For example, Lemckert and Brassil (2000) recommended a 30m buffer from a stream to protect breeding habitat of the endangered *Mixophyes iteratus* giant barred frog from logging where Rogers and Smith (1995) recommended a buffer greater than 100m to protect bird species along a coastal temperate forest also from logging in Vancouver Island, Canada. The main buffer that this DA will impact is due to the clearing on the north mound and the north riparian wildlife corridor (Figure 4.1).

3.2.4 North Spoil Mound Stabilisation and Tree Loss

The ground levels along a portion of the top of the north mound are going to be dropped to improve water management, facilitate a suitable gradient over the extent of the north mound and improve safety. The vegetation at the top of the mound predominately consists of Eucalypt canopy cover with an exotic mesic midstorey. The survey of Eucalypts present indicates a mixture of endemic and non-endemic species. It has also been consistently recorded that there are mature trees, trees approaching maturity and younger samplings present. Loss of these trees and their role as 'primary producers' (Table 3.1) is inevitable. In addition, the loss of the trees will expose the north mound riparian corridor (3.2.1) and remove emerging trees with the potential to form nesting hollows.

3.2.5 Clearing of Vegetation and Habitat Resources

Where possible, the focus on clearing works identified in the earthworks DA has been upon the recently and historically modified areas of the site.The works associated with the DA will result in 3.85 hectares of vegetation being cleared. This vegetation currently provides foraging, breeding and roosting resources for a range of fauna species including threatened species.

Both individually and in concert, structural layers of vegetation within vegetation communities on site provide key habitat attributes for a range of fauna (Tables 2.7 and 3.1). Threatened species on site use the mesic corridors for protection, hunting of prey and roosting. Vegetation plays a functional role regardless of whether it is exotic or native. Whilst reduction of the impacts from invasive floral species needs to be addressed within the Site, it is important to note that in some circumstances the presence of exotic species may not detract from their ecosystem function in providing habitat.

The clearing of connective native vegetation would result in the loss of connectivity within that strata, critically within the riparian zone on the Site, having direct impacts on arboreal mammals, removing safe movement corridors, nesting resources and protection from foxes and cats, indirectly creating potential reduction in food resources for the Powerful Owl.

Vegetation clearing within the site could directly impact:

- nectar resources
- foraging substrate for birds, reptiles (varanids),
- foraging and protection of arboreal species, such as birds, mammals and bats.

- fallen logs and rock outcrops,
- termite mounds
- low condition grassland habitat
- steep rocky face not currently surveyed, though likely habitat for frogs and reptiles

Within the Impact Area, the EIS identifies five known hollow bearing trees for removal. The fact that the Powerful Owls nesting hollows had not been detected in previous hollow tree surveys highlights the difficulties in accurately surveying for hollow bearing trees. Hollow entrance sizes effectively select for species suitability. *Eucalyptus pilularis* Blackbutt are known to begin forming small hollows beyond the DBH of 85 cm (Todarella and Chalmers 2007), common within the BGDF and BBGF PCT's on site. Small hollows here, including branch stubs, are likely to be utilised by species such as Sugar Glider, Brush Tail and Ringtail Possums, Sulphur Crested Cockatoos, Lorikeets and microbats. Large hollows suitable for Forest Owls commonly form in Eucalypts >150 years old (Giibons and Lindenmeyer 2002). Birdlife Australia has documented *Ninox strenua* Powerful Owls commonly using tree hollows with entrances greater than 35cm in both living and dead trees. A number of dead standing trees on site likely provide important hollows to several species, additionally they provide important browse trees for the threatened Varied Sitella located on site. A precautionary approach must be taken in all vegetation clearing to not directly harm Fauna and to avoid the removal of hollow bearing trees (Chapter 6 Habitat Management).

Whilst there is currently no proposed removal of natural creek lines, the landscape works and installation of artificial drains and culverts provide opportunities in design for works and associated revegetation/landscape installation to enhance some riparian zones on site. The EIS identified that:

"*Culverts represent potential roosting habitat for microbat species such as the Eastern Bentwing Bat .... extension of these culverts could provide additional roots habitat …*".

Figure 3. 1 Low Point behind North Spoil Mound

3.3 Cumulative Impacts

The Site brings a confluence of what are essentially a conflicting range of land uses in that the quarry sits within a bushland matrix connected to large tracts of regional National Park and bounded to the North by established residential and commercial areas. The current use of the natural area has identified inevitable conflicts between human activities and maintaining habitat attributes (Table 2.7). The VMP and HCEP aims to mitigate these and assist in maximising opportunities to enhance such attributes where practicable with the recommended management actions.

The Site currently has a 6-kilometre mountain bike track in the north, east and southern bushland parcels. It also has existing fire trails and a series of sandstone steps built in the 1930's, half of which degraded, the other half has been restored and now experiences high levels of visitation. The mountain bike and pedestrian tracks have been shown to have significant impacts within bushland areas, effectively increasing the critical distances of edge effects into bushland. The impacts include:

- increased soil erosion and sedimentation
- vegetation clearing and reduced ground layer biomass
- unforeseen extent of impact due to creation of informal tracks
- increased risk of introduction of domestic pets and/or predators to site
- increased noise levels
- increased introduction and spread of pathogens e.g. *Phytophthora cinnamomi*

Mountain bike tracks have also been shown to introduce more severe impacts including:

- damage from the construction of unauthorised tracks and jumps
- increased erosion from rutting, skidding and wheel spin
- increased native fauna flight initiation distances and escape behaviour

Night access into sensitive areas by both pedestrians and bikes using head torches is known to impact successful breeding and raising of young by *Ninox strenua* Powerful Owl.

The cumulative impact of regular switchbacks on steep terrain and exclusive separate pedestrian, vehicle and bike tracks can physically cover a substantial area of vegetation clearing multiplying the effect significantly. Careful consideration is required during any potential design to ensure these elements are designed to reduce any impact.

4. Impact Mitigation

Methods to mitigate impacts on flora and fauna caused by the DA are presented in this chapter and listed as management actions (Appendix A). They aim to reduce the extent of impacts and to restore sustainable ecological functions on the Site. Consideration has been given to the functional requirements of the natural area and role the group members or groups in establishing the desired outcomes (Table 3.1). For example, following earthworks on the north spoil mound, revegetation will incorporate nitrogen fixing plant species as primary succession species, revegetation with fast growing flowering species will provide habitat for pollinators, retained timber and installed nesting boxes will provide habitat for decomposes and the overall protection, conservation and restoration of vegetation over the Site will constitute the ultimate primary produces.

4.1 Areas of Habitat to be Retained, Enhanced or Created

All management actions have been prescribed with the intention of maintaining a high level of vegetative habitat on site (Chapter 6 Habitat Management, Appendix A).

4.1.1 Impact Area Wildlife Habitat Buffer

To mitigate edge effect impacts, wildlife buffers (buffers) are to be retained, enhanced or created along interface areas of management zones. The buffers around the perimeter of the Impact Area will protect the ecological functions of the vegetation on Site (Figure 4.1). Management actions include buffer creation with dense planting of quick growing shrub species, buffer enhancement with supplementary planting to improve the vegetation structural properties, or buffer retention, regardless of species. If a buffer is an existing weed plume, revegetation will need to be scheduled to complement the timing of staged weed treatment and/or any naturally occurring regeneration. The restoration of the north spoil mound with stabilisation, soil improvement and revegetation with plant species representative of BGDF will replace the current buffer due to be cleared and in time, mitigate fragmentation, enhance connectivity and assist with ongoing maintenance of the mound and adjacent natural areas.

4.1.2 Riparian Wildlife Corridor Enhancement and Revegetation

Riparian wildlife corridors are to be a high priority in habitat protection (Figures 2.15 and 4.1) along with the Powerful Owl breeding temporary authorised access area (Figure 4.2). A 30 metre buffer around the Impact Area edge and a 30 metre buffer along the riparian wildlife corridors outside the Impact area are to be maintained. These areas have been mapped and referred to in the management actions per zone. Figure 4.1 maps the extent of the 30 metre buffer to the Impact Area and the 30 metre buffer along the riparian wildlife corridor. The respective management actions have been listed beside ‘Management Issue’ in Appendix A and Performance Criteria in Appendix F. The mitigation summary of riparian wildlife corridor impacts is as follows:

- retain and enhance the remnant vegetation along the riparian corridor
- install a mosaic canopy and midstrata structure with supplementary rainforest plantings in conjunction with a conservative staged mosaic removal of weed species

- retain overhanging vegetation particularly horizontal branches over natural clearings or tracks and incorporate elements to mimic overhangs as a valuable structure within a movement corridor to assist with the natural 'hop-scotch' movement behaviour of the *Ninox strenua* Powerful Owl (Table 3.1 and Figure 4.1)
- prevent canopy or midstorey disturbance in densely vegetation areas within buffers to preserve roosting microclimates for *Ninox strenua* Powerful Owls

4.1.3 Protection and Creation of Permanent Water or Wet Areas

Permanent water including existing wet areas are to be retained and protected where possible. Additional natural water habitat features are to be incorporated into the landscape design process to facilitate an increase in habitat complexity. These features would become an attraction for visitors to the park. As valuable habitat, water features will support wildlife that could be observed from the security of a wildlife hide or the like. Examples of additional water features which could be utilised in the landscape are:

- permanent water features to act as a significant habitat requirement for all fauna, particularly bats and amphibians.
- the creation of vegetated wetlands to extend and supplement habitat for amphibians, reptiles, invertebrate and birds
- constructed drainage with design elements to facilitate shelter, food and breeding opportunities e.g. example, reed beds, rock stacks and overhanging vegetation

4.1.4 Retention of Natural Elements

Good opportunities exist within the construction phase to collect, retain and stockpile suitable habitat replenishment materials. Rocks, live and dead timber (including intact hollows) displaced through clearing, are to be harvested and incorporated into an extension of remnant vegetation edges. This will enhance and supplement suitable habitat for many ground mammals, reptiles, invertebrates and birds, particularly the complexity of ground layer of suitable habitat extensions and the creation of islands and refugia (Table 3.1) through installation of:

- felled or fallen timber
- rock piles or stacks

4.1.5 Retention of Standing Dead Trees Where Possible

Every consideration must be given to retaining dead standing trees as habitat. They provide valuable hollows and browsing sites. Any alignment design of mountain bike tracks, walking tracks, recreational areas and thoroughfares is to avoid the proximity of any standing dead trees or senescing trees containing important nesting, roosting, refuge and habitat. Firstly, to maintain a significant barrier to ongoing anthropogenic disturbances such as traffic, noise and light pollution by keeping these activities separate. Secondly, to avoid having to remove the trees later because they may pose a threat to any human activity below from falling branches and stags.

4.2 Nesting Boxes to Offset Habitat Loss

Approximately 300 plus species of wildlife use tree hollows throughout Australia. Vertebrate and invertebrate species rely on hollows as shelter sites, rearing young, feeding, thermoregulation and to facilitate dispersal and ranging behaviour. Hollows are formed by the process of failure and decay within a tree and can present as a small crack or split, to a very large cavity (Gibbons and Lindenmayer 2002). Generally small hollows with narrow entrances (2-5cm) are suitable for small animals such as Antechinus, Feathertail Glider and Sugar Glider species and can take upwards of 100 years to form. Medium sized hollows (6-10cm) suitable for larger mammal species such as the Greater and Yellow-bellied Glider, Common Ringtail Possum and parrot species can take around 200 years to form. Larger and deeper hollows occupied by Cockatoo and Owl species can take significantly longer with trees requiring at least 220 years of age to produce hollows of this nature. For many of these species hollow use is obligate, and no other habitat resource can be feasibly substituted (Gibbons and Lindenmayer 2002; NPWS 1999). This is the case for the extant keystone species, the Powerful Owl (*Ninox strenua*).

It is possible to shorten the long-term hollow forming process and provide habitat with reused natural habitat features to create artificial hollows as part of a nest box strategy (Figures 4.3 to 4.6). Nest boxes are a useful habitat remediation tool suitable where habitat features are limited on a site or where they cannot be preserved following disturbance. A well-designed nesting box strategy can help mitigate the transitional hiatus of hollow development in nearby remnants and offset some losses caused by tree removal for a diverse range of hollow using fauna including arboreal mammals, birds and bats Additionally, valuable research and field survey opportunities exist through the ongoing monitoring of nesting boxes onsite to evaluate existing fauna populations.

Prior to undertaking the design of any nest box strategy, an understanding of the current and future hollow tree resource on site is critical to best inform the nest box strategy requirements. As such, quality baseline data on the numbers of hollow-bearing trees (HBTs) within the Site's BGDF and BBGF was collected to inform the following:

- estimates of number of hollow bearing trees per hectare
- spatial distribution of hollows
- temporal changes and potential future recruitment of hollow resources
- density and distribution of nesting boxes required
- nesting box supplementation to meet immediate shortfall in available habitat
- nesting box supplementation to address immediate and direct impacts associated with adjacent habitat loss and disturbance from clear felling and stabilisation works in the northern section of Quarry
- hollow habitat requirements to meet in areas of intensive revegetation and restoration (nesting box/poles/rope bridges) to maintain the connectivity to the surrounding landscape

4.2.1 Nest Box Strategy Methodology

The following methods have been used to inform the nest box strategy requirements:

- hollow Bearing Tree (HBT) Survey to determine the spatial distribution and density of existing and future recruitment of hollow habitat resources (Appendix H)
- seasonal Fauna Surveys to inform the design and installation of nesting box requirements for the individual species encountered or identified shortfalls in habitat resources (Appendix D)

A HBT survey has been conducted prior to any works commencing using the Fixed Area Plot method recommended specifications outlined by Gibbons and Lindenmayer (2002), Bull et al (1990) and DECCW (2010). Fixed Area Plots are commonly used in forest inventories and habitat assessments and involve the measurement of the diameter of all trees in a set area. It has the advantages of marking permanent plots for future measurements and all trees in a stand counted (important for monitoring change over time). Plots can be set up in sensitive areas allowing increased and permanent monitoring of important stands.

A fauna survey undertaken on the Site by Gecko Environment Management was conducted during the Winter months of 2020 (Appendix D). The survey effort included a diurnal and nocturnal survey, two call-playback sessions at dusk and deployment of the following survey gear over four transects for two weeks:

- 80 hairtubes/funnels
- 5 cameras
- 1 songmeter for 8 days
- 1 Anabat Express for 1.5 hours from dusk

4.2.2 Hollow Bearing Tree and Fauna Survey Results

The results of the HBT survey provided a quantitative benchmark in the assessment of the trajectory of the hollow bearing resources of the Site. Additionally, the fauna surveys provided a quantitative benchmark for fauna requiring hollows on the Site. Some of the key habitat resource issues established within the HBT and Fauna surveys included:

- the HBT resource within the good condition Bushland on site correlated with being comparable with averages per hectare established in similar studies
- smaller diameter Branch end hollows were disproportionately represented
- survey within the more degraded areas on site established very limited representation of trees > 85cm Diameter at Breast Height (DBH) which correlated with a poor HBT resource within these zones
- hollows are poorly represented within the key riparian wildlife corridors
- the Powerful Owl remains as a keystone species on the Site
- arboreal Mammals on the Site include Ringtail Possums, Brushtail Possums and Sugar Gliders. These species would benefit from enhancement of the hollow resource within the riparian wildlife corridor

4.2.3 Nest Box Strategy

Informed by the HBT and fauna surveys, the nesting box commendations for targeted fauna and management objectives are listed in Table 4.1. Management Zones 4 and 5 (Figure 4.1) have been regarded as the highest priority sites for installation, catering for best enhancement of the wildlife habitat corridor hollow deficiencies and adjoining key impact areas on site. Management Zones 7 (south-west), 8 and 9 are of moderate priority though further enhance the hollow resources through ‘gaps’ in hollow distribution in the landscape. The appropriate specifications of nesting boxes will need to take the following into consideration:

- spatial distribution to negate any impact on existing hollow habitat by excluding nest boxes from occupied or existing hollows
- installation locations to consider aspect, levels of solar exposure, temperature extremes and predominant wind direction. The aspect is to avoid hot midday/afternoon sunlight (generally north to north-west) though several species occupy numerous locations believed to seasonally select suitable thermoregulation

- correct numbers/density considering fauna requirements to limit negative ecological consequences (over-population, pest, disease)

- varied designs accommodating relevant species and exclusion of pest species
- suitable fixing systems to ensure tree protection and capacity to last in the environment and accommodate for increasing tree girth over time
- sizes (entrance opening and depth) to select for the required fauna
- height to mitigate predation from invasive species and provide for native fauna requirements and allow for monitoring
- quality natural or manufactured materials containing thermal mass and insulating properties to provide thermoregulation and longevity

4.2.4 Nest Box Monitoring and Maintenance

A monitoring regime is to be conducted over the life of the nest box. A six-monthly inspection for the first four years is recommended to determine the efficacy and utilisation of installed nesting boxes and any maintenance requirements. This can be undertaken during vegetation management on the Site or in conjunction with the biannual fauna surveys. Annual inspections are to be undertaken for the life of the nest box. Inspections are to provide important information on:

- fauna populations including important prey species for Powerful Owl
- species diversity and densities
- invasive pest species such as European honeybee, ants or some bird species
- damage and dislodgement
- occupancy rates.

Nest boxes require regular maintenance in perpetuity to remain suitable for occupancy. Maintenance schedules are to include:

- eradication of unwanted pest species
- re-installation/ repair of damaged or compromised nest boxes
- removal of excessive nesting material
- replacement of decayed boxes
- maintenance of connection to structure
- retrofitting of predator and competitor exclusion devices such as lid latches, Indian Myna baffles, Brushtail Possum baffles, carpet installed under lids to discourage European Honey Bees

4.3 Feral Animal and Pest Management

Evidence of feral animals and pest species on the Site from anecdotal observations or the biannual fauna survey reports (8.1 Monitoring methods) are to be managed through Council's Biosecurity Management Strategy.

Table 4. 1 Nesting Box Recommendations for Targeted Fauna and Management Objectives

Management Zones	Nest Box requirements by entrance hole size										Total per MZ
	Arboreal Mammals				Birds				Bats		
	2-5 cm Small	6-10 cm Medium	10-20 cm Large	>20cm Extra large	2-5 cm Small	6-10 cm Medium	10-20 cm Large	>20cm Extra large	2-5 cm Small	6-10 cm Medium	
MZ4	30	27	22	7	20	20	5	5	15	4	161
MZ5	2	2				1	1		6	3	7
MZ7 South West	2	2	1	1	2	1			2		11
MZ8	10	8	6	1	8	5	2		5	1	47
MZ9	6	6	3	2	5	2	2	1	3	1	32
Total	**50**	**45**	**32**	**11**	**35**	**29**	**10**	**6**	**31**	**9**	**258**

Informed by the Hollow Bearing Tree survey, the orange highlighted management zones MZ4 and MZ5 have been regarded as the highest priority sites for installation, catering for best enhancement of the wildlife habitat corridor hollow deficiencies and adjoining key impact areas on site. Yellow highlighted zones are of moderate priority though further enhance the hollow resource through 'gaps' in hollow distribution in the landscape (Figure 4.1).

4.4 Protection of the *Ninox strenua* Powerful Owl

Data provided by Birdlife Australia confirming the presence of the keystone species *Ninox strenua* Powerful Owl has led the restoration focus to strongly consider its behavioural characteristics as well as its habitat composition and structural requirements as crucial to maintaining the functional ecosystem processes (Department Natural Resources 2011). The following conditions apply in order to protect the *Ninox strenua* Powerful Owl:

All Year Round

- all staff/contractors are to be provided with a fact sheet on large forest owl identification and behaviours, and how to identify roosting and breeding locations (Appendix I)
- no noisy works associated with vegetation clearing or Earthworks disturbance (e.g. chainsaw, mulching) between an hour before sunset and an hour after sunrise or within 50m of an identified roost site
- retain all hollows and canopy connection where possible
- avoid trimming of horizontal branches (including weed species) within one metre of tree hollows >30cm
- retain all horizontal perching branches 4-10 cm diameter in flyways to allow natural movement of Owls (i.e. overhanging creeks and tracks) where possible
- avoid vegetation trimming that opens the canopy and mid-storey in riparian zones (along a 50m corridor of a creek/river/riparian corridor), this includes any treatment of weed species
- midstorey weed treatment along 50m creek/river/riparian corridors and adjacent bushland to be strategically carried out with respect to roosting and fledging requirements and in accordance to this VMP and HCEP
- creek and wildlife buffer distances to be maintained, particularly in sensitive areas
- creek crossings for public use must be limited, maintained and fixed where possible

April to October (Breeding Season) in addition to above

- consult with Birdlife Australia via Hornsby Council prior to works commencing
- no clearing or Earthworks disturbance (chainsaw, mulching) is to occur within 100m of an identified active nesting tree
- if clearing or Earthworks disturbance (e.g. chainsaw, mulching) is unavoidable, works are not to be undertaken between an hour before sunset and an hour after sunrise within 100m of an identified nesting tree or 50m of an identified roost site

A strong emphasis must be given to staging earthworks in relation to the breeding cycle of *the Ninox strenua* Powerful Owl. In consultation with Birdlife Australia, every attempt is to be made to ensure works are not undertaken when a breeding pair are occupying a nest on Site. Through the implementation of this plan, it is hoped the management actions will encourage the Owls to return and continue breeding at the completion of the north spoil mound stabilisation and restoration works. Management actions to encourage the protection and return of the breeding pair includes:

- no works are undertaken within 100m of a breeding tree before the end of the current breeding season to allow any Owls that may currently be nesting on the Site, to safely move their fledglings prior to Earthworks commencing
- the cleared area is revegetated with a combination of fast-growing primary succession and long-lived canopy species representative of BGDF and BBGF Plant Community Types (Appendix B)
- restricted access to core habitat following construction by authorised personnel only for up to three years or until the area has stabilised (Figure 4.2). Ongoing consultation with Birdlife Australia on these matters is recommended

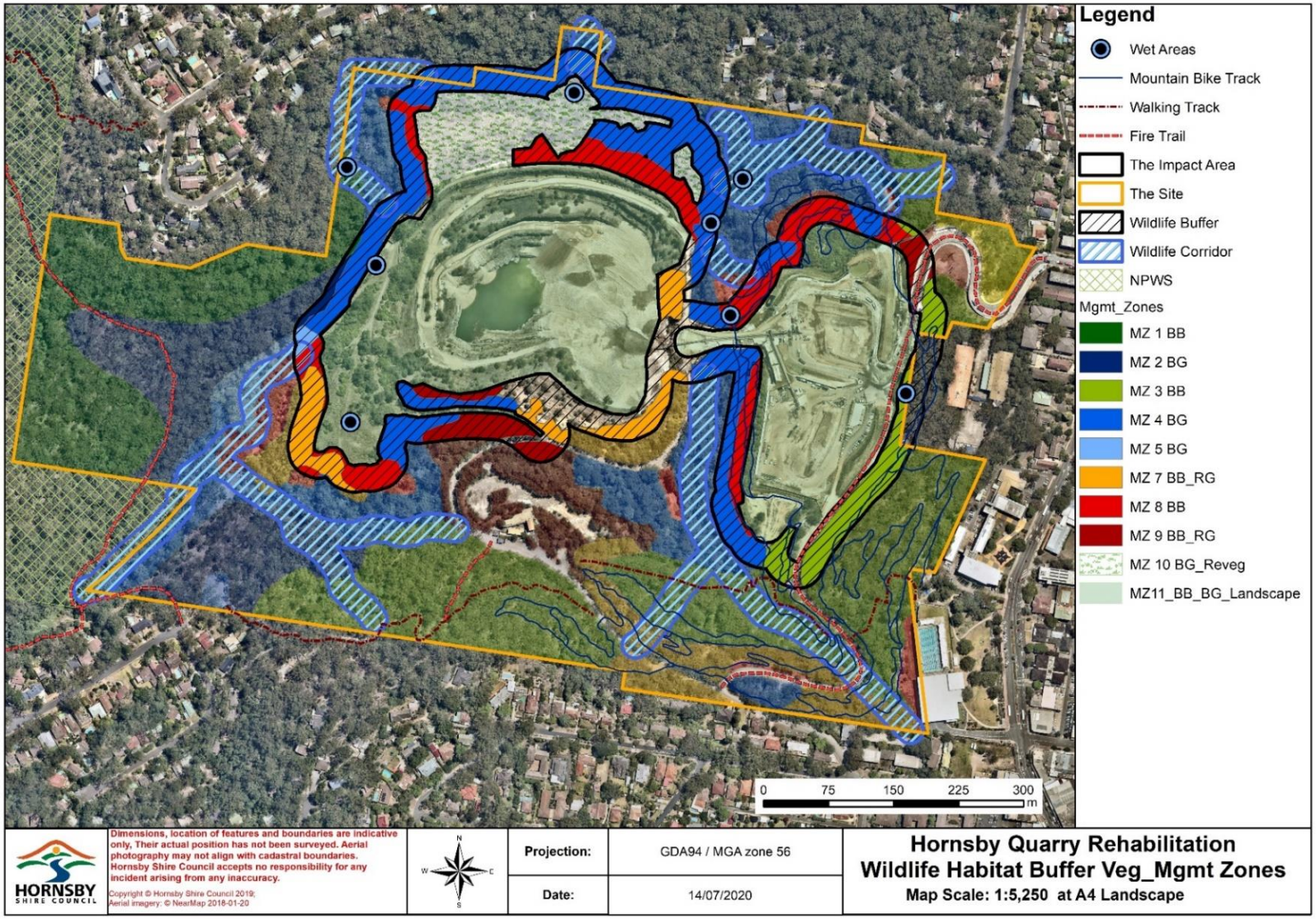

Figure 4. 1 Wildlife Buffer and Vegetation Management Zones

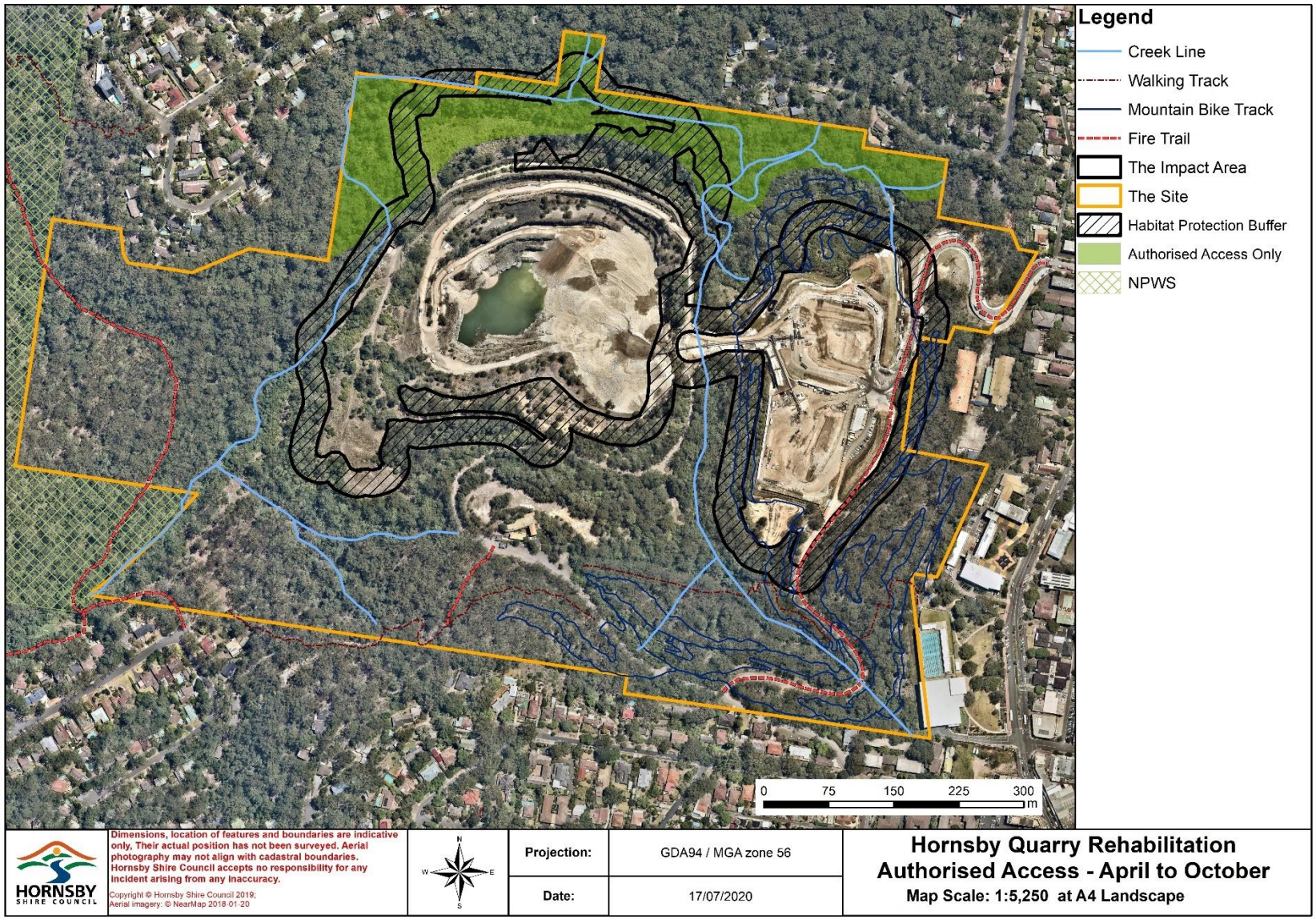

Figure 4. 2 Temporary Authorised Access Only during Owl Breeding Season

Figure 4. 3 Example of Branch Hollows to be Retained

Figure 4. 4 Example of Trunk Hollows to be Retained

Figure 4. 5 Example of Branch Hollows to be Retained

Figure 4. 6 Recycling Timber for Nest Boxes

5. Protection of Bushland during Construction

The following bushland and habitat protection measures are to be implemented prior to construction earthworks by Council engaged constructors and/or the principal earthworks contractor and documented within the approved Construction and Environment Management Plan (CEMP).

5.1.1 Bushland Fencing

Access to the bushland is to be restricted to authorised personnel only during construction. No machines or equipment are to go beyond the Impact Area. Signage is to be installed at regular intervals along the interface to signify no entry. Monitoring of the bushland is to be undertaken to identify if fencing is necessary. If so, fauna friendly and fit for purpose fencing is to be installed to enforce no access. No barbed wire or electric fencing is to be used.

5.1.2 Tree Protection

Tree protection measures to be installed around all trees to be retained. Tree protection measures are to reflect best practice in accordance with Australian Standard (AS) 4970-2009 *Protection of Trees on Development Sites.* Wherever possible, habitat trees must be identified, retained and protected.

5.1.3 Fauna Management during Clearing of Vegetation

Fauna injury and mortality are a real risk in any clearing works. Mitigation of impacts of clearing and earthworks disturbance within the Impact Area is a major focus of mitigation recommendations. Hanger & Nottidge (2009) outline extensive best practice in fauna harm mitigation surrounding vegetation clearing and disturbance. The removal of wildlife as soon as possible prior to the commencement of vegetation clearing and earthworks to minimise the risk of injury to animals is imperative. Wildlife load reduction measures must be implemented or conducted by the wildlife spotter/catcher for an appropriate period immediately prior to the onset of operational works. Measures may include, but are not be limited to:

- fauna trapping using an appropriate range of trapping methods
- fauna exclusion fencing
- use of fauna aversion techniques
- manual removal of fauna

Any technique, method or machine that may cause unmitigated risk to native fauna must not be used as the primary method of vegetation removal until native fauna has been thoroughly removed. Unacceptable methods include, but are not limited to:

- mobile mulching machines or those attached to plant equipment as the primary vegetation removal techniques
- the felling of hollow bearing trees prior to native fauna removal
- mulching or burning of vegetation or other potential refugia without spotter/catcher supervision
- the burning of habitat, standing vegetation or other fauna refugia

Licensed wildlife spotter/catchers must be engaged for any vegetation clearing and development activities or process undertaken onsite. They must:

- be present during the clearing of vegetation or damage or disturbance to any structural habitat or refugia
- clearly define the allowable and non-allowable methods of clearing vegetation to minimise risk of injury or death to wild animals

Figure 5. 1 Lace Monitor Onsite 24.01.2020

5.1.4 Timing and Sequence of Vegetation Clearing

Vegetation clearing and earthworks must comply with specifications in 4.2 Protection of the *Ninox strenua* Powerful Owl. Additionally, whenever possible, vegetation clearing must be scheduled for mid to late summer so that:

- impacts on nesting and hatching avifauna and herpetofauna are minimized (greatest impacts in spring)
- likelihood of detection and capture of fauna is increased
- wildlife load reduction measures are most productive

Clearing of vegetation sequentially or segmentally encourages natural movement of native animals into habitat remnants and may be an appropriate measure when:

- suitable habitat of enough area and resources is adjacent to the vegetation clearing boundary
- target wildlife species possess the ability to avoid potential harm caused by vegetation clearing e.g. sequential clearing may be enough to mitigate risk of harm to wallabies where suitable adjacent habitat exists, but is not an appropriate measure for arboreal fauna using tree hollows for nesting, or for herpetofauna, when clearing occurs during cold weather
- other mitigation measures are required to avoid or reduce harm to native animals that do not respond appropriately to sequential clearing e.g. erection of wildlife-proof fences to prevent wildlife moving into open and exposed areas
- sequential clearing must not be used as a substitute for wildlife load reduction, when wildlife load reduction is essential for proper management of wildlife in the present circumstance e.g. sequential clearing must not be used as a primary fauna management measure when remnant habitat is likely to be insufficient to sustain displaced fauna, or is deficient in key resources, such as water sources, food trees or shelter opportunities or refugia

5.1.5 Preservation of Tree Hollows and other Habitat Features

Preservation of tree hollow integrity and structure in trees which are to be removed must be preserved wherever possible. These are to be relocated to appropriate habitat retained on, or close to site, or to predetermined stockpile location for future use.

Important ground layer habitat features such as large fallen logs, log piles, rock piles or outcrops etc must be preserved onsite as much as possible. Removed material is to be translocated or stockpiled and re-established at appropriate habitat creation or enhancement areas.

To adhere to “no net loss” of tree hollows, in instances in which natural tree hollows are destroyed, the replacement of artificial hollows occurs at a rate of 4 artificial replacements per natural hollow destroyed.

5.1.6 Vegetation and Rubble Piles

Structural habitat features such as log piles, rocky outcrops, riparian and wetland areas are to be indicated on the site map prepared by a wildlife spotter/catcher and receive consideration as potential habitat. Less important surrounding habitat areas are to be cleared prior to disturbing or clearing identified habitat areas. This holds importance as it provides opportunities for intensive trapping around features and affords greater flexibility to apply less destructive clearing methods.

Piles of rubble, felled timber or any other material, proposed to be burnt, buried or chipped may quickly become occupied by wildlife seeking refuge during vegetation clearing and earthworks. Consideration is to be given to the prospect of injuring wildlife in the secondary disturbance of stock piled vegetation or rubble.

5.1.7 Wildlife Handling

The ideal outcome for wildlife removed from a site during operational works is to be relocated back to the same site at the completion of works. This limits any potential adverse ecological consequences associated with translocation and the potential adverse effects (on the individual) of placement in unfamiliar territory are avoided. Translocation of animals is not a preferred option unless retention at, or relocation back to, the original site is inappropriate.

In order of preference, outcomes for removed wildlife are as follows:

- relocation back to suitable habitat on original site following operational works
- translocation to suitable habitat adjacent to site
- translocation to distant suitable habitat
- placement in captive institution for conservation, educational or research purposes
- euthanasia.

5.1.8 Retention of Material for Reuse over the Site

Vegetative material required to be removed is to be retained for mulch, compost, habitat or site stabilisation as appropriate (7.5.1). The cleared vegetation is to be stockpiled separately as per its end use as landscape elements, habitat or compost. Stockpiling of felled timber to be as follows:

- Ground covers, shrubs, tree leaf litter and branches <50mm diameter
- Medium to large branches 50 - <200mm diameter and 2 -3 metre lengths
- Large branches > 200mm - < 300mm diameter and 2 – 3 metre lengths
- Tree barrels > 300mm diameter cut as long as feasible
- Hollows to remain intact

Fauna will quickly utilise piles as habitat soon after their formation. This must be considered when deconstruction of the piles for reuse occurs (Refer 5.1.6 Vegetation and Rubble Piles).

5.1.9 Hygiene

A strict hygiene protocol is essential to prevent the spread of pathogens, including *Phytophthora cinnamomi,* Myrtle Rust and weed propagules.

Procedures and guidelines must include disinfecting machinery, PPE, tools and equipment prior to entering and when leaving the site. Protocol details can by sourced from the following link, ‘Bushland Hygiene Protocols for Phytophthora’ and ‘Preventing spread of Myrtle Rust in bushland below: http://www.hornsby.nsw.gov.au/environment/flora-and-fauna/bushland-management/bushcare/volunteer-resources

6. Habitat Management

6.1 Management Zone Description

The proposal to rehabilitate the Quarry requires clearing of vegetation within the Impact Area as part of the Earthworks. To comply with the Secretary's Environmental Assessment Requirements (EAR No 1167) dated 6 September 2017 and the proposed Biodiversity Offset Strategy, Council plans to undertake vegetation management of the bushland occupying the Site and ensure the protection of its Biodiversity in-perpetuity. This Vegetation Management Plan (VMP) and Habitat Creation and Enhancement Plan (HCEP) addresses mechanisms to regenerate and revegetate areas of the Site. The intention is to sustainably conserve biodiversity by improving the Site's ecological integrity. The strategy is to work with the staging of the Hornsby Park Project and beyond to ensure the aims and objectives of this VMP and HCEP are achieved. Management actions to achieve these are as follows:

- protect existing vegetation that is providing a buffer along the Impact Area interface prior to, and during construction regardless of species
- when planning and designing future work for possible structural or safety issues, prioritised rehabilitation is required to reinstate buffers
- strategically plan a staged approach to the timing, location and extent of weed removal through best practice bush regeneration throughout the site (Appendices A and F)
- engineer site soils to reflect benchmark data for both plant communities as a medium for revegetation within the Impact Area
- propagate from locally sourced plant material
- revegetate with locally provenant species to mimic natural succession within the Impact Area and where required with the Site
- identify future threats to the natural environment and mitigate effects

To implement these management actions, the Impact Area and the Site have been divided into Management Zones based on vegetation type and vegetation condition (Figure 6.1). Predominately, condition is reflective of the level of site disturbance and therefore, weed density. The main types of disturbance on the Site have been vegetation clearing and soil disturbance because of historic agriculture and mining practices (excavation, piling of tailings or 'scree' and erosion). Other types of disturbance include anthropogenic activities including surrounding lands use and construction, track construction, sewer easements and water management. Each Zone has been allocated management actions to be implemented and monitored (Appendix A). The results of monitoring will be key indicators for adaptive management (Appendices E and F).

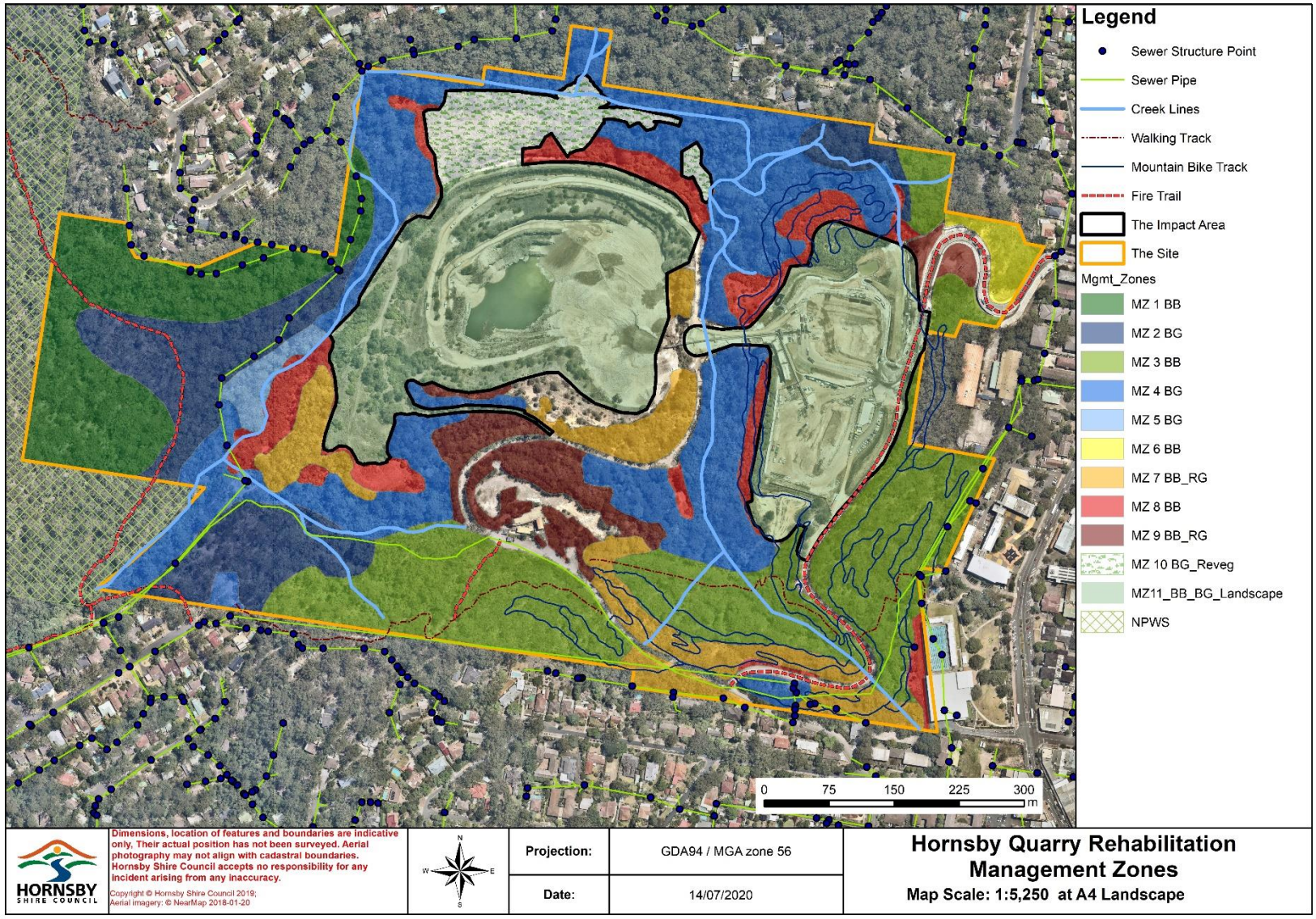

Figure 6. 1 Management Zones

6.1.1 Management Zone 1 (MZ1) BBGF Good

Management Zone 1 consists of 4.87 hectares of good condition Blackbutt Gully Forest (BBGF) in the most western area of the Site. It is beyond the Impact Area and bordered by the Berowra Valley National Park (BVNP) to the south and west, and private properties containing bushland to the north. The topography is that of steep slopes facing north and south with a depression running in an east west direction between the slopes. Large sandstone outcrops and boulders are present amongst a fern understorey on both sides. The soils in this zone are relatively undisturbed except for the fire trail that rises from Rosemead Road and then along the depression towards Fishponds, and the sewer easements on the bushland and private property interface. The resilience of this zone is good, however bird, wind and water dispersed weed may periodically be present. Encroachment and weed incursions may occur from neighbouring residential boundaries and there is a possibility of sewer infrastructure failure. Ongoing sewer infrastructure maintenance is to be expected.

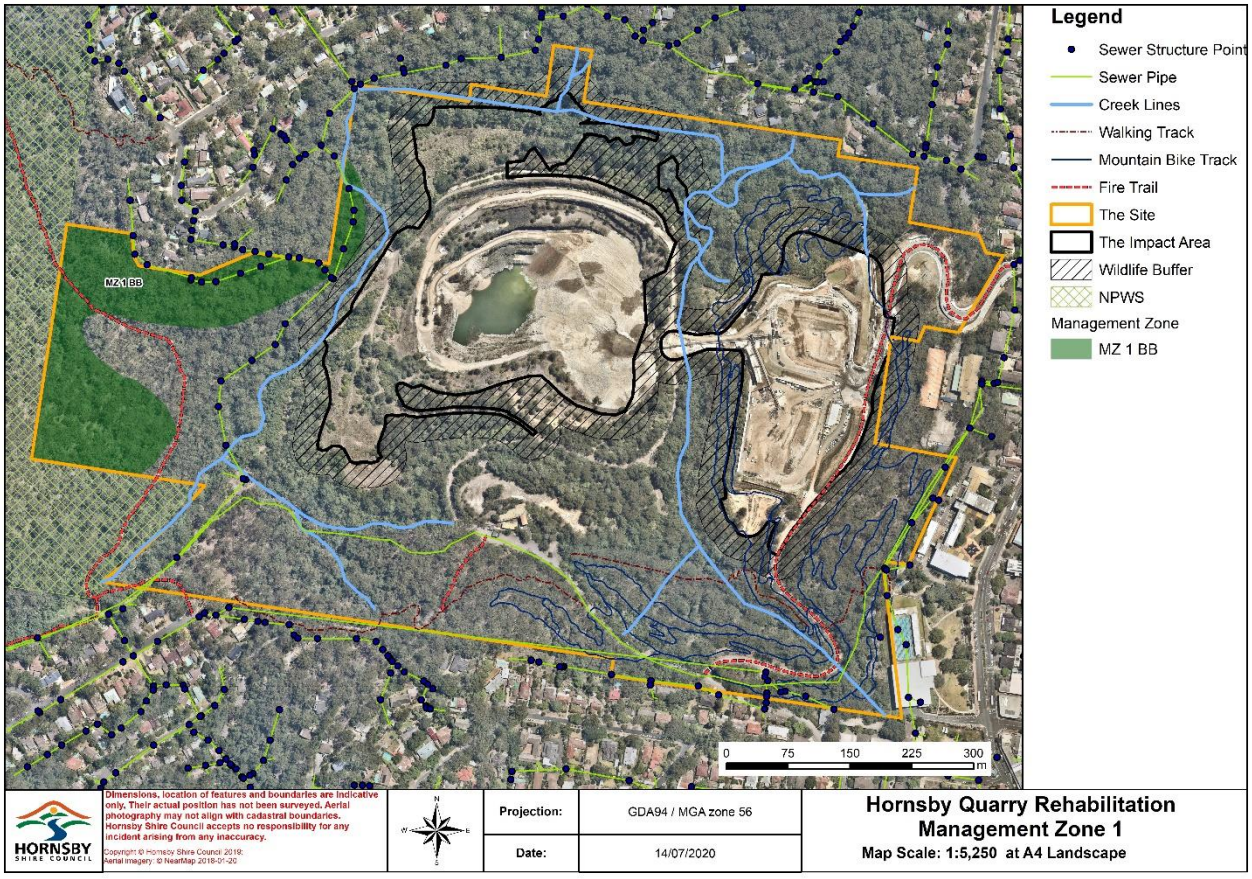

Figure 6. 2 Management Zone 1

6.1.2 Management Zone 2 (MZ2) BGDF Good

Management Zone 2 consists of 4.9 hectares of good condition Blue Gum Diatreme Forest (BGDF). It is represented by three separate areas of land.

MZ 2.1: The area to the west and consists of 2.5 hectares where vegetation transitions from the BBGF to BGDF as the topography slopes in an easterly direction towards the creek line. The zone is bordered by the BVNP to the south and zones of poorer quality BGDF to the east and north.

MZ 2.2: The area to the south consists of 1.86 hectares of relatively low gradient at the end of Rosemead Road. It encompasses the Rosemead Park and abuts fill material from mining activities to the north.

MZ 2.3: The area to the north east consists 0.6 hectares on a steep south-west facing slope. The soils in this zone are relatively undisturbed except for the sewer easement and a series of informal tracks throughout the two areas in the south.

The resilience of this zone is high however weeds from neighbouring bushland of less quality or bird, wind, water dispersed weeds may periodically be present. There is the possibility of encroachment and weed incursions from neighbouring residential properties and sewer infrastructure failure. Ongoing sewer infrastructure maintenance is to be expected.

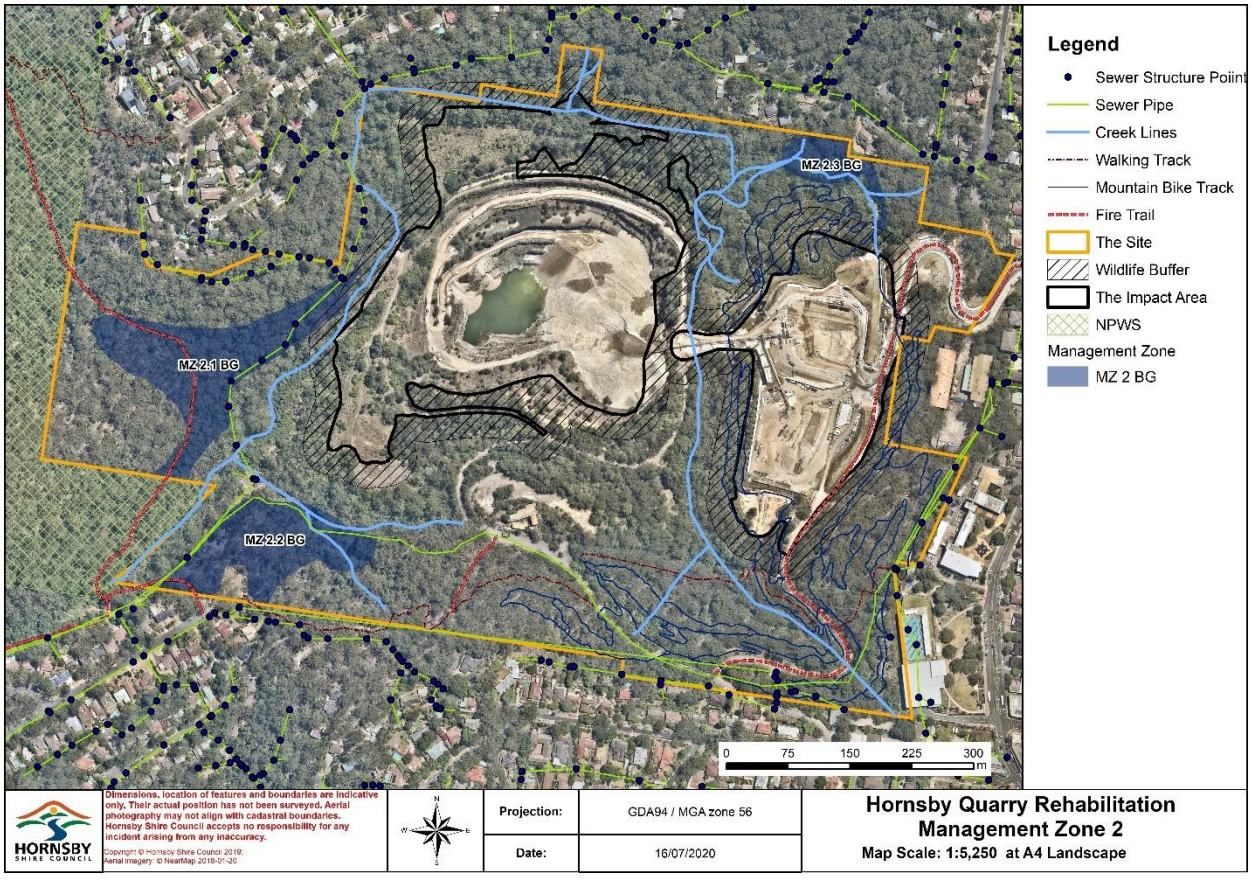

Figure 6. 3 Management Zone 2

6.1.3 Management Zone 3 (MZ3) BBGF Fair

Management Zone 3 consists of 10.04 hectares of BBGF in fair condition. It dominates the higher areas south, east and south-east of the Site. The topography features gradual slopes with some rocky outcrops. In the more sheltered area below Quarry Road and along the creek line in the south of the site, the midstorey is denser and mesophilic than the higher slopes above Quarry Road and above the fire trail. An existing mountain bike track occupies approximately 70% of the Zone and a significant amount of midstorey is visibly absent in these areas.

The soils in this Zone have been disturbed along the Site boundary near the pool, the TAFE and along the mountain bike track. Bird, wind and water dispersed weeds are present in this zone. Woody weeds dominate the more sheltered areas particularly along edges and the riparian corridor. Climber, ground cover and herbaceous weeds are also present on the more exposed areas particularly along edges.

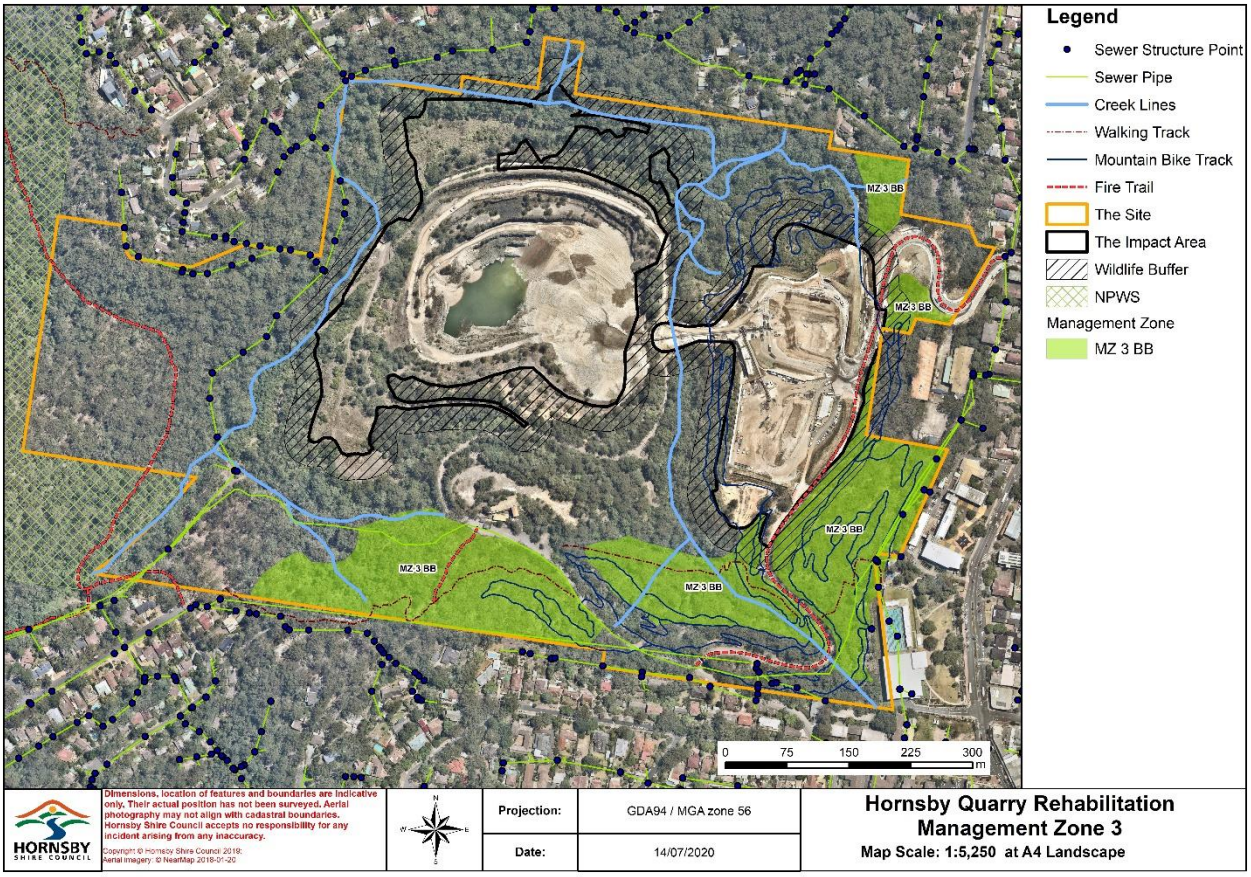

Figure 6. 4 Management Zone 3

6.1.4 Management Zone 4 (MZ4) BGDF Fair

Management Zone 4 consists of 10.75 hectares of BGDF in fair condition. It currently occupies areas stretching from the south west of the Site in a north easterly diagonal direction, surrounding most of the quarry void, to the north east of the Site. The topography varies in association with the position in the landscape and the level of soil disturbance due to mining practices varies. The condition of the zone also varies because of its position in the landscape but also because of water movement throughout the zone. The dominant weeds in this zone are *Ligustrum lucidum* and *Ligustrum sinense* Large and Small- leaved privet. They create a midstorey monoculture under a Eucalypt canopy and provide significant habitat (2.9.6).

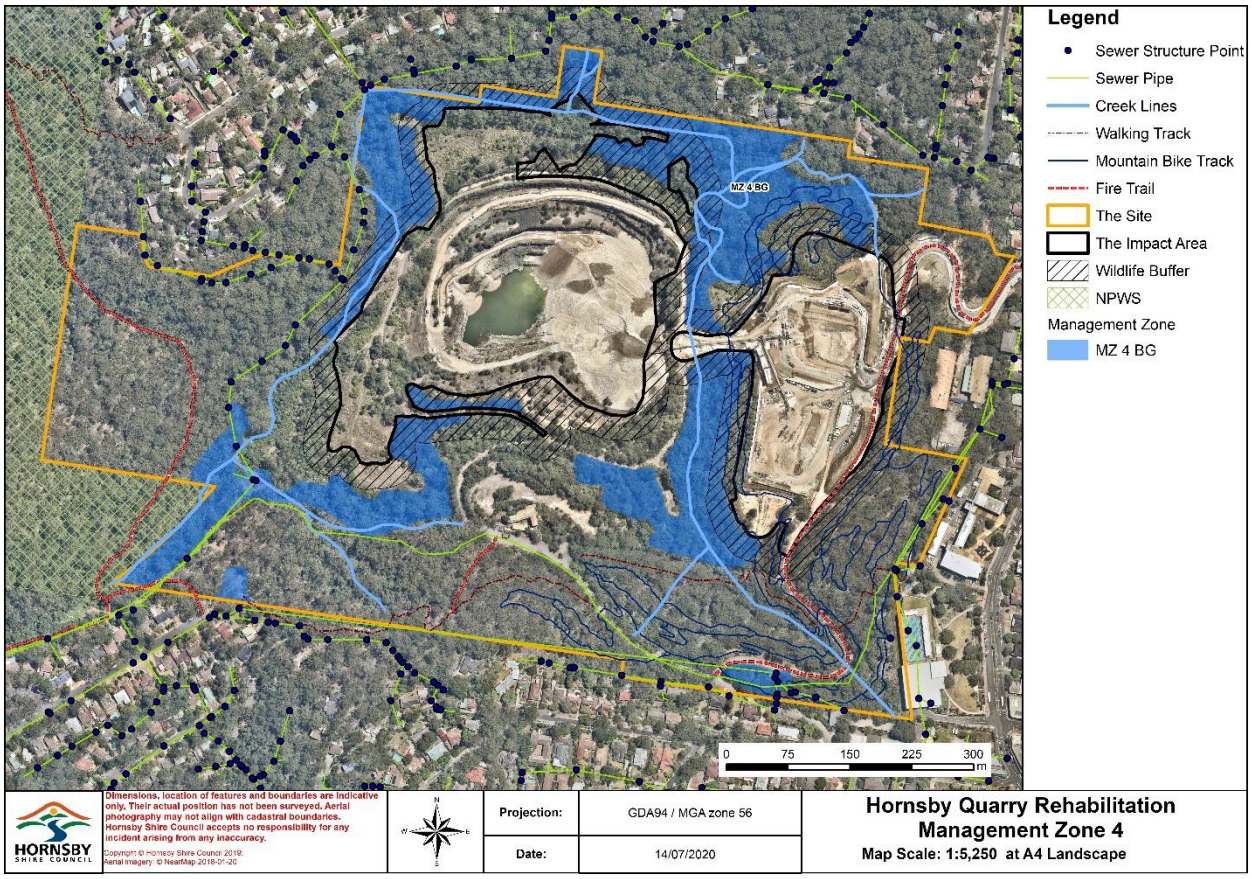

Figure 6. 5 Management Zone 4

6.1.5 Management Zone 5 (MZ5) BGDF Riparian

Management Zone 5 consists 0.47 hectares of BGDF in fair condition. It occupies a transitional area between the BGDF on the west of the Site and the overburden or 'scree' of the south west mound. The creek line (riparian corridor), water flow discharge pipe outlet, weed maturity and weed density are features which delineate this Zone from the surrounding zones. As a result, this Management Zone has specific management actions requirements, particularly in relation riparian corridor and weed treatment. The dominant weeds in this zone are *Ligustrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet. It forms a midstorey monoculture under a Eucalypt canopy.

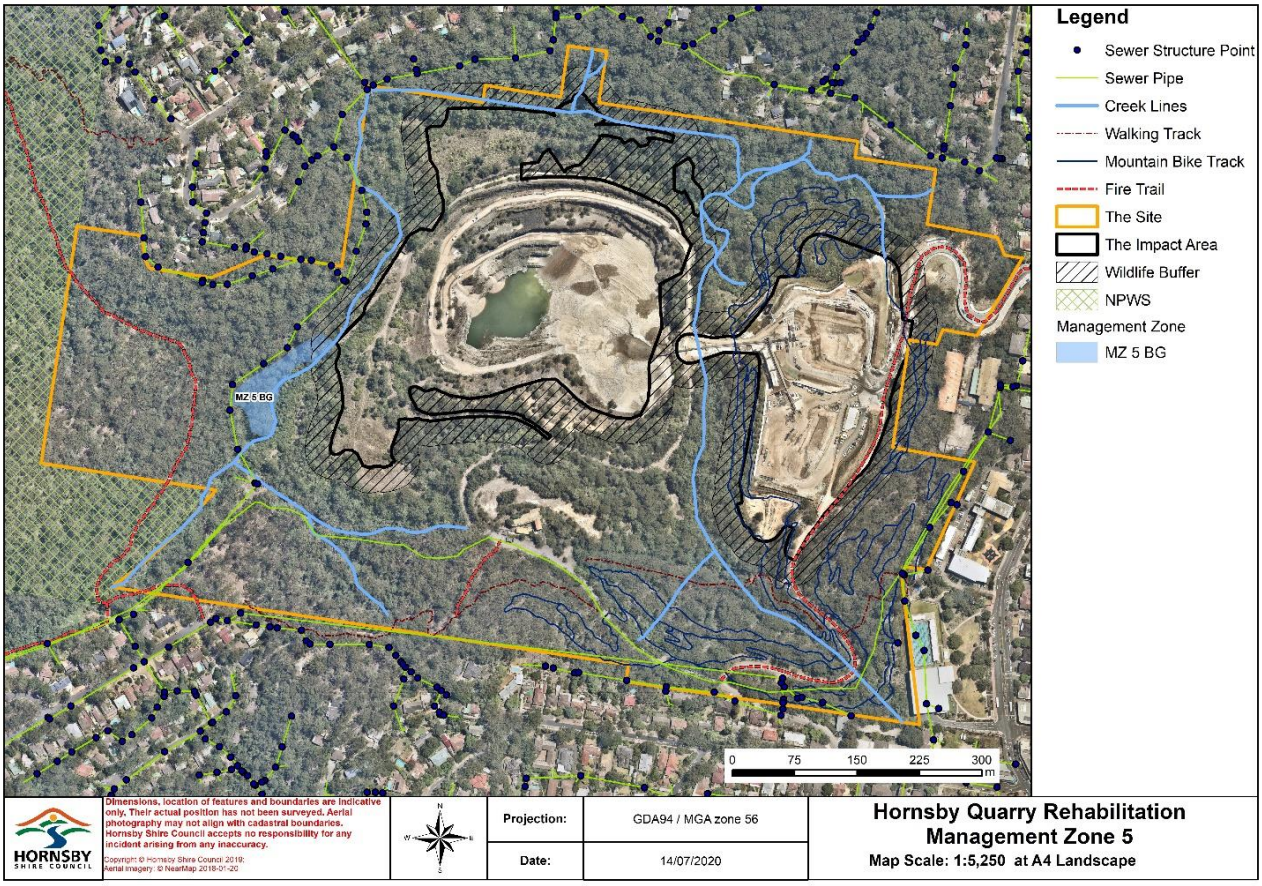

Figure 6. 6 Management Zone 5

6.1.6 Management Zone 6 (MZ6) BBGF Poor

Management Zone 6 consists of 0.49 hectares of BBGF in poor condition. Prior to filling the Quarry by NorthConnex, this zone was contiguous to what is now Management Zone 3, BBGF in fair condition. The Quarry filling process required construction of an access road to Old Mans Valley via Bridge Road Hornsby. The current zone and its condition are the result of these works. The topography is a steep south west facing slope. The soil in this zone is a mixture of imported soil with a high soil pH, a form of spray-crete and exposed shallow natural soils. Weeds species are representative of those found on road corridors, particularly wind dispersed species.

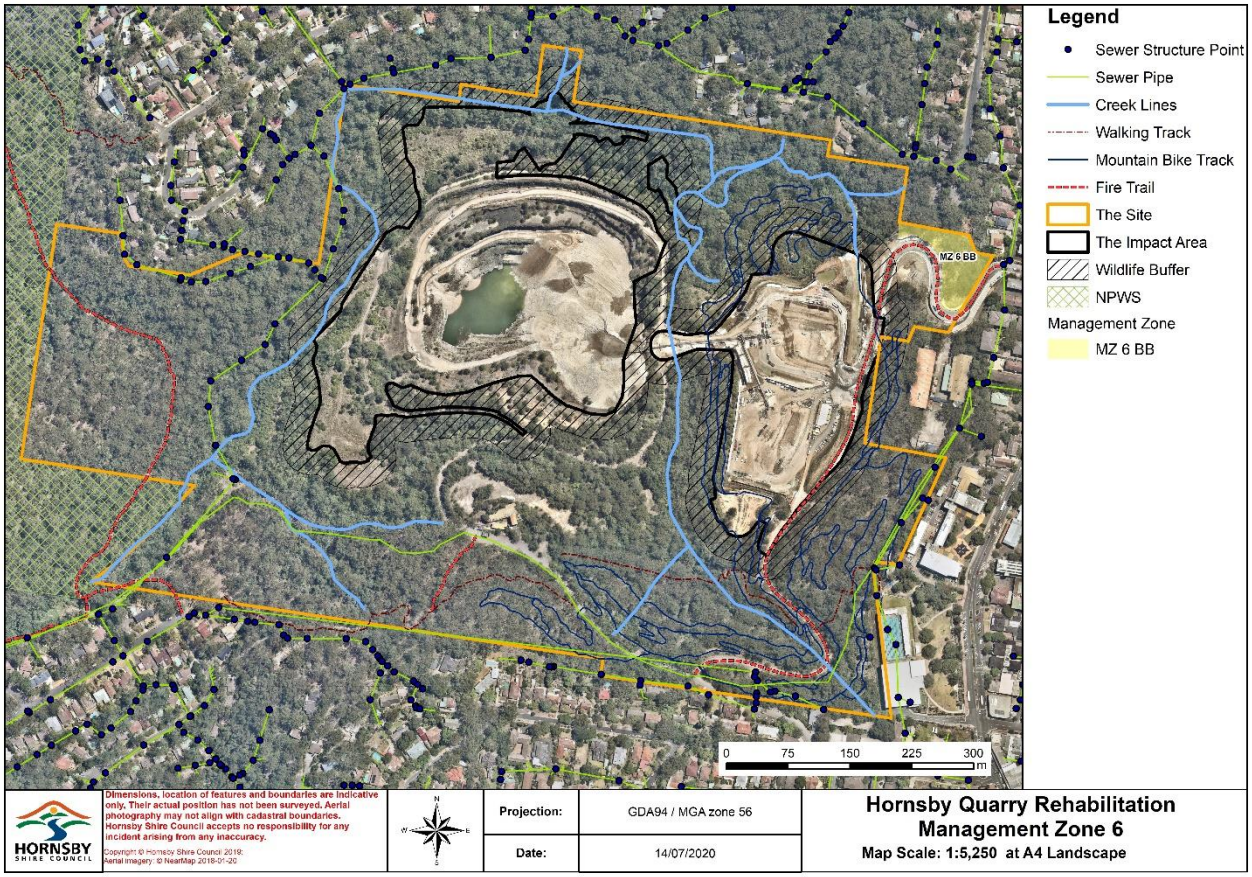

Figure 6. 7 Management Zone 6

6.1.7 Management Zone 7 (MZ7) BBGF Regrowth Poor

Management Zone 7 consists of 3.69 hectares of BBGF in poor condition. It is represented in 3 areas, all of which have had different soil disturbances.

MZ 7.1: The first area in the south west part of the site and to the west of the crusher plant consists of 0.73 ha of an area referred to as the 'south west mound'. Historical aerial photographs show this area clear of vegetation dating back to 1939 (Figure 2.4). Modifications to the soil and shape of the area appear to have commenced in the 1960's and by 1985 (Figure 2.7), the mound was the shape it is today, a terraced slope of overburden. Soil test results indicate soils are not engineered and vary in type and structure between the terraced slope and the plateau. The terraced slope has been filled with clayey gravel sands, large boulders and a variety of dumped manmade objects. In contrast, the plateau is composed of sandy gravels, cobbles and boulders. Whilst this section of the south west mound holds significant numbers of mature *Eucalyptus*

saligna Blue Gums, the vegetation of the area has been mapped as Blackbutt Gully Forest (BBGF) (Figure 2.13). The zone is predominately a woody and herbaceous weed understorey with a Eucalypt canopy.

MZ 7.2: The second area is located on the south east wall of the quarry void and occupies a steep area of 1.94 hectares. The current vegetation is growing in highly modified and eroded material from the void wall above. The canopy species is predominately *Casuarina cunninghamiana* River Oak. As this species is not endemic to the area, its origin in unknown however,t is likely to have been planted as part of a previous rehabilitation/revegetation exercise and has since become naturalised. Weeds present are predominately woody and herbaceous weed species.

MZ 7.3: The third area consists of 2.01 hectares along the verge of Quarry Road. The soil has been highly disturbed and significantly modified. This is most likely to have occurred during the construction of Quarry Road. The slope drops steeply from the road along the extent of the northern side and is dominated by a midstorey of *Ligsutrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet. Exotic climbers *Ipomoea indica* Morning Glory and *Asparagus aethiopicus* Asparagus Fern have a significant presence in this zone.

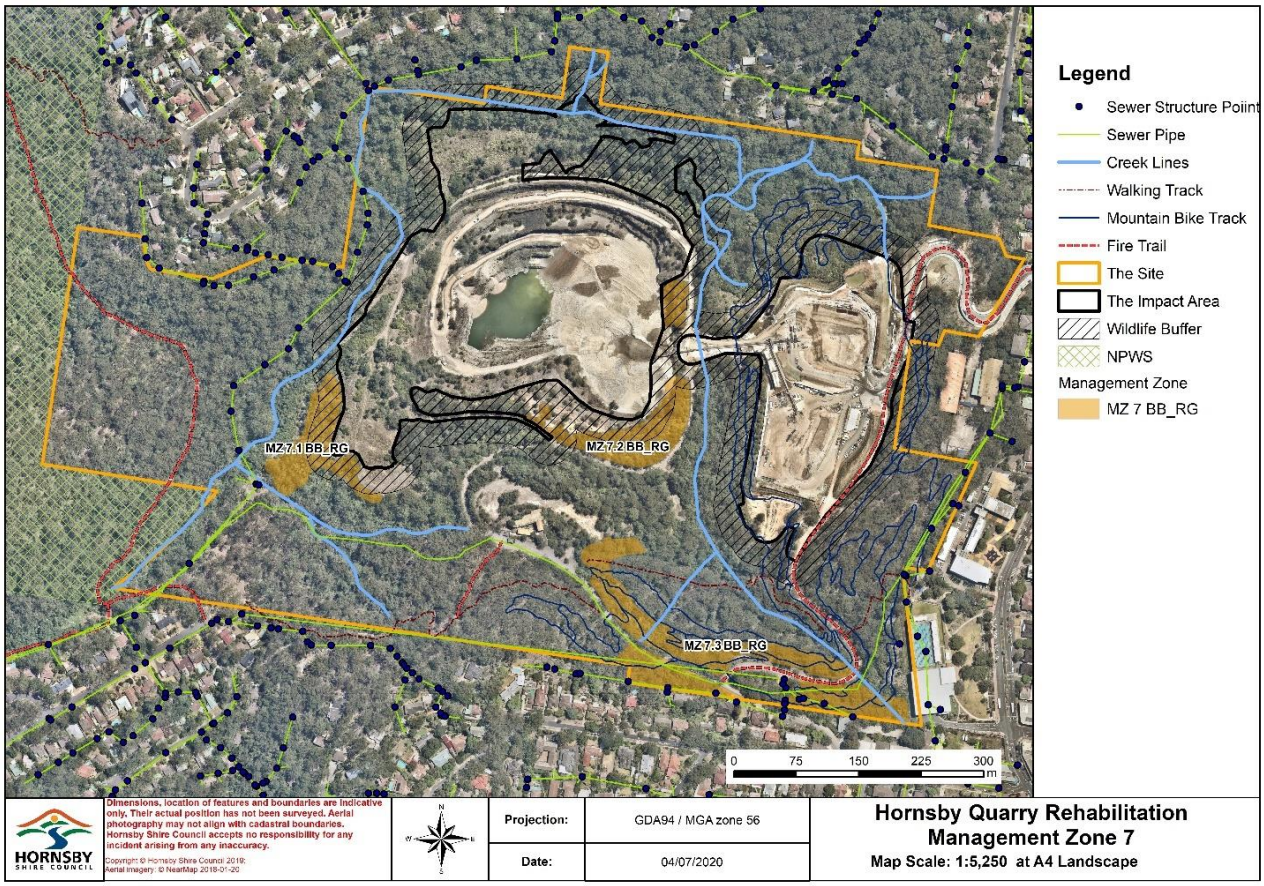

Figure 6. 8 Management Zone 7

6.1.8 Management Zone 8 (MZ8) BBGF Very Poor

Management Zone 8 consists of 3.15 hectares of very poor BBGF occupying seven areas outside the Impact Area. All areas except for the area below the pool, have direct contact with BGDF of fair condition. All soils in these areas have been highly modified.

MZ 8.1: This area of the south west mound is a terraced slope of overburden containing a mixture of clayey gravel sands, cobbles, large boulders and a variety of dumped manmade objects. The existing vegetation is a mixture of canopy species growing within midstorey and ground cover weed species.

MZ 8.2 The area to the west of the north mound is a *Ligustrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet midstorey monoculture under a Eucalypt canopy. This area is critical roosting habitat. The long strip of the MZ 8.2 above the drainage channel in the north mound is a steep gradient with exposed rock forming a cliff like structure. Weeds in this location dominate the vegetation type and are a mixture of opportunistic water loving herbaceous and woody weeds.

MZ 8.3: The area north of Old Mans Valley is predominately low growing herbaceous weeds that provide a Grassland habitat adjacent to Management Zone 4. There is currently a water soak in this zone. Mountain Bike Tracks occupy a portion of this Zone.

MZ 8.4: The area west of Old Mans Valley and adjacent to the Cemetery is a corridor of mature *Ligustrum lucidum* and *Ligustrum sinens*e Large and Small-leaved Privet that has created a mesophyllic monoculture of weeds under a Eucalypt canopy on disturbed soils. Mountain Bike Tracks occupy the majority of the area adjacent to Old Mans Valley.

MZ 8.5: The area on the interface of both the pool and the Quarry Road fire trail is a corridor of mature *Ligustrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet that supports climbing weed species and a ground cover of herbaceous and annual weeds under a Eucalypt canopy on disturbed soils.

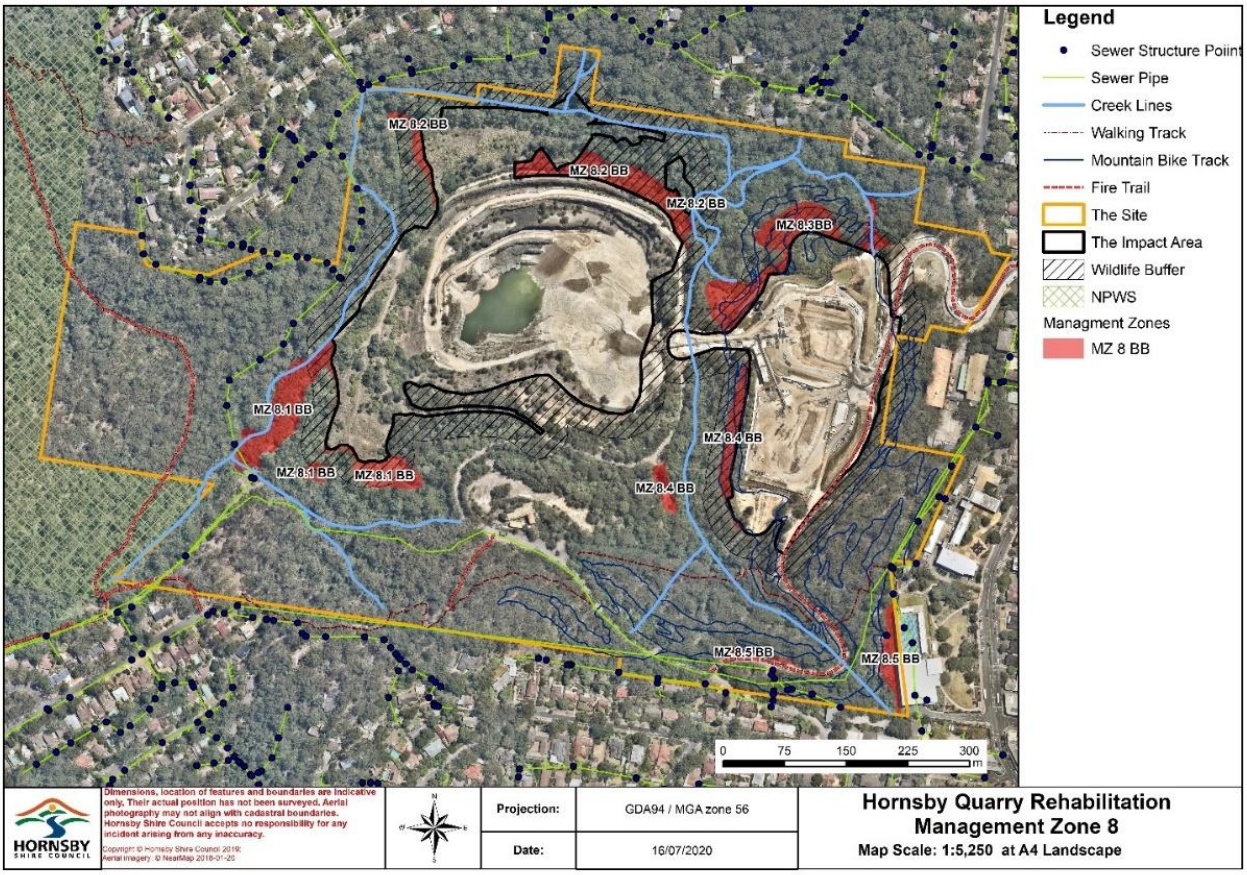

Figure 6. 9 Management Zone 8

6.1.9 Management Zone 9 (MZ9) BBGF Very Poor

Management Zone 9 consists of 2.15 hectares of very poor BBGF regrowth.

MZ 9.1: As with Management Zone 6, this area has been impacted by the Bridge Road construction for the purposes of filling the Quarry by North Connex. The area is steep and erodible with imported soil with a very high pH. The regrowth is herbaceous and grass weeds species are representative of those found on road corridors.

MZ 9.2: The area below the crusher plant is a monoculture of a *Ligsutrum lucidum* and *Ligustrum sinense* Large and Small-leaved Privet under a *Casuarina cunninghamiana* River Oak canopy and a sparse Eucalypt canopy. The stability of the soil in-situ requires assessment and geotechnical advice prior to any vegetation management.

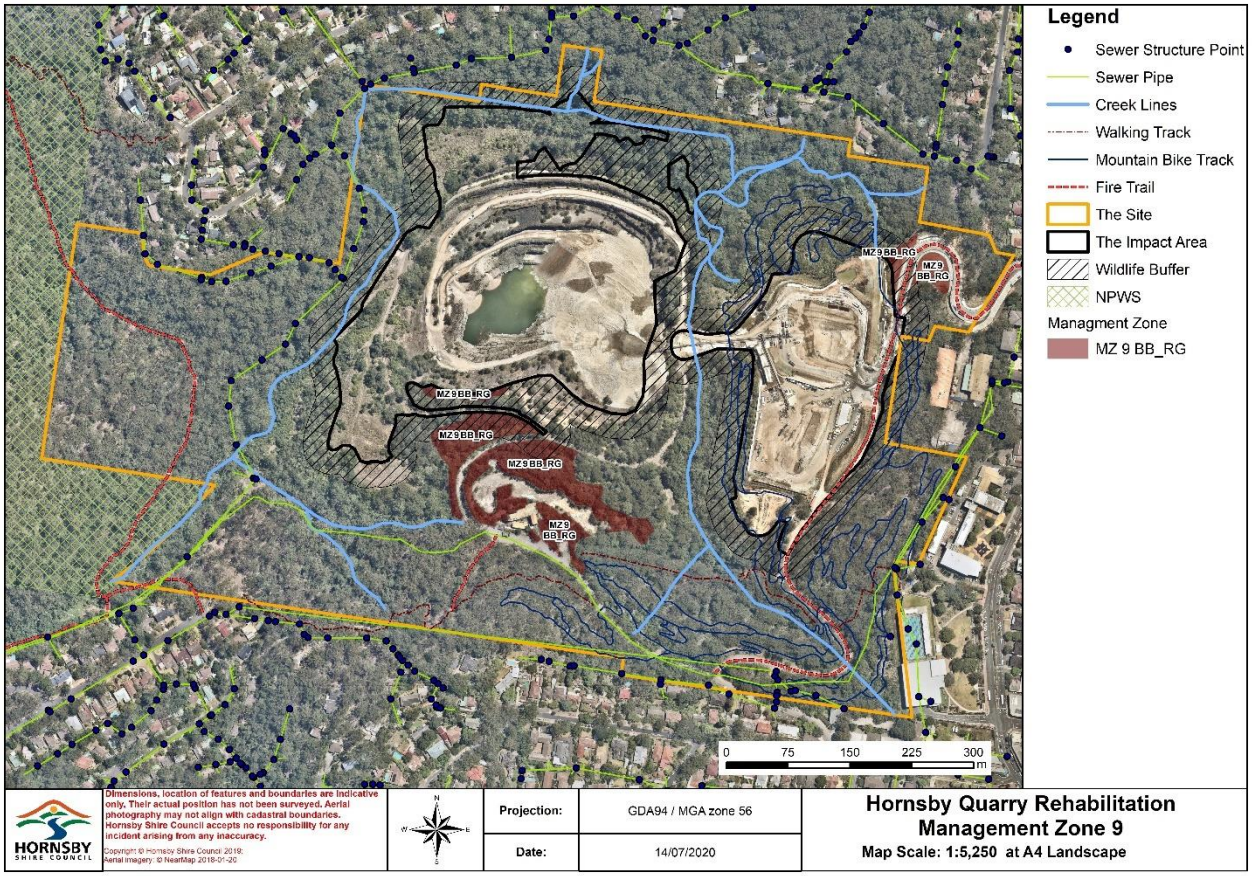

Figure 6. 10 Management Zone 9

6.1.10 Management Zone 10 (MZ10) Impact Area North Spoil Mound

The north spoil mound is a steep wall on the northern boundary above the quarry and this is clearly identified in the current LiDAR image (Figure 2.9). Historical photographs indicate its creation during the 1960's and then further excavation occurred from the eastern edge of the north mound from around 1989 resulting in a modified slope of 1:1.2. Soil testing results indicate both varying soil profile types and depths. Geotechnical reports

indicate localised high levels of instability. Current access for management is limited due to the steep slope. Weed density is high and consists of woody and wind dispersed weed species. The weeds present are a source of weed seed within the Impact Area, the Site and beyond to adjoining land. Of concern is the large population of *Cortaderia selloana* Pampas Grass that dominates the mound face.

The proposal is to stabilise the area and reduce the slope with earthworks to make the area safe and improve access for vegetation management. Some of the material from the slope will be used to partially fill the void. The vegetation on the north spoil mound has been mapped as Blue Gum Diatreme Forest (BGDF), Blackbutt Gully Forest (BBGF) and BBGF Regrowth (GHD 2019). Where earthworks are undertaken revegetation will be carried out. Improved site soils to support BGDF and BBHF PCTs are to be engineered and applied prior to planting.

6.1.11 Management Zone 11 (MZ11) Impact Area Old Mans Valley and the Quarry Void

Old Mans Valley was previously a non-engineered fill area (PSM 2006) with a low vegetative cover consisting predominately of weed species. NorthConnex occupied and reshaped the area for transporting and partially filling the void with material excavated from the NorthConnex tunnel. The proposal is to use this area as the main access point to the Hornsby Park are as well as to provide a sports field and other recreation activities. The void has been largely filled with material from the NorthConnex tunnel and re-shaped in preparation for further fill and final landscaping as a recreational area for public use. Landscape plans for both areas must incorporate planting with both BBGF and BGDF species where possible to increase the connective integrity within the site.

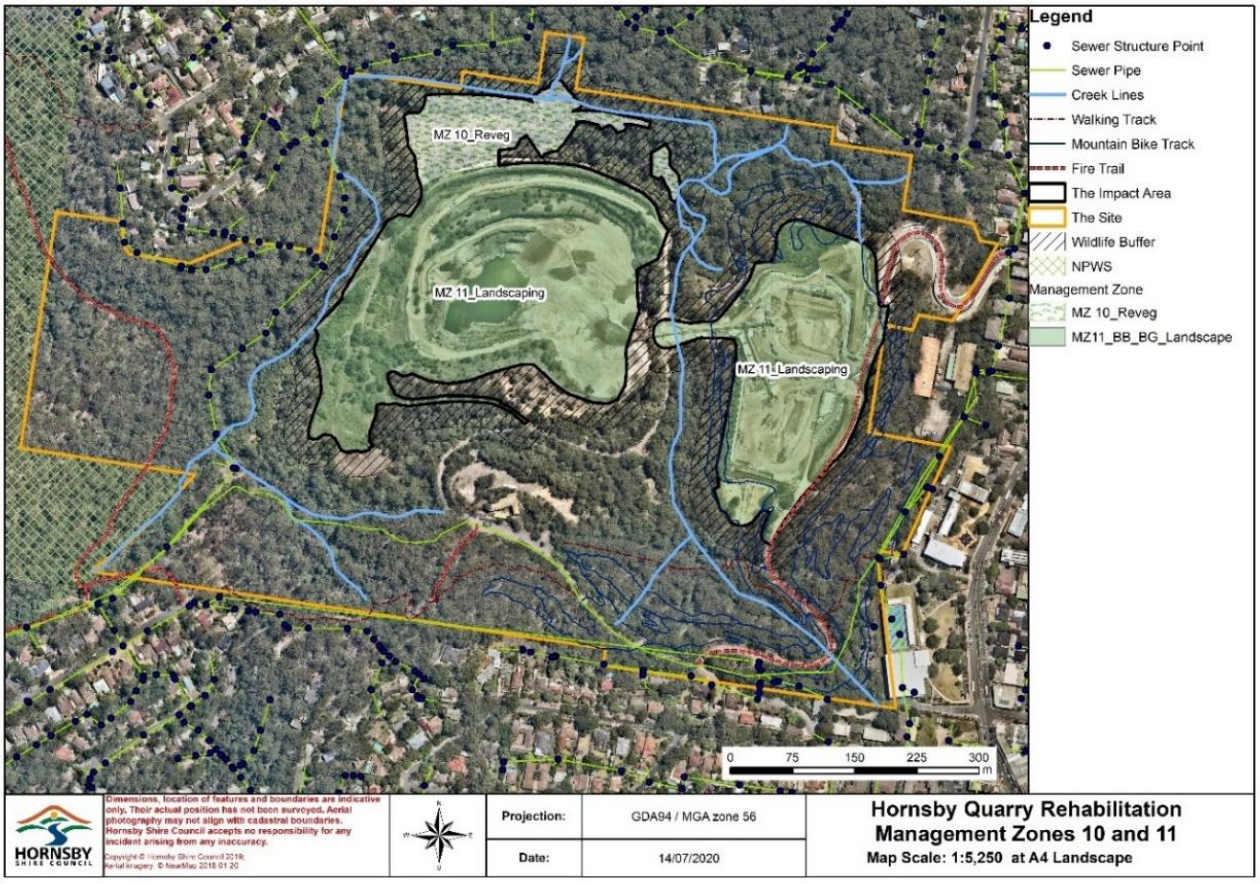

Figure 6. 11 Management Zones 10 and 11

6.2 Management Actions

Management actions have been prepared for each management zone based on the vegetation condition assessment (2.6.2) and to underpin Council's proposed Biodiversity Offset Strategy. With reference to choosing species for revegetation, it is to be noted that there are plant species represented in both BGDF and BBGF. Considering this overlap will be of value in landscape transitional areas or on the south west mound mapped as BBGF. Here,*Eucalyptus saligna* Sydney Blue Gum has been recorded as the predominant canopy species (Arterra 2019) and the location within the centre of the diatreme indicates that it could more than likely have originally been Blue Gum Diatreme Forest (BGDF). All management actions as mechanisms to achieve the aims of this report have been itemised in Appendix A.

6.3 Weed Control Methods

Weed control is required to restore the native plant communities and therefore improve the ecological integrity of the Site. It is necessary to assist the natural systems present by removing competition from weeds and prevent further spread of weeds. Best practice bush regeneration works from 'good' bush to 'poor' bush, thus allowing natural processes the best opportunity to re-establish and defend against potential weed incursions. Weed treatment is to be undertaken in the following stages:

- Primary – the initial weed treatment. The appropriate timing, area and method of treatment is determined by weed species, weed density, site resilience, adjoining land use and the weeds potential to stabilise soil structure or habitat.
- Secondary – weed control that is the follow-up work required after primary weed control. Work is targeted on germinating weed seed in the soil or opportunistic weed spread following primary weed treatment. Secondary weed control can be the most time consuming and expensive weed management stage. Timing of works is crucial to efficient and effective secondary weed treatment.
- Maintenance – this final stage of work is to be applied following restoration success. The amount of maintenance required depends on whether the cause of weed incursion has been or can be, effectively controlled.

Weed control is to be undertaken by professional bush regenerators who are adept in undertaking integrated weed management. The complexity of the Site and the nature and extent of degradation will require a combination of management methods. These may include the following:

- Manual hand removal
- Biological control
- Herbicide application
- Slashing, mowing
- Flame or steam weeding
- Fire
- Supplementary Planting
- Surface capping and mulching

6.4 Revegetation vs Regeneration

Bush Regeneration is the dynamic and specialised process used to restore an altered natural area to a healthy and sustainable representation of its original composition of Australian Plant Community Types (PCT). It is a complex and evolving process requiring strategic methods, precise observations and adaptive management to relieve the native plants from existing impacts, favour their growth and allow for germination of the native seed bank and spores in the soil whilst protecting habitat.

Natural bush regeneration involves controlling weeds using weed control methods. Assisted regeneration combines the natural regeneration methods with revegetation. Revegetation is the process of artificially reintroducing native plant material through a variety of methods including planting, transplanting, direct seeding, surface capping, mulching, hydromulching or brushmatting.

Best practice bush regeneration only considers revegetation in areas that have been extensively modified for a long period of time resulting in little or no native seed bank within the soil and a low likelihood of natural regeneration. The act of revegetation reintroduces native plants to provide an environment conducive to further native germination, out compete exotic weed species, create buffers on good bush interfaces and restock the native seed bank.

7. Revegetation

7.1 Propagation and Planting protocols

All plant material used for revegetation is to be locally provenant species sourced from similar Plant Community Types (PCTs) including the neighbouring BGDF. Where planting requires propagation, the material required will be propagated in Council's Community Nursery or similar. The Community Nursery has NIASA accreditation (2005-2019) and EcoHort Certification (2017-2019). There is currently Blackbutt Gully Forest (BBGF) seed stock available in the Nursery Seed Bank collected from the Bridge Road area prior to NorthConnex occupation of the site.

Planting material is to be a combination of Hiko Cells or tubestock. The optimum planting density is between five and eight plants per square metre. As planting is to reflect the existing plant communities, densities from each stratum is to reflect the mature PCTs and to consider successional plant growth.

If a situation arises where hydromulching is deemed to be the best solution for stabilising soil profiles, a mixture of sterile grasses and a native grass mix can be used prior to planting.

To assist establishment, each plant is to be planted into a pre-watered hole with water-holding crystals and slow-release fertiliser then watered in post planting.

7.2 Seed and propagule collection

7.2.1 Tree Canopy

Wherever Eucalyptus tree species are to be removed for earthworks, available ripe seed is to be taken from the crowns before the material is chipped or disposed of. This must happen on the day of felling as the seed is quickly released once sap flow is stopped.

For every 10 trees felled, seed is to be collected from at least one (10% of trees felled are then sampled).
At least three branches of seed-bearing material is to be reserved. Branches would ideally be 10cm in diameter at the cut end and be approximately 2-3 m in length. These must then have the fruit removed as soon as possible into a bag/container.

7.2.2 Mid-storey/Understorey smaller trees and shrubs

These species either have seed held within the canopy available 12 months of the year, or, they are shed annually in a short window of time and hence are only available once a year. As such, species with seed available 12 months of the year can be treated as per 7.2.1 Tree Canopy.

The other plants will need to be targeted when they have seed shed imminent. These species need to be identified and mapped in order of abundance on the Site before clearing can occur. Most of these species have seed available in autumn if they are of mesophilic origin or in November/ December if they are of sclerophylic origin. Seed for both types of plants are hand harvested from the individuals following Florabank Guidelines.

7.2.3 Ground layer

Ground layer consists of grasses, herbs and groundcovers. Many can be propagated by cloning if seed is unavailable at the time of collection. This is best undertaken in cooler months. Grasses generally shed seed over mid-summer to early autumn depending on species. They can easily be collected in volume by hand collecting. As with shrubs these species need to be identified and mapped in order of abundance on site for targeted seed collecting before clearing can occur.

Natural areas abundant in seed and propagules outside of the Impact Area and the Site is to be identified as donor sites to provide seed where critical species for PCT to be restored are missing or unavailable in the Site itself.

7.3 Revegetation timing

Timing of planting will be subject to the completion of the earthworks program. Ideally planting is to be undertaken in Autumn to enable the plants to establish prior to hot Summer weather conditions. Spring has been viewed as the next best time for planting as Winter has been deemed to be too cold and Summer too hot for new plants to establish. However, due to Sydney's recent climate exhibiting dry Spring, wet Summer and relatively warm Winter conditions, consideration can be given to altering the timing of planting and adapted to suit long term weather forecasts.

Staged and supplementary planting will be necessary to enable successional growth and assist with maintenance. Some locations will primarily be planted with fast growing canopy and shrub species representative of primary succession species (Fabaceae Family species). This will deter annual weed establishment by creating shade cover and nurture the soil for secondary succession (longer lived slower growing species).

7.4 Planting schedules

A list of suitable species currently being propagated by Council's Community nursery and suitable for both revegetation of natural and landscape areas is available (Appendix B).

7.5 Revegetation Site Preparation

7.5.1 Earthworks

Earthworks is required on the north spoil mound to stabilise the soil and provide detailed contouring to prevent erosion and reflect the adjacent environment. Earthwork planning and design is to accommodate extraction of different soil types to be stockpiled and used in soil profile engineering. The success of revegetation will depend highly on the quality of the engineered soils and early consideration of the soil properties required is highly recommended.

Once soil profiles are established, landscape features are required to assist with stabilisation and erosion control. They will also create microclimate pockets to 'kick-start' habitat creation and provide decomposition elements. These are to include but are not limited to rock boulders, natural debris and any timber required to be felled as part of the works. Landscape features are to mimic the natural environment. While random in their

location, they are to follow contours and maintain connectivity where practical. Earthworks planning and design is to include survey and stockpile areas for any material that can be used for habitat. Any machines used for earthworks must aerate soils as they exit the site to avoid risk of soil compaction.

7.5.2 Soils

As it is Council's intention to utilise the Site soils for all revegetation on site, namely the Breccia sourced from stockpiles around the Quarry void or excavated soils from the north mound, and crushed sandstone deposited in the Quarry void by NorthConnex.

The objective of the soil assessment report by SESL (2019) was with respect to examining the feasibility of, and directions to, engineering the site soils for re-establishing and supporting both BGDF and BBGF vegetation.

Testing of the two soil types available have indicated they both need a level of engineering to improve their soil chemical structure, so they can suitably support establishment of BGDF and BBGF species as part of the revegetation proposal. Specifications for soil improvement have been developed with the aim of formulating topsoils and subsoil horizons to reflect the soil profiles found at BH1 and BH4 for sandstone soil profile (BBGF) and BH14 and BH16 for breccia soil profile (BGDF) (SESL 2019).

A trial is currently underway to test recommended treatments on both soil types and their ability to support native vegetation (Figure 7.1). Results of the trial will direct soil treatment specifications for revegetation and landscaping.

Figure 7. 1 Planted Soil Trial Plots

7.6 Revegetation maintenance

Follow up watering will be required. Deep watering on a weekly basis until plant establishment is optimal (at least 6 weeks). Additional water may be required depending on weather conditions. Watering to be via a water

breaker to ensure the soil surface structure is not damaged, runoff is minimised, and water reaches the roots of the plants where it is required.

Weed management during the establishment phase will be necessary. All weeds must be treated with the aim of breaking the life cycle, i.e. prior to flowering and seeding where practically possible.

A planting schedule will be required to monitor plant survival and replacement requirements. Monitoring of plants for herbivory will indicate the necessity for protective fencing.

8. Monitoring and Reporting

Monitoring the effectiveness of implementing flora and fauna management on this Site will be necessary to ensure the aims and objectives are met. Monitoring is to be carried out on an annual basis to assess the response of the Site to restoration works, to the use of the Site as a parkland and to identify any successes or threats that may be presented. Results of monitoring will be used to plan future works as part of an adaptive management process.

8.1 Monitoring methods

8.1.1 Fauna surveys

Quantitative data is required to measure changes at the Site against baseline data over time. The data collected to date and collaborated in this report is to be supplemented with additional fauna data due to be collected again in Summer 2021. Further fauna survey effort will extend the timeframe over different seasons and include nocturnal surveys, wildlife cameras and specific fauna survey equipment. The data collected is to be analysed by an ecologist and results presented in a report.

8.1.2 Citizen Science

Robust evidence has been recorded by members of the local community to suggest a breeding pair of *Ninox strenua* Powerful Owls are currently using the Site. The evidence is scientifically being collated and monitored by Birdlife Australia through the “Powerful Owl Project” and has now been provided to the Quarry Rehabilitation Project Team.

As a keystone species, the presence of *Ninox strenua* Powerful Owls indicates the good health and function of the existing ecosystem. The Birdlife Australia monitoring program provides evidence on the health of *Ninox strenua* Powerful Owl prey, chicks and genetic transfer. Monitoring Owl movements through Citizen Science provides extremely valuable insight and direction to guide conservative and adaptive Site management. It is not surprising that the presence of the breeding pair has sparked great excitement in the Quarry Rehabilitation Project and the value of its natural area as an asset to be protected. The momentum of this excitement is to be utilised to encourage more education about the *Ninox strenua* Powerful Owl and more training of survey methods for the wider community. Even though *Ninox strenua* Powerful Owls have never been recorded as utilising a constructed nesting box, other Fauna, *including Ninox* strenua Powerful Owl prey, have been known to. It is recommended that nesting box design, construction and monitoring is incorporated into a citizen science objective (Figures 8.2 to 8.3).

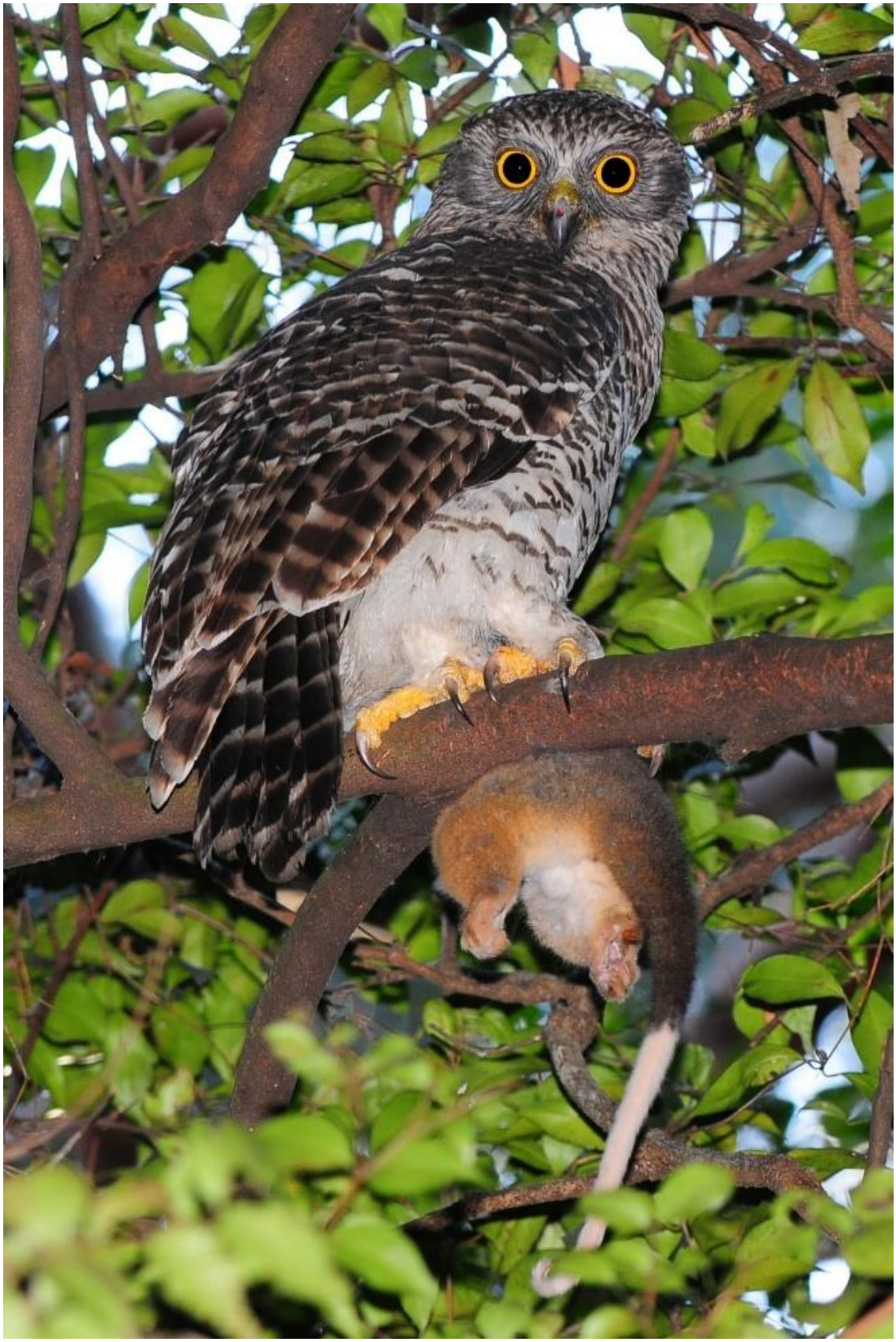

Figure 8. 1 *Ninox strenua* Powerful Owl © Birdlife Australia

Figure 8. 2 Nest box created by Denman and Murrundi Mens Shed

Figure 8. 3 Next Box created by Merriwa Mens Shed and Microbat Box

8.1.3 Rapid Data Points and Vegetation Condition

Rapid data points were collected by Kleinfelder in 2016/17 (Appendix E). The points are to be revisited at the commencement of the project and those points which will best indicate change over time are to be determined (Figure 8.4). Additional points are to be added to the current data at the commencement of the project where there is no point in the centre of a Management Zone (Figure 6.1). These points will formalise baseline data that can be used to monitor and compare the percentage of canopy cover, native understorey cover and exotic species in each Management Zone. The results will also provide information to support the preparation of ongoing vegetation condition mapping using The National Trust of Australia (NSW) bushland condition methodology (2.6.2) and compare the condition to the baseline results and map in this report (Figure 2.14).

8.1.4 Photo monitoring points

Photo monitoring points are to be set up at the project commencement. There is no restriction to the amount of photo points however there must be at least one with each rapid data point. A photo point is to be indicated with a painted survey peg or yellow star picket and labelled 'Photo Point No. x'. The focal points are to be a labelled yellow star picket or similar and positioned a suitable distance from the photo point to capture the surrounding landscape. As a rule, the preferred distance is 10 metres but this can vary depending upon the topography and density of the weed plume. An additional reference point such as a tree, rock or feature in the distance is useful. All photo points to be GPS referenced with a bearing to the focal point. Photographs are to be taken from the photo point with a digital camera on an annual basis, preferably at the same time of day and with cloud cover to eliminate dappled light. Each photograph is to be labelled with the photo point number, date taken and a description of the vegetation present.

8.1.5 Revegetation monitoring

All revegetation is to be documented with a map showing the location of the area planted and the number and species of plants installed. It will be necessary to evaluate, identify and mitigate fatality causes where practical prior to installing replacement plants.

8.1.6 Tree register

An annual tree register is to be prepared supplementing Council's current tree data. The register is to record numbers of tree failures, deaths and management requirements. Ongoing monitoring will be a valuable tool in monitoring tree health and canopy connectivity as part of adaptive management strategies.

8.2 Reporting

Bush regeneration is to be undertaken on a regular basis to achieve aims and address performance criteria (Appendix F). All work is to be reported following each work session. Information required to include: date and time worked, area covered, type of work, treatment, major weeds targeted, fauna observed, site or work constraints, incidents and recommendations, and a map of work location.

An annual report is to be prepared to present a consolidation of monitoring results and the works undertaken. The report is to also address the items in the performance criteria, with a description of successes or failures and short- and long-term recommendations for future works (Appendix F).

The management actions are to be reviewed after five years. Any changes to be presented and justified on a case by case basis for approval by Council's Offset representative in the Natural Resources Branch.

8.2.1 Performance criteria

The role of vegetation management in the creation and enhancement of habitat has formed the basis of this document. Its success will depend on works addressing the performance criteria. Specifications have been summarised in Appendix A and monitoring works will be assessed against the performance criteria and timing of work specifications in Appendix F.

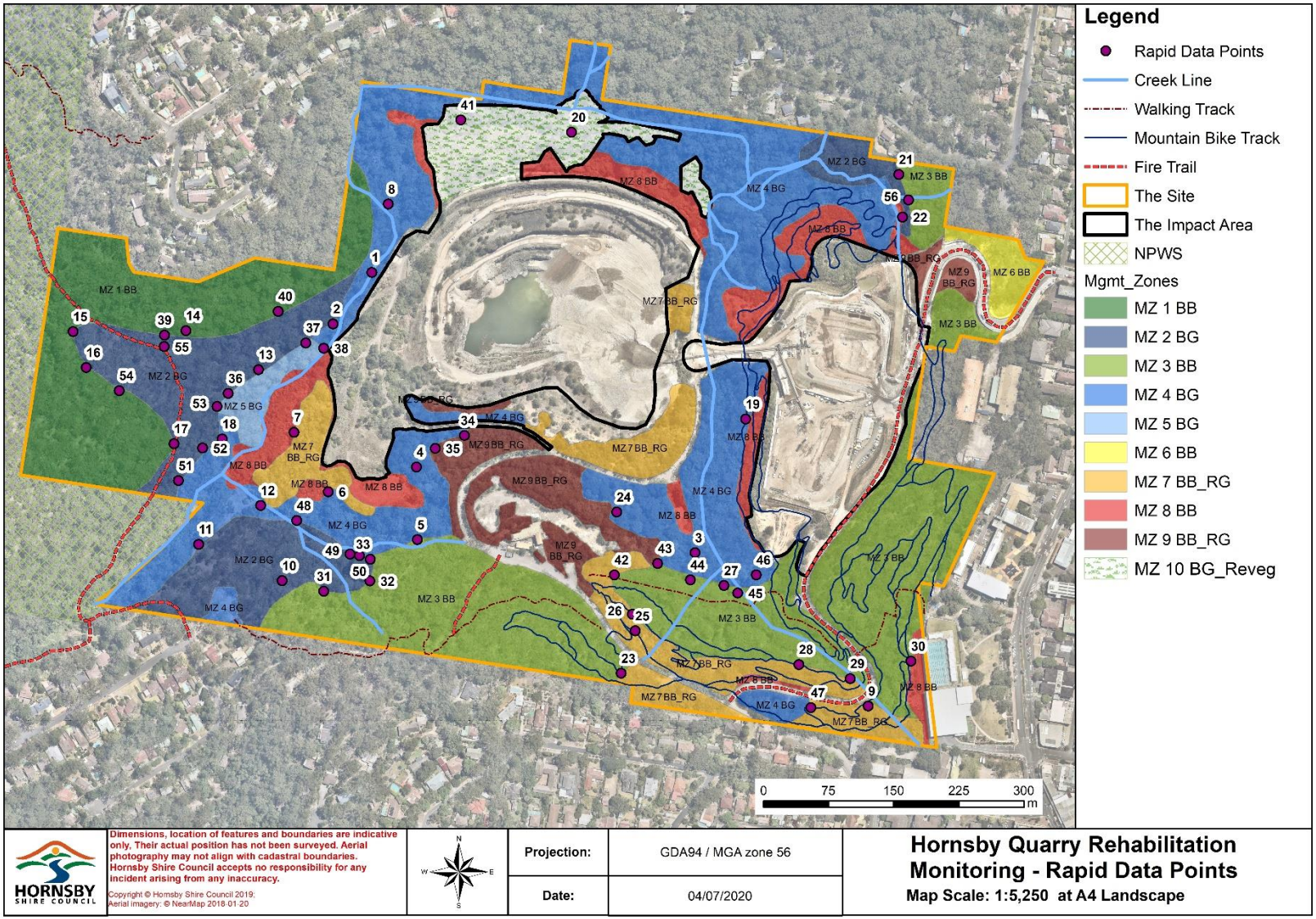

Figure 8. 4 Rapid Data Point Locations

9. Implementation

The responsibility for the implementation of this VMP and HCEP will be upon Hornsby Shire Council. The Natural Resources Branch must be assigned to the management of bushland areas. All project management meetings and decisions must be inclusive of the assigned project manager. It must be noted, activities can directly or indirectly impact the surrounding bushland, in this regard the precautionary principle must be applied.

Any weed management must be undertaken by suitably qualified and experienced bush regenerators with a TAFE Certificate IV in Conservation and Land Management or similar. All works must comply with best practice bush regeneration techniques within an adaptive management program (Buchanan 2009).

10. Summary and Recommendations

Hornsby Park is to be developed as a parkland which supports recreational pursuits and prioritises conservation of its natural areas. To obtain such conservation and recreation objectives, priority is to be given to managing impacts on the natural area from the threatening process of fragmentation, edge effects and loss of habitat. This can be achieved by increasing areas of core native vegetation, connectivity and appropriate access as discussed. The final detail on management actions for the Site are to be developed in accordance with the principles of this VMP and HCEP and recommendations are as follows:

- the discussion of the Key Threatening Processes must serve to inform the prioritised avoidance, modification or mitigation of these processes and associated impacts on site in all activities including future planning
- the *Ninox strenua* Powerful Owl is known to be highly sensitive to disturbance and strong consideration must be given to the life cycle of this Keystone Species in planning works and bushland access. Refer to Birds Australia for Citizen Science data (Figure 4.2)
- prepare an ongoing fauna monitoring program incorporating increased spatial and temporal sampling to enhance the current fauna baseline data and fauna representation across the site and adjacent areas.
- survey open rocky areas to the north and south of the quarry for fauna to assist future management recommendations
- retain canopy and understory vegetation cover as an important aspect in maintaining a mesic microclimate (Paris 2002) with the additional benefits of ground debris for refuge and shelter from predation (Ferraro and Burgin 1993)
- consider seasonal timing and sequencing of mosaic removal of weeds and replacement via regeneration or revegetation with native trees to maintain canopy connectivity and the current mesic microclimate of riparian wildlife corridor (Figure 2.15)
- a precautionary approach is to be taken in all vegetation clearing so as not to directly harm fauna
- avoid the removal of hollow bearing trees
- any tracks are preferably limited and well maintained, canopy connection retained above tracks, recommended buffer distances maintained from sensitive areas, and creek crossings be limited maintained and fixed
- all accessible access tracks be designed wherever possible to mitigate noise likely to deter wildlife

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Appendix A: Management Actions per Zone

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
MZ 1	BBGF	Good	Western Boundary	Intact	<5%	High	Minimal disturbance	1.1	Monitor for bird, wind and water dispersed weeds biannually. Treat any incursions to ensure zone is weed free.
							Fire trail	1.2	Monitor track for evidence of erosion and track side weeds. Treat any incursions to ensure zone is weed free. Stabilise any erosion.
							Residential boundaries	1.3	Monitor boundaries for encroachment, garden escapes, dumping. Treat any incursions on boundaries and communicate with residents to prevent further activity.
							Sewer easement	1.4	Monitor sewer easement for system failures. Liaise with Sydney Water should system failures occurs to ensure best practice remediation around vegetation.
MZ 2	BGDF	Good	MZ2.1 Western Boundary	Intact	<5%	High	Some disturbance	2.1	Monitor for bird, wind and water dispersed weeds biannually. Treat any incursions to maintain high quality native vegetation representation.
							Fire trail	2.2	Monitor track for evidence of erosion and track side weeds. Treat any incursions and stabilise any identified erosion.
							Sewer easement	2.3	Monitor sewer easement for system failures. Liaise with Sydney Water should system failures occur to ensure best practice remediation around vegetation.
							Impact Area	2.4	Monitor buffer adjacent to MZ4 for unforeseen vegetation damage and undertake best practice vegetation remediation if damage is identified.
			MZ 2.2 Southern Boundary	Intact	<5%	High	Riparianwildlife corridor	2.5	Monitor for bird, wind and water dispersed weeds: monitor for erosion. Treat weeds and stabilise erosion if identified.
							Walking track	2.6	Monitor track for evidence of erosion and track side weeds. Treat weeds and stabilise erosion if identified.
							Sewer easement	2.7	Monitor sewer easement for system failures. Liaise with Sydney Water should system failures occur to ensure best practice remediation around vegetation.
			MZ 2.3 North-Eastern Bndry	Intact	<5%	High	Creek wildlife corridor	2.8	Monitor for bird, wind and water dispersed weeds: monitor for erosion. Treat weeds and stabilise erosion if identified.
							Steep slope	2.9	Monitor for erosion. Stabilise slope if erosion identified.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
							Residential boundaries	2.10	Monitor boundaries for encroachment, garden escapes, dumping. Treat any incursions on boundaries and communicate with residents to prevent further activity.
MZ 3	**BBGF**	**Fair**	Eastern and Southern Boundaries	Disturbed	20%	Mod-Low	Moderate disturbance	3.1	Monitor for bird, wind and water dispersed weeds in actively growing months and treat incursions with best practice bush regeneration techniques.
							Weed encroachment	3.2	Maintain edges to prevent encroachment of weeds from neighbouring zones and protect zone core.
							Mountain bike track Walking track Fire trail	3.3	Reinstate representation of all strata levels with species from BBGF PCT.
								3.4	Regulate and remediate track erosion, widening and any illegal work. Undertake measures to prevent future damage.
								3.5	Record senescing tree, tree repair and tree removal to establish a canopy replacement strategy.
								3.6	Retain all dead timber and rocks for habitat.
							Riparian wildlife corridor	3.7	Monitor creek line for weeds, erosion and rubbish.
							Impact area	3.8	Revegetate to create a dense vegetation buffer to Impact Area.
MZ 4	**BGDF**	**Fair**	Centre of the Site including the Impact Area interface	Disturbed	20%	Mod-Low	Moderate disturbance	4.1	Monitor for bird, wind and water dispersed weeds in actively growing months and treat incursions with best practice bush regeneration techniques.
							Weed encroachment	4.2	Maintain edges to prevent encroachment of weeds from neighbouring zones and protect zone core.
							Historic clearing and weed species dominating mid storey	4.3	Establish strategic mosaic mid storey weed removal. Consider existing canopy, evidence of native species present in any strata and the value of weeds as habitat.
								4.4	Allow vegetation structure to be reinstated prior to connecting cleared mosaic areas with further weed removal.
								4.6	Assist regeneration with revegetation in areas exhibiting low resilience using species representing all strata levels from BGDF PCT.
							Riparian wildlife corridor	4.7	Maintain habitat value of weeds along the riparian corridors of the creek line.
								4.8	Establish mesophilic native species amongst weed plumes as replacement habitat prior to weed removal.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
								4.9	Monitor creek line for weeds, erosion and rubbish.
							Steep slope	4.10	Prevent erosion with the retention of structural elements (dead timber and rocks) and strategic weed removal.
							Mountain bike track	4.11	Regulate and remediate track erosion, widening and any illegal work. Undertake measures to prevent future damage.
								4.12	Record senescing trees, tree repair and/or tree removal to establish a canopy replacement strategy.
								4.13	Retain all dead timber and rocks for habitat.
							Impact Area	4.14	Revegetation to repair any damage by machines on their approach to the knoll during stabilisation work is to be a priority. It is highly likely that immediate supplementary planting within bushland north of the north mound will be necessary to re-establish mesic corridor as quickly as possible.
								4.14	Maintain all vegetation directly adjacent to impact area in buffer regardless of species until construction works have been completed. Suppressing and containing climbers may be preferred over eradication depending on location, species and adjacent bushland condition.
							Nesting Box Plan	4.15	Install nesting boxes as per Table 4.1 Nesting Box Recommendations for Targeted Fauna and Management Objectives. Ensure monitoring and maintenance of nest boxes occurs as per 4.2.4 Nest Box Monitoring and Maintenance specifications
MZ 5	**BGDF**	**Good**	Western Riparian Coridor	Modified	20%	High	Moderate disturbance	5.1	Monitor for bird, wind and water dispersed weeds in actively growing months.
							Weeds dominate mid storey	5.2	Establish strategic mosaic mid storey weed removal. Consider existing canopy, evidence of native species present in any strata and the value of weeds as habitat.
								5.3	Allow vegetation structure to be reinstated prior to connecting cleared mosaic areas with further weed removal.
								5.4	Assist regeneration with revegetation in areas exhibiting low resilience using species representing all strata levels from BGDF PCT.
							Riparian corridor and drainage channel	5.5	Maintain habitat value of weeds along the riparian corridors of the creek line.
								5.6	Establish mesophilic native species amongst weed plumes as replacement habitat prior to weed removal.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
								5.7	Monitor creek line for weeds, erosion and rubbish.
							Impact Area	5.8	Maintain all vegetation directly adjacent to impact area in buffer regardless of species until construction works have been completed.
							Nesting Box Plan	5.9	Install nesting boxes as per Table 4.1 Nesting Box Recommendations for Targeted Fauna and Management Objectives. Ensure monitoring and maintenance of nest boxes occurs as per 4.2.4 Nest Box Monitoring and Maintenance specifications
MZ 6	**BBGF**	**Poor**	North East Corner - Bridge Street	Disturbed	50%	Low	Vegetation clearing Road construction	6.1	Treat weed species.
								6.2	Revegetate with species from all strata levels of BBGF PCT.
MZ 7	**BBGF**	**Poor**	MZ 7.1 South West Mound	Scree	50%	Low	Highly modified soils Regrowth from mining period	7.1	Establish strategic mosaic midstorey weed removal within the core - concentrate on existing canopy, evidence of any native species present and value of weeds as habitat.
								7.2	Allow vegetation structure to be reinstated prior to connecting mosaic areas or clearing weeds from interface with further weed removal.
								7.3	Revegetate with species from all strata levels of BGDF PCT.
							Impact Area	7.4	Enhance buffer on Impact Area interface by installing shrub species from BBGG and BGDF PCTs amongst existing weed species.
							Nesting Box Plan	7.5	Install nesting boxes as per Table 4.1 Nesting Box Recommendations for Targeted Fauna and Management Objectives. Ensure monitoring and maintenance of nest boxes occurs as per 4.2.4 Nest Box Monitoring and Maintenance specifications
			MZ 7.2 Quarry Road verge	Disturbed	60%	Low	Weed encroachment/fill from road and housing development	7.5	Prevent spread of weeds into MZ 3.
								7.6	Treat weeds and revegetate in low resilient areas.
								7.7	Retain weeds as a buffer from road verge until revegetation within the Zone establishes and is stabilised.
							Riparian corridor and drainage channel	7.8	Maintain habitat value of weeds along the riparian corridors of the creek line.
								7.9	Establish mesophilic native species amongst weed plumes as replacement habitat prior to weed removal.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
								7.10	Monitor creek line for weeds, erosion and rubbish.
			MZ 7.3 Quarry walls - South east	Disturbed	30%	Low	Excavation	7.11	Manage vegetation with respect to quarry wall stability and safety.
								7.12	Replace any necessary vegetation removal with revegetation using low growing or shrub species from BBGF or BGDF PCTs that exhibit a dense fibrous root system and a thick foliage cover (see planting schedule Appendix B).
								7.13	Treat weed species with the aim to prevent spread of weed propagules.
MZ 8	**BBGF**	**Very Poor**	MZ 8.1 South West Mound	Scree	>61%	Low	Highly modified soils Regrowth from mining period	8.1	Establish and maintain buffer on the MZ 5 edge and the Impact Area interface.
								8.2	Maintain habitat value of weeds along the riparian corridors of the creek line.
								8.3	Revegetate with species from all strata levels of BGDF PCT.
							Riparian corridor and drainage channel	8.4	Maintain habitat value of weeds along the riparian corridors of the creek line.
								8.5	Establish mesophilic native species amongst weed plumes as replacement habitat prior to weed removal.
								8.6	Monitor creek line for weeds, erosion and rubbish.
							Impact Area	8.7	Create a buffer with revegetation where none exists. Supplement vegetation with shrub species where canopy is present.
			MZ 8.2 North Mound - North West Strip and rock shelf on south edge	Scree	>61%	Low-Mod	Highly modified soils on a steep slope with midstorey weedy regrowth	8.8	Maintain a buffer on the Impact Area interface until MZ 10 revegetation is established and able to provide buffer to edge effects and habitat.
								8.9	Enhance buffer with revegetation incorporating species from all strata levels BGDF PCT once MZ 10 revegetation is established. Establish strategic mosaic midstorey weed removal. Focus on maintaining vegetative structure and value of weeds as habitat.
								8.10	Maintain buffer to upslope vegetation until revegetation following earthworks has established. Treat priority weeds (Table 2.5).
			MZ 8.3 North of Old Mans Valley	Disturbed	>61%	Low-Mod	Highly modified soils	8.11	Establish a buffer on the Impact Area interface and connectivity with MZ 4, through weed treatment and revegetation using representatives from all strata levels of BGDF PCT.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
								8.12	Treat weed species with the aim to maintain soil cover but to prevent the spread of weed propagules.
			MZ 8.4 West of Old Mans Valley	Disturbed	>61%	Low-Mod	Highly modified soils	8.13	Enhance buffer with revegetation incorporating species from all strata levels BGDF PCT. Establish strategic mosaic midstorey weed removal. Focus on maintaining vegetative structure and value of weeds as habitat and protection for MZ4.
			MZ 8.5 Below pool and Quarry Road entrance	Disturbed	>61%	Low-Mod	Fill from pool development	8.14	Establish a buffer on the pool interface and connectivity with MZ 3 by revegetating with nutrient and moisture tolerant species from BBGF PCT.
							Fire trail entrance	8.15	Revegetate edge to fire trail. Use the opportunity to improve aesthetics of entrance.
							Mountain bike track	8.16	Regulate track erosion, widening and illegal work.
								8.17	Record senescing tree, tree repair and tree removal to establish a canopy replacement strategy.
								8.18	Retain all dead timber and rocks for habitat.
			All Zone				Nesting Box Plan	8.19	Install nesting boxes as per Table 4.1 Nesting Box Recommendations for Targeted Fauna and Management Objectives. Ensure monitoring and maintenance of nest boxes occurs as per 4.2.4 Nest Box Monitoring and Maintenance specifications
MZ 9	**BBGF**	**Very Poor**	MZ 9.1 Below Crusher Plant	Scree	>61%	Very Low	Vegetation clearing Highly modified soils Regrowth from mining	9.1	Geotechnical advice required prior to improving soils and revegetating with BGDF PCT species.
			MZ 9.2 Bridge Road	Imported	>61%	Nil	Vegetation clearing Road construction Inappropriate imported soils	9.2	Improve soils as per specifications from current soil trials.
								9.3	Prevent erosion, provide erosion control and habitat with structural elements such as timber logs and rocks. Size of each can vary from small to large.
								9.4	Revegetate with all strata levels of BBGF.

Mgmt Zone	PCT	Condition	Location	Soil	Weed %	Resilience	Management Issue	Action	Management Actions
			All Zone				Nest Box Plan	9.5	Install nesting boxes as per Table 4.1 Nesting Box Recommendations for Targeted Fauna and Management Objectives. Ensure monitoring and maintenance of nest boxes occurs as per 4.2.4 Nest Box Monitoring and Maintenance specifications
MZ 10	**BGDF**	**Very Poor**	North Mound Impact Area	Scree Disturbed	>61%	Very Low	Vegetation clearing Highly modified soils Regrowth from mining	10.1	Reshape mound based on current geotechnical advice.
								10.2	Improve soils as per specifications from current soil trial.
								10.3	Prevent erosion and create habitat with structural elements salvaged from earthworks.
								10.4	Revegetate mesic corridor with primary successional species, both fast growing shrub and canopy layer species, and mesophilic species tolerant of high levels of light/ heat and low levels of available moisture.
								10.5	Revegetate whole area with all strata levels of BGDF PCT.
MZ 11	**BGDF and BBGF**		Landscaping	Improved			Earthworks	11.1	Planting schedules for landscaped areas are to compliment the surrounding plant communities by utilising plant species representative of BGDF and BBGF PCTs and suitable to landscaping.
Whole site								12.1	Target climbers and *Cortaderia selloana*.
Whole site	Feral Animal Management							12.2	Feral animal numbers are managed as part of Council's Biosecurity Pest Management Strategy when significant feral animal observations occur through anecdotal evidence, nest box monitoring or fauna surveys.

Appendix B: Planting Schedule

		Plant Community Type		Suitablity					Habitat		
Botanical Name	**Common Name**	**BGDF**	**BBGF**	**Mesophyllic**	**Primary**	**Long Lived**	**Landscaping**	**Stability**	**Shelter**	**Foraging**	**Breeding**
TREES											
Acmena smithii	Common Lilly Pilly	x	x	x					x	x	
Allocasuarina littoralis	Black Sheoak		x		x				x	x	
Allocasuarina torulosa	Forest Oak	x	x			x			x	x	
Angophora costata	Sydney Red Gum	x	x			x			x	x	x
Angophora floribunda	Rough-barked Apple	x	x			x			x	x	x
Backhousia myrtifolia	Grey Myrtle	x	x	x					x	x	
Ceratopetalum apetalum	Coachwood	x	x	x		x			x	x	x
Doryphora sassafras	Sassafras	x		x					x	x	x
Elaeocarpus reticulatus	Blueberry Ash	x	x	x	x				x	x	
Eucalyptus pilularis	Blackbutt	x	x	x		x			x	x	x
Eucalyptus resinifera	Red Mahogany	x	x			x			x	x	x
Eucalyptus saligna	Blue Gum	x	x	x		x			x	x	x
Ficus coronata	Sandpaper	x	x	x		x			x	x	x
Ficus rubiginosa	Rusty Fig or Port Jackson Fig		x	x		x			x	x	
Glochidion ferdinandi	Cheese Tree	x	x	x	x				x	x	
Syncarpia glomulifera	Turpentine Tree	x	x			x			x	x	x
Tristaniopsis laurina	Water Gum	x	x	x					x	x	
SHRUBS											
Acacia floribunda	Gossamer Wattle	x	x				x			x	
Acacia implexa	Hickory Wattle	x	x							x	
Acacia linifolia	White Wattle	x	x				x			x	
Acacia longifolia subsp. longifolia	Sydney Golden Wattle	x	x				x			x	
Acacia longissima	Long-leaf Wattle	x	x							x	
Acacia myrtifolia	Myrtle Wattle	x	x							x	
Acacia stricta	Straight Wattle, Hop Wattle	x	x							x	
Acacia terminalis	Sunshine Wattle	x	x				x			x	
Acacia ulicifolia	Prickly Moses	x	x						x	x	
Banksia serrata	Old Mans Banksia	x	x			x	x		x	x	
Banksia spinulosa	Hairpin Banksia	x	x				x			x	
Breynia oblongifolia	Coffee Bush	x	x		x					x	
Bursaria spinosa	Blackthorn, Sweet Bursaria	x	x						x		
Callicoma serratifolia	Black Wattle	x		x							
Ceratopetalum gummiferum	NSW Christmas Bush	x	x				x				
Daviesia ulicifolia	Gorse Bitter Pea	x	x								
Dodonaea triquetra	Large-leaf hop-bush	x	x		x		x			x	
Eupomatia laurina	Native Guava	x							x	x	
Grevillea linearifolia	Linear-leaf Grevillea	x	x				x			x	

		Plant Community Type		Suitablity					Habitat		
Botanical Name	**Common Name**	**BGDF**	**BBGF**	**Mesophyllic**	**Primary**	**Long Lived**	**Landscaping**	**Stability**	**Shelter**	**Foraging**	**Breeding**
Leptospermum polygalifolium	Tantoon, Jellybush	x	x				x		x		
Leptospermum trinervium	Flaky-barked Tea-tree	x	x				x		x		
Leucopogon lanceolatus	Lance-leaved Beard Heath	x	x				x			x	
Myrsine howittiana	Brush Muttonwood	x		x		x			x	x	
Ozothamnus diosmifolius	Rice Flower	x	x				x				
Persoonia laurina	Laurel Geebung	x	x							x	
Pittosporum revolutum	Rough Fruit Pittosporum	x	x				x			x	
Platylobium formosum	Handsome Flat Pea	x	x				x			x	
Pultenaea flexilis	Graceful Bush-pea	x	x	x			x			x	
Pultenaea retusa	Notched bush-pea	x	x							x	
Synoum glandulosum	Scentless Rosewood	x	x	x		x			x	x	
Trema tomentosa var. aspera	Native Peach	x	x		x		x			x	
Trochocarpia laurina	Tree Heath	x	x			x			x	x	
Zieria smithii	Smithian Zieria	x	x				x				
GROUND COVERS											
Adiantum aethiopicum	Common Maidenhair	x	x				x				
Calochlaena dubia	Rainbow Fern	x	x		x				x		
Coronidium elatum subsp. Elatum	White Paper Daisy	x	x								
Coronidium scorpioides	Button Everlasting	x	x								
Dichondra repens	Kidney Weed	x	x		x		x				
Pterostylis curta	Blunt Greenhood Orchid	x	x								
Viola hederacea	Native Violet	x	x				x				
VINES											
Billarderia scandens	Apple Berry	x	x							x	
Clematis glycinoides	Headache Vine	x	x								
Eustrephus latifolius	Wombat Berry	x	x							x	
Gynochthodes jasminoides	Sweet Morinda	x	x							x	
Hardenbergia violacea	Purple Coral Pea	x	x				x				
Hibbertia dentata	Toothed Guinea Flower	x	x				x				
Hibbertia scandens	Golden Guinea Vine	x	x				x				
Pandorea pandorana	Wonga Wonga Vine	x	x				x			x	
Tylophora barbata	Bearded Tylophora	x	x								
GRASSES											
Cymbopogon refractus	Barbed Wire Grass	x	x				x	x		x	
Dichelachne rara		x	x							x	
Echinopogon ovatus	Forest Hedgehog/Echidna grass	x	x							x	
Entolasia marginata	Bordered Panic	x	x							x	

		Plant Community Type		Suitablity					Habitat		
Botanical Name	**Common Name**	**BGDF**	**BBGF**	**Mesophyllic**	**Primary**	**Long Lived**	**Landscaping**	**Stability**	**Shelter**	**Foraging**	**Breeding**
Entolasia stricta	Wiry Panic	x	x							x	
Imperata cylindrica	Blady Grass	x	x		x			x	x	x	
Microlaena stipoides	Weeping Rice Grass	x	x		x		x			x	
Poa affinis	Poa	x	x				x			x	
Rytidosperma tenuius	Wallaby Grass	x	x							x	
Themeda triandra	Kangaroo Grass	x	x				x	x	x	x	
RUSHES/SEDGES/LILIES											
Arthropodium milleflorum	Pale Vanilla-Lily	x	x								
Dianella caerulea	Blue Flax-Lily	x	x				x	x	x	x	
Gahnia spp.	Saw Sedge	x	x				x	x	x	x	
Juncus usitatus	Common Rush	x	x		x			x	x	x	
Lomandra longifolia	Spiny-headed Mat-rush	x	x		x			x	x	x	
Lomandra multiflora	Many-flowered Mat-rush	x	x								

Appendix C: Native Species List

Native Species List	
Trees	**Shrub**
Angophora costata	*Banksia spinulosa*
Angophora floribunda	*Boronia ledifolia*
Casuarina cunninghamiana	*Bossiaea ensata*
Corymbia gummifera	*Bossiaea obcordata*
Corymbia maculata	*Breynia oblongifolia*
Eucalyptus pilularis	*Dillwynia retorta*
Eucalyptus piperita	*Epacris pulchella*
Eucalyptus saligna	*Gompholobium latifolium*
Syncarpia glomulifera	*Hakea sericea*
	Hibbertia bracteata
Small Trees	*Hovea linearis*
Allocasuarina littoralis	*Lambertia formosa*
Banksia serrata	*Micrantheum ericoides*
Callicoma serratifolia	*Persoonia linearis*
Callistemon salignus	*Pittosporum revolutum*
Clerodendrum tomentosum	*Platysace linearifolia*
Elaeocarpus reticulatus	*Polyscias sambucifolia*
Pittosporum undulatum	*Pultenaea retusa*
	Pultenaea villosa
Ferns	
Blechnum ambiguum	
Blechnum cartilagineum	**Sedge**
Calochlaena dubia	*Cyperus sp*
Cheilanthes sieberi subsp. sieberi	*Gahnia aspera*
Cyathea australis	*Gahnia erythrocarpa*
Doodia caudata	*Gahnia sieberiana*
Pellaea falcata	*Gahnia sp.*
Pteridium esculentum	*Juncus usitatus*
Selaginella uliginosa	*Lepidosperma filiforme*
	Lepidosperma laterale

Native Species List	
Grass/Ground Covers	**Climbers**
Aristida pubescens	*Billardiera scandens*
Aristida vagans	*Clematis aristata*
Cynodon dactylon	*Clematis glycinoides*
Dianella caerulea	*Eustrephus latifolius*
Dianella prunina	*Geitonoplesium cymosum*
Dichelachne micrantha	*Hibbertia dentata*
Dichondra repens	*Hibbertia scandens*
Echinopogon caespitosus	*Marsdenia sp*
Entolasia marginata	*Morinda jasminoides*
Entolasia stricta	*Pandorea pandorana*
Gonocarpus teucrioides	*Passiflora herbertiana*
Goodenia heterophylla subspeglandulosa	*Sarcopetalum harveyanum*
Imperata cylindrica	*Smilax australis*
Lepidosperma laterale	*Smilax glyciphylla*
Lomandra filiformis subsp *filiformis*	*Stephania japonica*
Lomandra glauca	
Lomandra gracilis	**Orchids**
Lomandra longifolia	*Cryptostylis erecta*
Lomandra multiflora subsp. multiflora	*Dipodium punctatum*
Lomandra obliqua	*Dipodium sp.*
Microlaena stipoides	
Opercularia diphylla	
Oplismenus aemulus	
Oxalis perennans	
Panicum simile	
Poa affinis	
Poranthera microphylla	
Pratia purpurascens	
Pseuderanthemum variabile	
Themeda australis	
Vernonia cinerea	
Veronica plebia	
Xanthorrhoea arborea	
Xanthorrhoea media	
Xanthosia tridentata	

Appendix D: Fauna Survey Results

Fauna Group	Common Name	*Scientific Name*	Exotic	BC Act	EPBC Act	Gecko/Future Ecology (2020)	GHD	Eco Aus	PB	Aquilla(2011)	Kleinfelder
Birds	Australian Brush-turkey	*Alectura lathami*				*O*	*O*	*O*			
Birds	Australian King-Parrot	*Alisterus scapularis*				*W*	*W*	*O*	*O*		
Birds	Australian Magpie	*Cracticus tibicen*				*W*	*W*	*O*	*O*		
Birds	Australian Raven	*Corvus coronoides*				*W*		*O*	*O*		
Birds	Bellbird	*Manorina melanophrys*				*W*		*W*			
Birds	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*					*O*	*O*	*O*		
Birds	Brown Gerygone	*Gerygone mouki*				*W*	*W,E*				
Birds	Brown Thornbill	*Acanthiza pusilla*				*O,W*			*O*		
Birds	Buff-rumped Thornbill	*Acanthiza reguloides*							*O*		
Birds	Channel-billed Cuckoo	*Scythrops novaehollandiae*					*O*	*O*			
Birds	Crimson Rosella	*Platycercus elegans*							*0*		
Birds	Dollar Bird	*Eurystomus orientalis*					*O*				
Birds	Double-barred Finch	*Taeniopygia bichenovii*				*W*					
Birds	Eastern Rosella	*Platycercus eximius*							*O*		
Birds	Eastern Spinebill	*Acanthorhynchus tenuirostris*				*W*	*0*				
Birds	Eastern Whipbird	*Psophodes olivaceus*				*W*			*0*		
Birds	Eastern Yellow Robin	*Eopsaltria australis*				*O*	*O*		*O*		
Birds	Fan-tailed Cuckoo	*Cacomantis flabelliformis*					*W*				
Birds	Galah	*Eolophus roseicapilla*							*O*		
Birds	Golden Whistler	*Pachycephala pectoralis*				*W*	*W*		*O*		
Birds	Grey Butcherbird	*Cracticus torquatus*						*W*			
Birds	Grey Fantail	*Rhipidura fuliginosa*				*W*	*O*		*O*		
Birds	Grey Shrike-thrush	*Colluricincla harmonica*					*0*				
Birds	Jacky Winter	*Microeca fascinans*							*O*		
Birds	Laughing Kookaburra	*Dacelo novaeguineae*				*O*	*O*	*W*	*O*		
Birds	Lewins Honeyeater	*Meliphaga lewinii*				*W*	*O*				
Birds	Little Corella	*Cacatua sanguinea*					*O*				
Birds	Magpie-lark	*Grallina cyanoleuca*							*O*		
Birds	Noisy Friarbird	*Philemon corniculatus*							*O*		
Birds	Noisy Miner	*Manorina melanocephala*					*O*		*O*		
Birds	Pacific Black Duck	*Anas superciliosa*				*O*	*O*	*O*			

Fauna Group	Common Name	*Scientific Name*	Exotic	BC Act	EPBC Act	Gecko/Future Ecology (2020)	GHD	Eco Aus	PB	Aquilla(2011)	Kleinfelder
Birds	Pied Butcherbird	*Cracticus nigrogularis*				*w*					
Birds	Pied Currawong	*Strepera graculina*				*w*		*w*			
Birds	**Powerful Owl**	***Ninox strenua***		***v***		*o*		*H*			*o*
Birds	Rainbow Lorikeet	*Trichoglossus haematodus*				*w*	*w*		*o*		
Birds	Red Wattlebird	*Anthochaera carunculata*				*w*	*o*		*o*		
Birds	Red-browed Firetail	*Neochmia temporalis*				*o,w*			*o*		
Birds	Red-whiskered Bulbul*	*Pycnonotus jocosus**	*				*o*		*o*		
Birds	Sacred Kingfisher	*Todiramphus sanctus*					*o*				
Birds	Scarlet Honeyeater	*Myzomela sanguinolenta*				*w*	*o*				
Birds	Silvereye	*Zosterops lateralis*				*o*			*o*		
Birds	Southern Boobook Owl	*Ninox novaeseelandiae*					*o,w*		*o*		
Birds	Spotted Pardalote	*Pardalotus punctatus*				*w*					
Birds	Striated Thornbill	*Acanthiza lineata*				*w*	*o*				
Birds	Sulphur-crested Cockatoo	*Cacatua galerita*				*w*	*o*		*o*		
Birds	Superb Fairy-wren	*Malurus cyaneus*					*o*	*o*			
Birds	**Varied Sitella**	***Daphoenositta chrysoptera***		***v***						***o***	
Birds	Variegated Fairy-wren	*Malurus lamberti*				*o,w*	*o*			*o*	
Birds	Welcome Swallow	*Hirundo neoxena*								*o*	
Birds	White-browed Scrubwren	*Sericornis frontalis*				*o,w*	*o*				
Birds	White-throated Gerygone	*Gerygone olivacea*							*o*		
Birds	White-throated Treecreeper	*Cormobates leucophaea*				*o*					
Birds	Wonga Pigeon	*Leucosarcia picata*					*w*				
Birds	Yellow Thornbill	*Acanthiza nana*							*o*		
Birds	Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*				*w*					
Birds	Yellow-throated Scrubwren	*Sericornis citreogularis*				*o,w*					
Frogs	Common Eastern Froglet	*Crinia signifera*				*w*	*w*		*o*		
Frogs	Dusky Toadlet	*Uperoleia fusca*				*w*					
Frogs	Peron's Tree Frog	*Litoria peronii*					*w*				
Mammals	Brown Antechinus	*Antechinus stuartii*							*o*		
Mammals	Brush-tailed Possum	*Trichosurus vulpecula*							*o*		
Mammals	Bush Rat	*Rattus fuscipes*							*o*		
Mammals	Common Ringtail Possum	*Pseudocheirus peregrinus*				*o*	*0*		*0*		

Fauna Group	Common Name	*Scientific Name*	Exotic	BC Act	EPBC Act	Gecko/Future Ecology (2020)	GHD	Eco Aus	PB	Aquilla(2011)	Kleinfelder
Mammals	**Eastern Bentwing-bat**	***Miniopterus orianae oceanensis***		***v***			***U***				
Mammals	Forest Bat	*Vespadelus sp.*	*				*U*				
Mammals	Fox*	*Vulpes vulpes**				*P*	*O,P*				
Mammals	Gould's Wattled Bat	*Chalinolobus gouldii*						*U*			
Mammals	**Grey-headed Flying-fox**	***Pteropus poliocephalus***		***v***					***O***		
Mammals	Little Forest Bat	*Vespadelus vulturnus*						*U*			
Mammals	Short-beaked Echidna	*Tachyglossus aculeatus*					*F,X*				
Mammals	Swamp Wallaby	*Wallabia bicolor*				*O*	*O*	*O*	*O*		
Mammals	White-striped Freetail Bat	*Tadarida (Austronomus) australis*						*U*			
Reptiles	Dark-flecked Garden Sunskink	*Lampropholis delicata*					*O*				
Reptiles	Eastern Water Dragon	*Physignathus lesueurii*				*O*		*O*	*O*		
Reptiles	Red-bellied Black Snake	*Pseudechis porphyriacus*						*O*			
Birds	Richard's Pipit	*Anthus novaeseelandiae*							*O*		

Key

Bold and v – Vulnerable

Observation codes

E - nest

F – tracks/traces

H – feathers

L – possible identification from anabat recording

O – observed

P – scats

U – anabat recording

W – heard

X – in scat

Appendix E: Rapid data point results (Kleinfelder 2017)

Point No.	Mgmt Zone	Direction_1	CanopCov1	NtvUnd1	Exotic1	Direction_2	CanopCov2	NtvUnd2	Exotic2
1	MZ4	E	10% - 50%	<10%	10% - 50%	W	10% - 50%	>50%	<10%
2	MZ2/MZ4	E	<10%	<10%	>50%	W	10% - 50%	10% - 50%	<10%
3	MZ4	E	10% - 50%	<10%	>50%	W	10% - 50%	<10%	>50%
4	MZ4	SE	10% - 50%	<10%	10% - 50%	NW	10% - 50%	<10%	>50%
5	MZ3/MZ4	N	10% - 50%	<10%	>50%	S	>50%	>50%	<10%
6	MZ3/MZ8	SE	10% - 50%	<10%	>50%	NW			
7	MZ7/MZ8	E	10% - 50%	<10%	>50%	W	<10%	<10%	>50%
8	MZ4	SE	10% - 50%	<10%	>50%	NW	>50%	10% - 50%	10% - 50%
9	MZ7/MZ8	N	>50%	>50%	<10%	S	10% - 50%	<10%	>50%
10	MZ2	NW	>50%	>50%	<10%	SE	>50%	>50%	<10%
11	MZ2/MZ4	S	>50%	10% - 50%	<10%	N	10% - 50%	<10%	>50%
12	MZ4	N	10% - 50%	<10%	>50%	S	>50%	>50%	<10%
13	MZ2/MZ5	E	10% - 50%	<10%	>50%	W	>50%	>50%	<10%
14	MZ 1/MZ2	S	>50%	>50%	<10%	N	>50%	>50%	<10%
15	MZ 1/MZ2	E	>50%	>50%	<10%	W			
16	MZ 1/MZ2	N	>50%	>50%	<10%	S	>50%	>50%	<10%
17	MZ 1/MZ3	W	>50%	>50%	<10%	E	10% - 50%	>50%	<10%
18	MZ4	W	>50%	>50%	<10%	E	10% - 50%	<10%	>50%
19	MZ4	W	10% - 50%	<10%	>50%	E	<10%	<10%	>50%
20	MZ10	E	10% - 50%	<10%	>50%	W	<10%	<10%	>50%
21	MZ2/MZ3	E	>50%	>50%	<10%	W	<10%	<10%	>50%
22	MZ2/MZ8	E	>50%	>50%	<10%	W	<10%	<10%	>50%
23	MZ3/MZ7	W	>50%	>50%	<10%	W	>50%	<10%	>50%
24	MZ9/MZ4	E	10% - 50%	<10%	>50%	E	<10%	<10%	>50%
25	MZ7	NE	10% - 50%	10% - 50%	<10%	SW			
26	MZ3/MZ7	E	10% - 50%	10% - 50%	<10%	W	10% - 50%	<10%	>50%
27	MZ3/MZ4	N	10% - 50%	<10%	>50%	S	10% - 50%	>50%	<10%
28	MZ3/MZ7	N	>50%	>50%	<10%	S	>50%	<10%	>50%
29	MZ3/MZ7	S	>50%	<10%	>50%	S	>50%	>50%	<10%
30	MZ3/MZ8	E	<10%	>50%	10% - 50%	W	>50%	>50%	<10%
31	MZ2/MZ3	S	>50%	>50%	<10%	N	>50%	>50%	<10%
32	MZ2/MZ4	E	>50%	>50%	<10%	W	>50%	>50%	<10%
33	MZ2/MZ4	N	10% - 50%	<10%	>50%	S	>50%	>50%	<10%
34	MZ4/MZ9	W	10% - 50%	<10%	>50%	E	10% - 50%	<10%	>50%
35	MZ4/MZ9	SE	10% - 50%	<10%	>50%	NW	10% - 50%	<10%	>50%
36	MZ2/MZ5	E	10% - 50%	10% - 50%	10% - 50%	W	>50%	>50%	<10%
37	MZ2/MZ5	E	10% - 50%	10% - 50%	10% - 50%	W	>50%	>50%	<10%
38	MZ4/MZ5	E	<10%	<10%	>50%	W	10% - 50%	<10%	10% - 50%
39	MZ 1/MZ2	N	>50%	>50%	<10%	S	>50%	>50%	<10%
40	MZ 1/MZ2	N	10% - 50%	>50%	<10%	S	>50%	>50%	<10%
41	MZ10	E	10% - 50%	<10%	>50%	W	10% - 50%	<10%	>50%
42	MZ3/MZ7	W	<10%	<10%	>50%	E	>50%	>50%	<10%
43	MZ3/MZ9	W	<10%	<10%	>50%	E	<10%	10% - 50%	>50%
44	MZ3/MZ4	S	>50%	>50%	<10%	N	10% - 50%	<10%	>50%

Point No.	Mgmt Zone	Direction_1	CanopCov1	NtvUnd1	Exotic1	Direction_2	CanopCov2	NtvUnd2	Exotic2
45	MZ3/MZ4	N	>50%	>50%	<10%	S	>50%	>50%	<10%
46	MZ3/MZ4	E	>50%	>50%	<10%	W	>50%	>50%	<10%
47	MZ4/MZ7	W	10% - 50%	<10%	<10%	E	>50%	<10%	10% - 50%
48	MZ2/MZ4	S	>50%	>50%	<10%	N	10% - 50%	<10%	>50%
49	MZ2/MZ5	N	10% - 50%	<10%	>50%	S	>50%	>50%	<10%
50	MZ2/MZ6	N	10% - 50%	<10%	>50%	S	>50%	>50%	<10%
51	MZ2/MZ3	W	>50%	10% - 50%	<10%	SE	10% - 50%	10% - 50%	10% - 50%
52	MZ2/MZ3	W	>50%	10% - 50%	<10%	E	10% - 50%	<10%	>50%
53	MZ2/MZ5	E	10% - 50%	10% - 50%	>50%	W	>50%	>50%	<10%
54	MZ 1/MZ2	N	>50%	>50%	<10%	S	>50%	>50%	<10%
55	MZ2	N	>50%	>50%	<10%	S	>50%	>50%	<10%
56	MZ2/MZ3	S	>50%	10% - 50%	10% - 50%	N	>50%	>50%	<10%

Appendix F: Performance Criteria

Mgmt Zone	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16	Yr 17	Yr 18	Yr 19	Yr 20
All zones																				
Brief of works prepared																				
Area of primary work decided upon and marked out																				
Area of revegetation mapped and plants ordered																				
Climbers and priority weed species have been treated and suppressed																				
Budget prepared and contractor/s engaged																				
Site set up including photo points																				
All tree work recorded in register																				
Fauna monitoring																				
Tree hollow survey																				
Feral Animal and Pest Management when necessary																				
Nesting box Installation																				
Nesting box monitoring and maintenance																				
Annual report and recommendations																				
Management Zones 1 and 2																				
Core, edges and boundaries monitored for weeds and dumping																				
Track and easements in good condition																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Mangement Zone 3																				
No encroachment of weeds from neighbouring zones																				
Creeklines free of weeds and rubbish																				

Mgmt Zone	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16	Yr 17	Yr 18	Yr 19	Yr 20
Tracks surveyed and maintained. Any damaged prevented/mitigated																				
Revegetation																				
Revegetation maintained																				
CanopCov >50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Management Zone 4																				
No encroachment of weeds from neighbouring zones																				
Creeklines free of weeds and rubbish																				
Tracks surveyed and maintained. Any damaged prevented/mitigated																				
Revegetation - North Mound																				
Revegetation - Impact Area Interface																				
Revegetation maintained																				
CanopCov 10-50%: NtvUnd 10-50%: Exotic 10-50%																				
CanopCov >50%: NtvUnd 10-50%: Exotic 10-50%																				
CanopCov >50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Mangement Zone 5																				
Creekline free of rubbish																				
Strategic weed removal to maintain habitat																				
Revegetation																				
Revegetation maintained																				
CanopCov 10-50%: NtvUnd 10-50%: Exotic 10-50%																				
CanopCov >10%: NtvUnd >10%: Exotic 10-50%																				
CanopCov >10%: NtvUnd >10%: Exotic <10%																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				

Mgmt Zone	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16	Yr 17	Yr 18	Yr 19	Yr 20
Management Zone 6																				
All weeds treated																				
Revegetation																				
Revegetation maintained																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Management Zone 7																				
Revegetation - Quarry Road verge, SE Quarry walls, SWM buffer																				
Revegetation maintained, replacement planting undertaken																				
All Zone boundaries contained, no weeds spreading to Zone 3																				
Weeds treated prior to spread of weed propagules																				
CanopCov 10-50%: NtvUnd 10-50%: Exotic 10-50%																				
CanopCov 10-50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Management Zone 8																				
Weedy buffer maintained above MZ5																				
Weedy buffer maintaiined next to Western edge of MZ10																				
Weeds not acting as buffer treated prior to spread of weed propagules																				
Revegetation - SWM, NWS, pool batter, FT and ImpactArea buffers																				
Revegetation maintained, replacement planting undertaken																				
Tracks survey and maintained																				
CanopCov 10-50%: NtvUnd 10-50%: Exotic 10-50%																				

Mgmt Zone	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16	Yr 17	Yr 18	Yr 19	Yr 20
CanopCov 10-50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd 10-50%: Exotic <10%																				
CanopCov >50%: NtvUnd >50%: Exotic <10%																				
Management Zone 9																				
Improvement mechanisms for slope explored																				
Soils improved - area enhanced with habitat elements- Bridge Road																				
Revegetation - Bridge Road																				
Revegetation maintained																				
Management Zone 10																				
Mound stabilised and stabilised																				
Soils improved - area enhanced with habitat elements																				
Revegetation																				
Revegetation maintained, replacement planting undertaken																				
Management Zone 11																				
Soils improved																				
Landscape designed																				
Landscape construction and planting																				

Appendix G: Photo Points

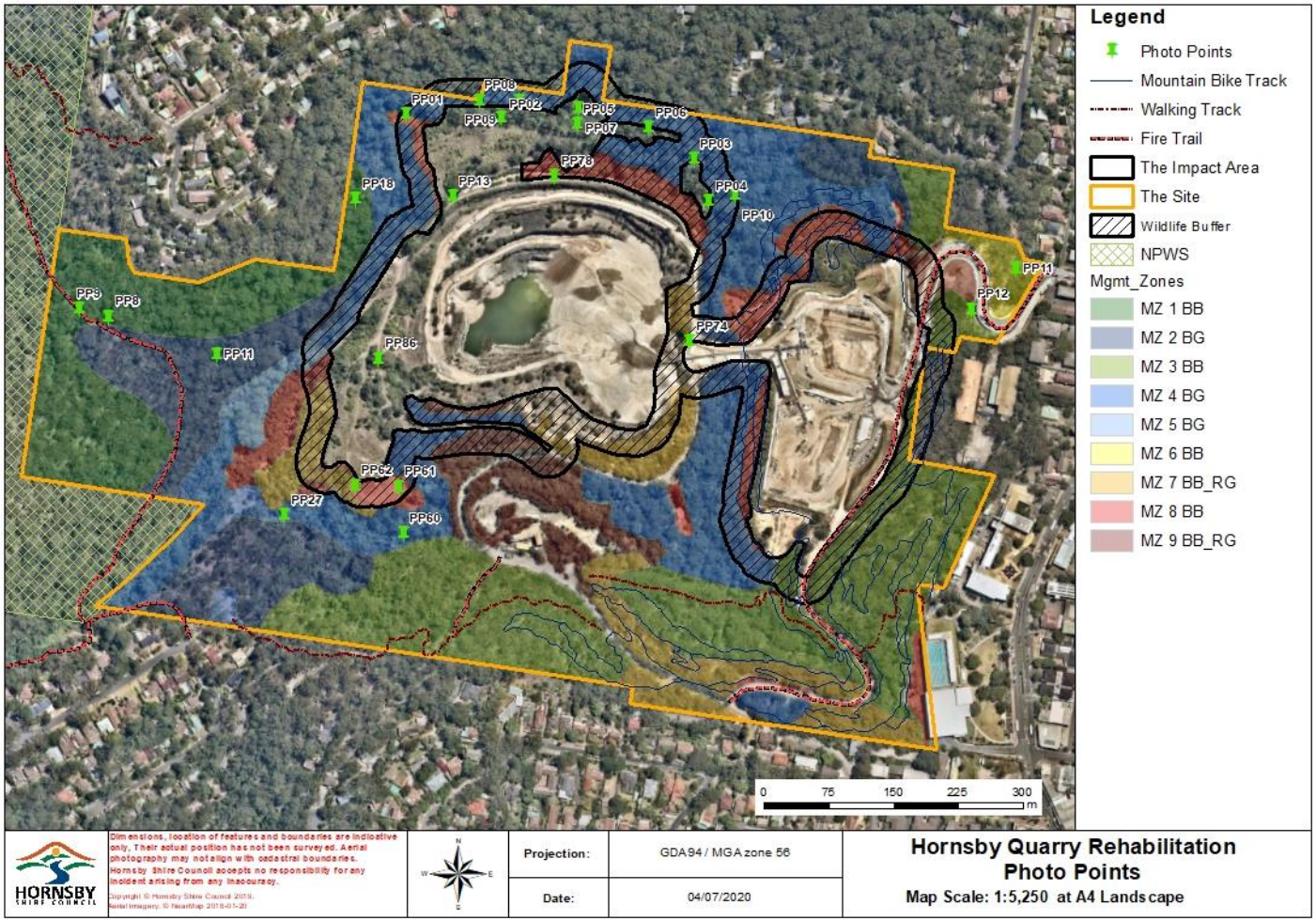


Photo Point 01 – MZ8 – View over Quarry to OMV and southern rockface

Photo Point 02 – MZ10 – Pampas Grass.on north mound and view to southern rockface

Photo Point 05 – MZ10 – Top of North Spoil Mound View East

Photo Point 05 – MZ10 – Top of North Spoil Mound View South East

Photo Point 06 – MZ4 – back of North Spoil Mound

Photo Point 07 – MZ4 – low point back of North Spoil Mound

Photo Point 08 – MZ4 - back of North Spoil Mound west view

Photo Point 08 –MZ4 - back of North Soil Mound north west view

Photo Point 09 – MZ4 – back of North Spoil Mound southern view

Photo Point 09 – MZ4 – back of North Spoil Mound west view

Photo Point 03 - Impact Area – Top of unstable soils with dense privet – view south west

Photo Point 03 – Impact Area – Top of unstable soil with dense privet – view south

Photo Point 03 – Impact Area – MZ4 Interface – Top of unstable soils with dense privet

Photo Point 03 – Impact Area – MZ4 Interface

Photo Point 04 – MZ4 – Base of unstable mound to be removed - Privet habitat to be retained

Photo Point 04 – MZ 4 – Base of unstable mound to be removed – Privet habitat along corridor

Photo Point 10 – MZ4

Photo Point 10 – MZ4

Photo Point 11 – MZ7 – View south west

Photo Point 11 – MZ7 – View west

Photo Point 12 – MZ3 and MZ9 Interface – View south west

Photo Point 12 – MZ3 and MZ9 Interface – View north west

Photo Point 12 – MZ3 and MZ9 Interface – View east

Photo Point 74 – View west

Photo Point 74 – View north west

Photo Point 78 – View south east

Photo Point 13 – Panoramic view south – south east

Photo Point 78 – MZ 8 – View up North Spoil Mound

Photo Point 78 – MZ 8 – View up North Spoil Mound

Photo Point 61 – MZ 8 and Impact Area interface - View north west from South West Mound

Photo Point 62 - MZ 8 and Impact Area interface – View north from South West Mound

Photo Point P60 – MZ4 and MZ 8 interface – Privet buffer as habitat

Photo Point 86 – Impact Area – Privet on each of Quarry void

Photo Point 27 – MZ2 and MZ 7 interface – buffer to be maintained

Photo Point 27 – M2 and MZ7 interface – buffer to be enhanced with revegetation

Photo Point 11 - MZ2 looking east to MZ5

Photo Point 11 – MZ 2 looking east north east

PP8 – MZ1 - BBGF – south facing slope

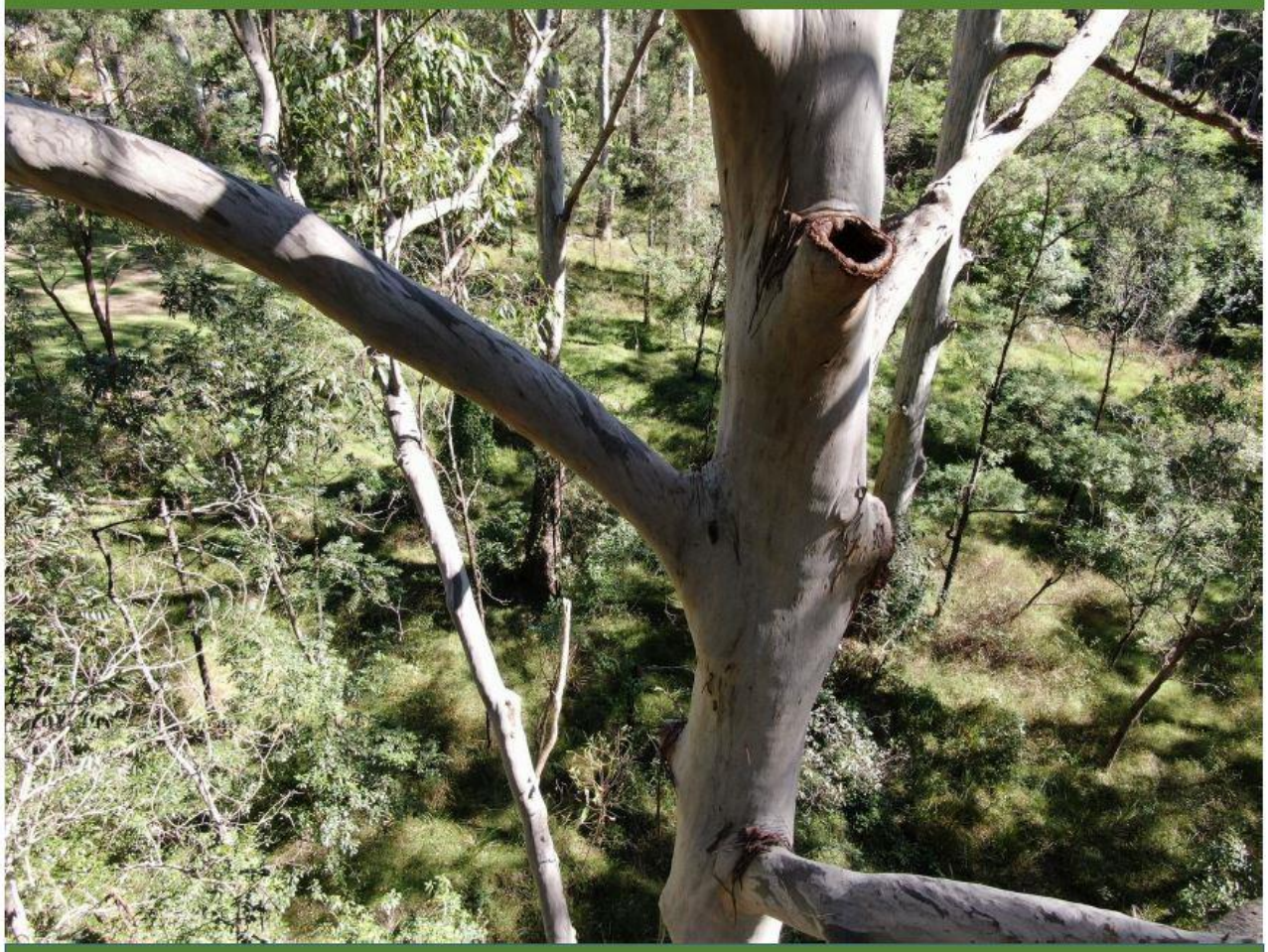
PP9 – MZ1 – BBGF north facing slope

Photos – Two examples of *Ninox strenua* habitat suitable for different stages of life cycle

Privet habitat for *Ninox strenua* Powerful Owl

***Ninox strenua* Powerful Owl**

Appendix H: Tree Hollow Survey Results



Hollow Bearing Tree Survey

Hornsby Quarry Rehabilitation

Prepared for Hornsby Shire Council | April 2021

GECKO ENVIRONMENT MANAGEMENT

Hollow Bearing Tree Survey

Introduction

Tree hollows are semi-enclosed cavities that form naturally in the environment over time. As trees age, they are subject to a number of natural forces and disturbances so generally only mature and senescent trees contain valuable hollows. The variable nature of different species growth forms and physical characteristics coupled with varying disturbances allows for diverse hollow formation, catering to many ecological niches and species. Openings range from 2-75cm and depths from 10cm to 10m (NPWS 1999) depending if the hollow is a branch stub (bayonet) or a trunk fissure caused by lightening or fire.

Many vertebrate and invertebrate species rely on hollows as shelter sites, rearing young, feeding, thermoregulation and to facilitate dispersal and ranging behaviour. Generally small hollows with narrow entrances (2-5cm) are suitable for small animals such as Antechinus, Feathertail Glider and Sugar Glider species and can take upwards of 100 years to form. Medium sized hollows (6-10cm) suitable for larger mammal species Greater and Yellow-bellied Glider, Common Ringtail Possum and parrot species can take around 200 years to form. Larger and deeper hollows occupied by Cockatoo and Owl species can take significantly longer with trees requiring at least 220 years of age to produce hollows of this nature. For many of these species hollow use is obligate, and no other habitat resource can be feasibly substituted (Gibbons and Lindenmayer 2002; NPWS 1999). This is the case for the extant keystone species, the Powerful Owl (*Ninox strenua*).

The probability of a tree containing hollows can be associated with several factors:

- Tree diameter
- Tree form
- Tree species
- Tree age
- Presence of fire scar

Tree age and diameter are correlated and a positive relationship between the presence of hollows and diameter in eucalypts has been reported in many studies – the proportion of trees with hollows increases significantly with diameter (Gibbons, P. and Lindenmayer, D. 2002).

Understanding the current and future hollow tree resource on site is critical in determining ongoing management actions.

Quality baseline data on the numbers of hollow-bearing trees (HBTs) of both Blue Gum Diatreme Forest (BGDF) and Blackbutt Gully Forest (BBGF) was required to inform ongoing management decisions in the following areas:

- Estimates of hollow bearing trees currently on site per hectare
- Spatial distribution of hollows
- Temporal changes – potential future recruitment of hollow resources
- Density and distribution of nesting boxes required

- Nesting box supplementation to meet shortfall in available habitat
- Nesting box supplementation to address impacts associated with adjacent habitat loss/disturbance from clear felling and stabilisation works - northern section of Quarry
- Habitat requirements to maintain the hollow resource connectivity to the surrounding landscape

The dominant vegetation communities and species include:

- Blue Gum Diatreme Forest (BGDF)
    - *Eucalyptus saligna*
- Blackbutt Gully Forest (BBGF)
    - *Eucalyptus pilularis*

Table 1: Numbers of hollow bearing trees from different forest types in Australia adapted from Gibbons, P. and Lindenmayer, D. (2002)

Location	Dominant tree species	Management history	HBTs (mean per ha)	Reference
Batemans Bay NSW	E. pilularis E. saligna	logged	6.7	Davey 1989
Urbenville NSW	E. saligna	unlogged	6.0*	Andrews et al. 1994
Urbenville NSW	E. saligna	logged	5.6*	Andrews et al. 1994

* Trees with large hollows only

This table illustrates the average hollow bearing tree density per hectare for forest type and relevant species: *Eucalyptus saligna* and *Eucalyptus pilularis.*

An extensive study by the NSW Forestry Corporation (2001) covering over 188,702 hectares of current and former State forests on the Mid North Coast, 67, 600 ha of which are now National Park estate surveyed for the abundance and spatial distribution of hollow bearing trees. 539 plots were assessed, only trees > 40cm diameter were considered and only trees with definite hollows were included in the analysis.

This study provides an in-depth assessment of tree hollows across species, forest types and age classes over a vast geographical area subject to differing management regimes.

We have gathered the data from this study relevant to the site, therefore, appropriate species, age classes and forest types to provide a quantitative benchmark in the assessment of the trajectory of the hollow bearing resources of the site (Figure 1, Table 2).

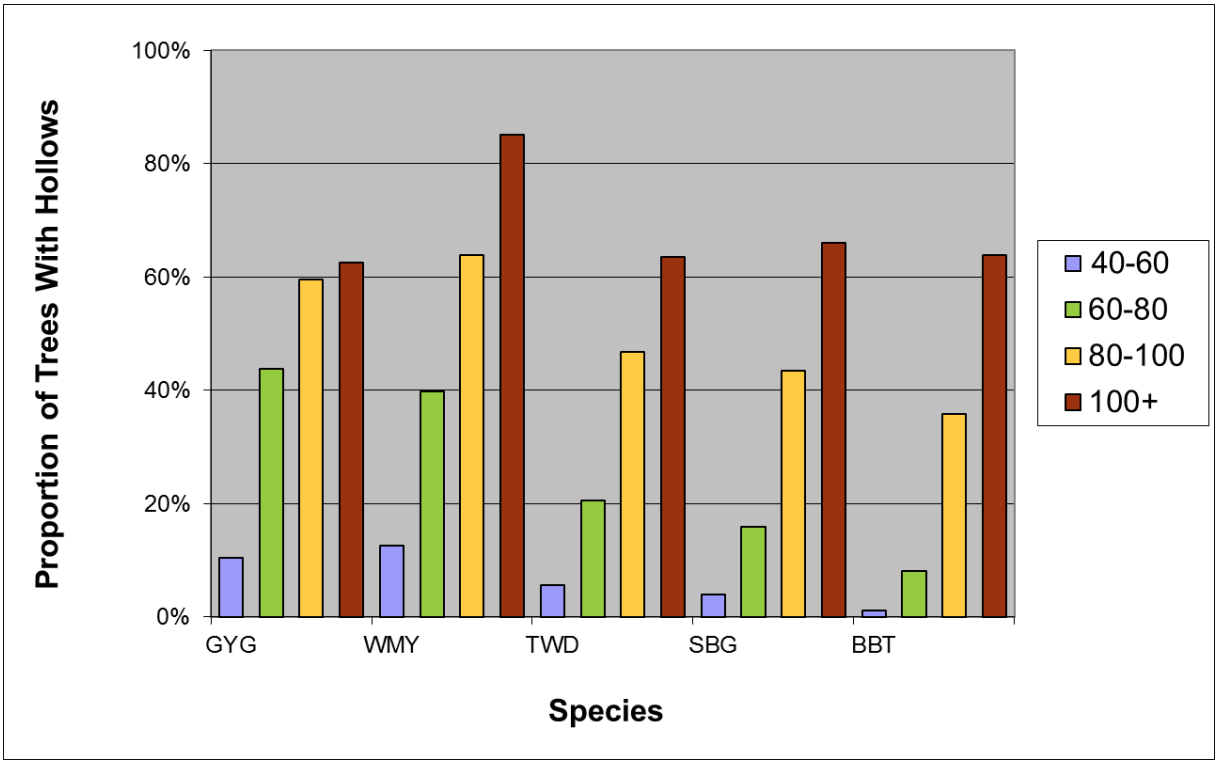


Figure 1. Proportions of trees with hollows for five common species in the 40-60, 60-80, 80-100 & 100+ cm diameter size classes. Species included are Grey Gum (GYG), White Mahogany (WMY), Tallowwood (TWD), Sydney Blue Gum (SBG) and Blackbutt (BBT). Significant increase in hollow formation is obvious in trees reaching over 80cm dbh. Percentage results for trees over 100cm dbh showing visible hollows were; Blackbutt 63.8%, Sydney Blue Gum 66.1%. At 60-80cm dbh results were Blackbutt 8.2%, Sydney Blue Gum 15.8%. (NSW Forestry Corporation, 2001).

Table 2. Hollow-bearing Tree Abundance by Strata in the Year 2000, (Adapted from NSW Forestry Corporation, 2001)

Strata Name	Area (ha)	N Plots	% of Plots with Hollows	Average Hollow-bearing trees/hectare
Regrowth Blackbutt	6,860	28	36%	6.7
Regrowth Moist Hardwood	6,453	14	36%	10
Regrowth Mixed Hardwood	6,621	26	38%	6.5
Regrowth Spotted Gum/ Blackbutt	4,772	31	13%	2.6
Regrowth Dry Sclerophyll	1,467	6	33%	15
Mixed Age Blackbutt	9,729	34	50%	8.5
Mixed Age Moist Hardwood	31,656	79	63%	13.5
Mixed Age Mixed Hardwood	45,083	137	58%	12.8
Mixed Age Spotted Gum/ Blackbutt	16,214	72	32%	5.7
Mixed Age Dry Sclerophyll	19,355	40	55%	10
Mature Regrowth Blackbutt	17,451	32	34%	4.7
Mature Regrowth Moist Hardwood	8,243	18	50%	12.8
Rainforest with Emergent Eucalypts	14,800	22	59%	10.9
Total and area weighted mean	188,702	539	255	10.1
Yield Association group only results				
Blackbutt	34,040	94	40%	6.2
Moist Hardwood	46,352	111	58%	12.9
Mixed Hardwood	51,704	163	55%	12.0
Spotted Gum/Blackbutt	20,986	103	26%	5.0
Dry Sclerophyll	20,822	46	52%	10.4
Growth Stage only results				
Regrowth	26,173	105	30%	7.2
Mixed Aged	122,037	362	53%	11.3
Mature Regrowth	25,694	50	40%	7.3

Note: Green highlights the most appropriate forest types applicable to the site.

Methodology

Fixed area plots

Fixed area plots are recommended as an appropriate sampling technique by Gibbons and Lindenmayer (2002) to determine the hollow resource in a landscape. Plots were stratified across

the two dominant vegetation communities onsite exhibiting a high level of moderate to good condition class (Figure 2).

This method is commonly used in forest inventories and habitat assessments and involves the measurement of the diameter of all trees in a set area. It has the advantages of marking permanent plots for future measurements and all trees in a stand counted (important for monitoring change over time).

Although, one-tenth hectare plots are normal forestry practice (for example 50 m x 20 m) (DECCW 2010). Gibbons and Lindenmayer (2002) along with Bull et al (1990) recommend conducting fixed area plot sampling of specific parameters in areas with low hollow densities such as previously logged areas. They found data from plots 0.4 ha or larger provided the most accurate estimates. Sampling at a rate of 1 plot per 8-10ha was found to be provide 25% of actual hollow density 95% of the time.

Plots were set out using Nikon Rangefinder and Garmin GPS units to the following specifications recommended by Gibbons and Lindenmayer (2002) and Bull et al (1990):

- 0.4ha (100m x 40m) plots
- 1 plot per 8-10ha
- 7 plots per approximately 63 ha of forested site
- All trees over 65cm DBH were recorded
- All trees between 40-65cm DBH were recorded for future recruitment
- All trees exhibiting hollows were recorded

A number of parameters were measured or estimated, including:

- Tree species
- Diameter at Breast Height (DBH)
- Tree Height
- Age class
- Defects
- Number of hollows present
- Type, height and aspect of hollow
- Entrance class size of hollow

Hollows were identified and counted from ground-based survey initially. A drone (DJI Mavic 2 Pro Zoom) was used to confirm pre-identified hollows and survey inaccessible or obscured hollows or trees. All trees surveyed were tagged with individual identification and photographs taken of significant features.

Collected data extrapolated across the site to obtain an estimate of the hollow resources found in adjacent good condition forested areas to inform the habitat requirements outlined in NBMP. The complete dataset has been provided as spatial data to HSC in the form of shp. files.

Disturbed, poor condition bushland and areas adjoining the impact area were separately surveyed by random meander to locate any trees of suitable dbh for hollow formation, and to confirm the presence of any established HBT's.

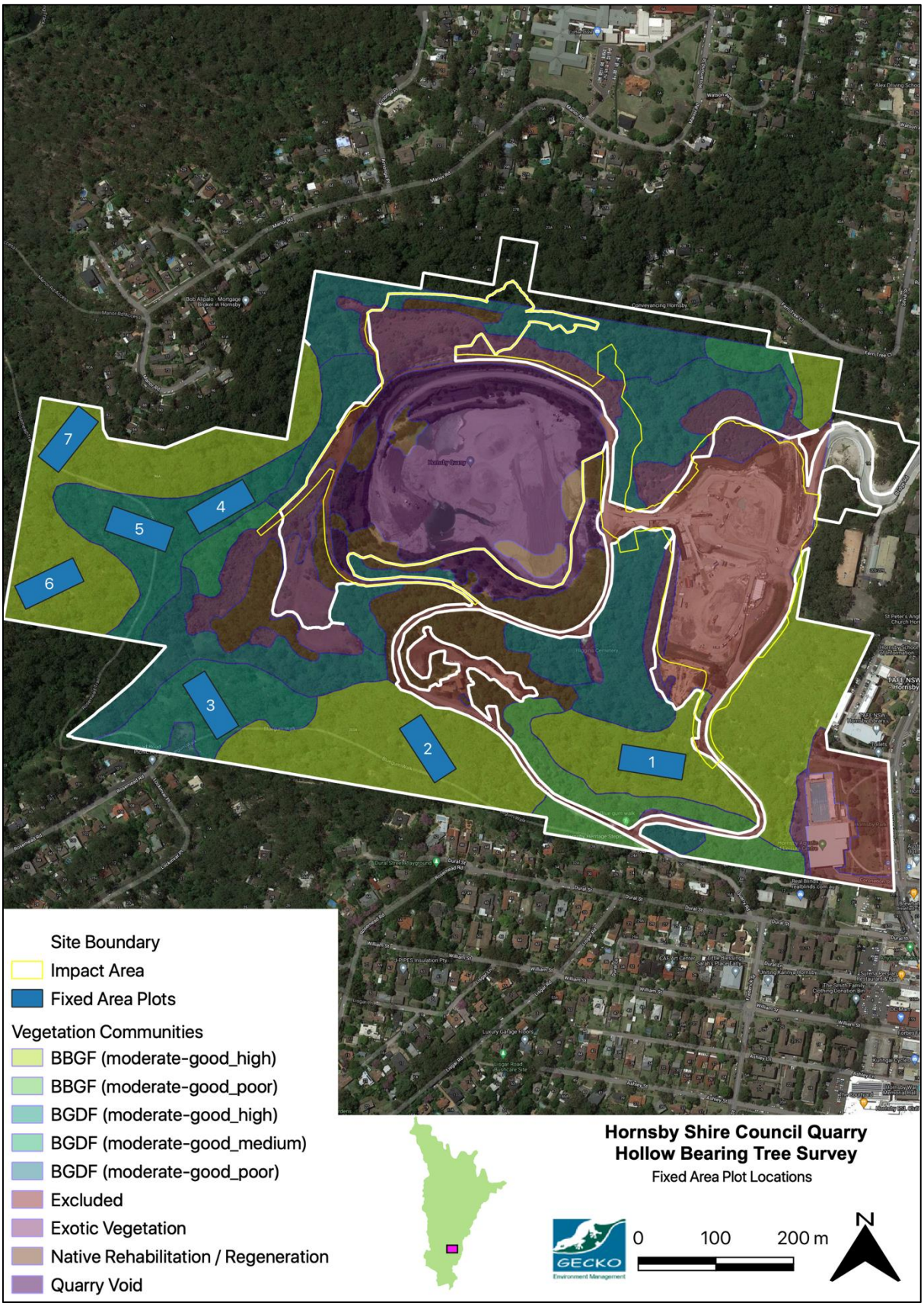


Figure 2: Hollow-bearing tree survey map indicating the locations and stratification of the seven fixed area plots and relative vegetation condition.

Results

On average BBGF contained more than double the amount of HBTs and total hollows (11.8 and 21) than BGDF (5.3 and 8.3) respectively (Figure 3). This may be attributed to the BBGF community

retaining larger DBH trees across the landscape whilst the BGDF may have endured a more intensive historical logging regime that is reflective in current condition class and even stand age of the community. The hollow bearing tree resource per hectare (within good condition bushland) demonstrated an average of 13.3 (BGDF) and 29.7 (BBGF) HBT's and 20.8 (BGDF) and 52.5 (BBGF) hollows per hectare. An average of 9 HBTs and 15.5 hollows per hectare were obtained for the total across both communities (Figure 4). These results were consistent with findings from a number of studies (NSW Forestry Corporation, 2001). These are consistent with findings with forest types; Regrowth Moist Hardwood or Mixed Age Blackbutt, Table 3 adapted from NSW Forestry Corporation (2001).

Further, *Eucalyptus pilularis* is the dominant species of the BBGF community and larger specimens are prolific hollow producers in comparison to other tree species present. *E. pilularis* exhibited more than double the amount of HBTs (21) and total hollows (45) than both *Angophora costata* (9 and 18) and *Eucalyptus saligna* (9 and 12) respectively. Of note is the second largest contributor of hollow bearing resources, standing dead trees (SDTs) or stags which accounted for 18 HBTs and 19 hollows (Figure 5).

In relation to the types of hollows encountered (Figure 6, Table 4) it is evident there is a proliferation of branch end type hollows accounting for 37% of all hollows. Of the 37%, 58% of these are in the 6-10 cm medium range. This size class also is the most common for all hollows found, at 39%. Small 2-5 cm hollows only accounted for 16% of total hollows and most were distributed as small fissures or branch ends in the canopy. Although large 10-20 cm and extra-large >20 cm hollows accounted for nearly 50% of all hollows at 23% each, they were distributed across all hollow types, suggesting a general lack in larger, above ground strata trunk main, trunk top and fissure type hollows across the site. Additionally, a deficiency in hollows produced by fire scars, one of the key drivers of hollow production across the landscape was evident with only 3 counted. This is most likely attributed to changing fire regimes in regard to urban proximity of the bushland.

Interestingly, drone confirmation of 171 hollows surveyed from the ground led to 109 confirmed hollows. 36% less, as many 'hollows' were confirmed to be blind (timber filled). Conversely, the drone surveyed numerous hollows that were not or could not be sighted from the ground adding significantly greater accuracy to the survey.

In observation, across the site generally there was sufficient dead, fallen timber resources in the ground layer providing habitat (apart from FAP 2 which was largely devoid of a ground layer). Larger trees facilitated numerous and diverse hollows, one *E.* pilularis of DBH 113 cm exhibited 13 hollows of varying size and type, whereas smaller trees either completely lacked or only exhibited small temporary branch end type hollows.

It is of utmost importance to facilitate the retention of and minimise disturbance around any large DBH (>100 cm) and SDTs as these are critical hollow habitat resources that cannot be replaced or synthesized in the forms of artificial hollows.

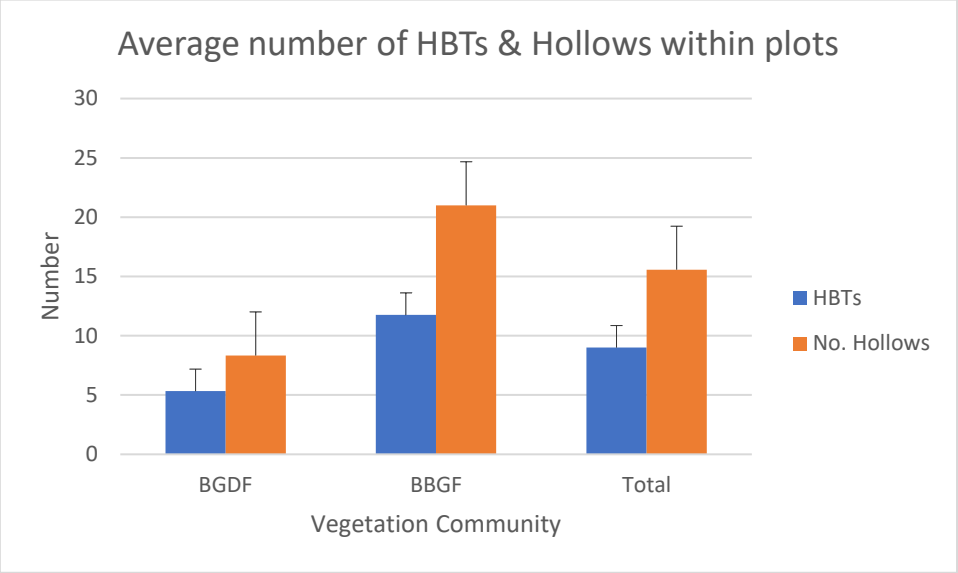


Figure 3: Mean ± S.E. of Hollow bearing trees (HBTs) and hollows encountered within fixed-area plot surveys in total and across the two dominant vegetation communities; Blue Gum Diatreme Forest (BGDF) and Blackbutt Gully Forest (BBGF).

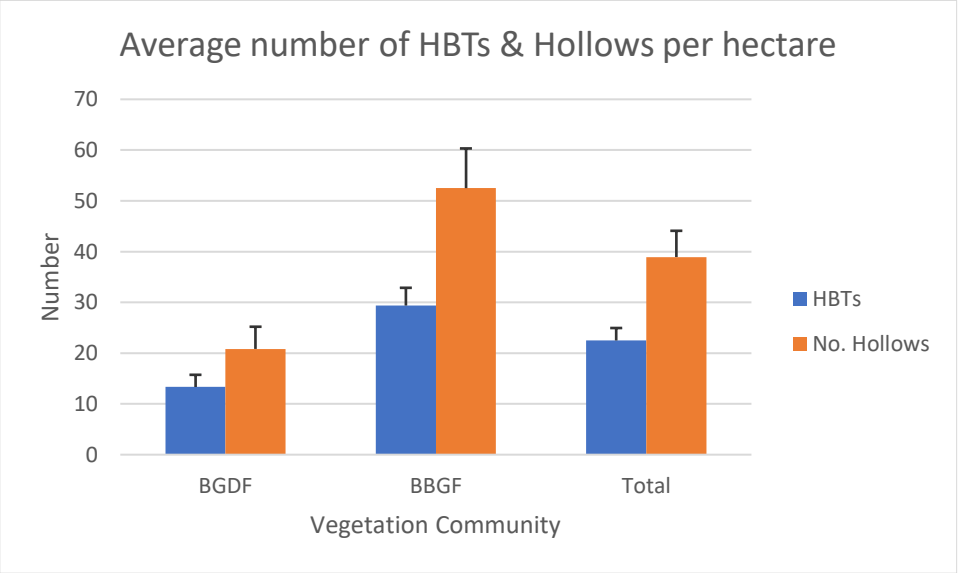


Figure 4: Mean ± S.E. of Hollow bearing trees (HBTs) and hollows calculated per hectare in total and across the two dominant vegetation communities; Blue Gum Diatreme Forest (BGDF) and Blackbutt Gully Forest (BBGF).

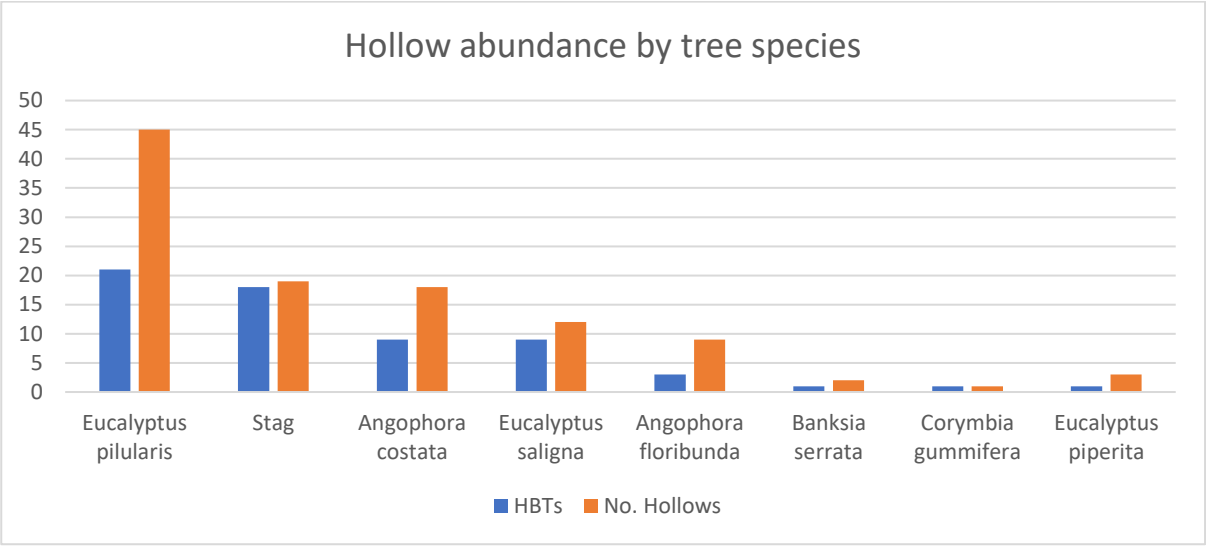


Figure 5: Abundance of all hollows per species across fixed-area plot surveys.

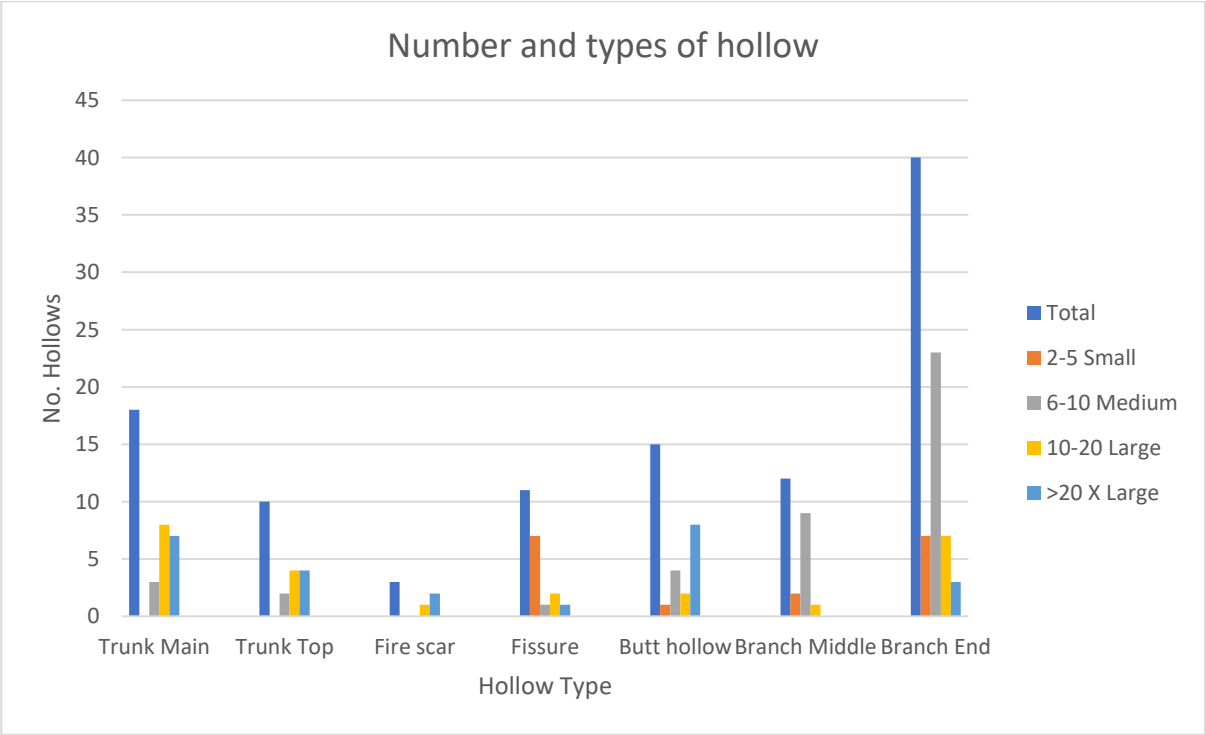


Figure 6: Abundance of size class per hollow type encountered across fixed-area plot surveys. Note the high representation of branch end hollows.

Table 3: Distribution of hollow type and associated size classes across surveyed plots.

Hollow type	Hollow size class				
	2-5 small	6-10 medium	10-20 large	>20 X large	Total
Trunk Main		3	8	7	**18**
		17%	44%	39%	**16%**
Trunk Top		2	4	4	**10**
		20%	40%	40%	**9%**
Fire scar			1	2	**3**
			33%	67%	**2.8%**
Fissure	7	1	2	1	**11**
	64%	9%	18%	9%	**10%**
Butt hollow	1	4	2	8	**15**
	7%	27%	13%	53%	**14%**
Branch Middle	2	9	1		**12**
	17%	75%	8%		**11%**
Branch End	7	23	7	3	**40**
	18%	58%	18%	8%	**37%**
TOTAL	**17**	**42**	**25**	**25**	**109**
	16%	**39%**	**23%**	**23%**	

Fixed Area Plots (FAP)

FAP	Indicative vegetation and habitat condition BBGF	
1		
		
		
		

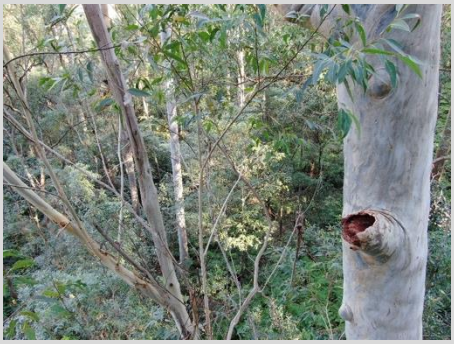
FAP 1 was found to contain two of the most significant individual HBT's within the survey. one *E. pilularis* here of DBH 113 cm exhibited 13 hollows of varying size and type. The fallen hollow log resource was also significant here. King Parrots and Lorikeets were sighted using hollows within FAP 1. Recent fauna survey recorded Sugar gliders in this area.

FAP	Indicative vegetation and habitat condition BBGF	
2		
		
		
		

FAP 2 was largely devoid of ground layer habitat.

FAP	Indicative vegetation and habitat condition BGDF	
3		
		
		

FAP 3 adjoined parkland at Rosemead Road, this plot contained some large hollows, which appeared insignificant prior to confirmation with the drone.

FAP	Indicative vegetation and habitat condition BGDF	
4		
		
		
		

FAP 4 contained a number of *E. saligna* which had recently had large branches or canopy fall, a process often hastening hollow formation. Ground layer habitat here was excellent with numerous hollow logs, steep rocky terrain, though most Blue Gums here were generally many years from forming significant hollows.

FAP	Indicative vegetation and habitat condition BGDF	
5		
		
		
		

FAP 5 had dense fern ground layer with a number of low stumps/ stags bearing hollows. Recent fauna survey recorded Sugar gliders in this area

FAP	Indicative vegetation and habitat condition BBGF	
6		
		
		
		

FAP 6 contained a number of larger HBT's, and numerous hollow logs throughout the ground layer

FAP	Indicative vegetation and habitat condition BBGF	
7		
		
		
		

FAP 7 spanned steep rocky terrain adjoining residences, Numerous larger hollows were located in stags, trunk mains and ground layer hollow logs here. Residents here commented that they had “many years ago commonly sighted Sugar gliders in the adjoining bushland from their yards” though thought they were now gone

Indicative Hollow Type		
Trunk Main		
Trunk Top		
Fire Scar		
Fissure		

Butt Hollow		
Branch Middle		
Branch End		

Progress Shots	
	
	
	
	

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ENVIRONMENTAL FACT SHEET

Powerful Owls and other Forest Owls within Hornsby Shire

Powerful by name, and powerful by nature:

- **The Powerful Owl is Australia's LARGEST OWL**
- **Is classified as Threatened**
- **It needs old tree hollows for nesting**

Powerful Owl *Ninox strenua*

Background

Powerful Owls are Australia's largest nocturnal bird. Adults reach approximately 60cm in length, have a wingspan of up to 140 cm and weighs up to 1.45 kilograms. Powerful Owls are a NSW listed threatened species.

The Powerful Owl breeding season is between the months APRIL to OCTOBER.

Any vegetation works within proximity of Powerful Owls breeding territory during their breeding season can disturb forest owl's breeding cycle by scaring the adults, chicks and fledglings due to noisy works and through the removal of roosting branches and other branches close to hollows or nests. This Fact Sheet also relates to other forest owls including the Masked Owl, Barking Owl and Sooty Owl.

Identifying Nest Trees and Roosting Branches / Sites

Hornsby Council has been working in close association with Birdlife Australia and can provide information on the breeding territory and habitually used nest and roost tree locations in the Shire.

Nest Trees and Hollows—large old trees with a diameter at chest height of at least 80cm, typically Eucalypts or Angophoras. Hollows are vertical and in the trunk of the tree to a depth of at least 0.5m, a width of 35cm and at least 6m off the ground.

Roosting Sites— Powerful Owls normally roost in vegetation along the banks of rivers and waterways and mid-slopes with good cool canopy cover.

Roosting Branches– small (4-10 cm diameter) horizontal branches of vegetative matter over creeks and tracks. Owls do not discriminate between weeds or native vegetation. The branches just need to be big enough to support the weight of the owl but also small enough to get their talons around. Horizontal branches within one metre of nesting hollows are important for the fledging process, providing a perch for the fledglings to develop flight strength on.

'Whitewash' and prey remains— other identifying features of an Owl's presence include large splashy areas of faeces called 'whitewash' and often prey remains (e.g. 'butchery circles') or regurgitated pellets that look like balls of vacuum-cleaner dust.

MANAGERS and SUPERVISORS—please ensure this fact sheet is circulated to relevant staff and contractors

General conditions include (all year round):

- All staff/contractors to be provided information on large forest owl identification and behaviours, and how to identify roost sites and breeding locations at all times (this Environmental Fact Sheet)
- Noisy works (chainsaw, mulching) must not be carried out between an hour before sunset and an hour after sunrise or within 50 m of an identified roost site
- Retain all hollows and canopy connection where possible
- Avoid trimming of horizontal branches of vegetation (including weed species) within one metre of tree hollows >30cm
- Retain all horizontal perching branches of 4-10cm diameter in flyways to allow natural movement of Owls (i.e. overhanging creeks and tracks) where possible
- Avoid vegetation trimming that opens the canopy and mid-storey in riparian zones (along a 50m corridor of a creek/river/riparian corridor), this includes any treatment of weed species
- Mid-storey weed treatment along 50m creek/river/riparian corridor to be strategically carried out with respect to roosting and fledging requirements and in accordance with approved Vegetation Management Plan or similar

Breeding Season APRIL to OCTOBER (in addition to above):

- Consult with Birdlife Australia via Council prior to works commencing
- No clearing or earthworks disturbance (chainsaw, mulching) is to occur within 100m of an identified nesting tree
- If clearing or earthworks disturbance (chainsaw, mulching) is unavoidable, works are not to be undertaken between an hour before sunset and an hour after sunrise within 100m of identified nesting tree or within 50m of an identified roost site

Key messages

- **Powerful Owls are a NSW listed threatened species**
- **Consultation with Birdlife Australia via Council is required prior to any works during the breeding season, APRIL to OCTOBER**
- **If works are unavoidable, the preferred period for works within proximity of Powerful Owl breeding territories is November to March**

More information: Refer to the Birdlife Australia website on Powerful Owls

Htts://www.birdlife.org.au/projects/

Prey remains—a 'butchery circle'

MANAGERS and SUPERVISORS—please ensure this fact sheet is circulated to relevant staff and contractors