Appendix 8.
Hayes Creek Project
Flora and Fauna Report

HAYES CREEK PROJECT

FLORA AND FAUNA REPORT

Report Prepared for PNX Metals Pty Ltd

April 2020

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LIST OF ABBREVIATIONS

Abbreviation	Definition
ASC	Australian Soil Classification
BMP	Biodiversity Management Plan
BFMP	Bush Fire Management Plan
BoM	Bureau of Meteorology
CR	Critically Endangered
DD	Data Deficient
DENR	Department of Environment and Natural Resources (Northern Territory)
DLRM	Department of Land Resource Management (Northern Territory) (no DENR)
DME	Department of Mines and Energy (Northern Territory) (now DPIR)
DPIR	Department of Primary Industries and Resources (Northern Territory)
EA Act	Environmental Assessment Act 1982 (Northern Territory)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EN	Endangered
EPBC Act	Environment Protection and Biodiversity Conservation Act (Commonwealth)
ESCP	Erosion and Sediment Control Plan
FFMP	Flora and Fauna Management Plan
IBRA	Interim Biogeographic Regionalisation of Australia
Km	Kilometres
LES	Low Ecological Services P/L
Ma	Marine
Mi	Migratory

MM Act	Mine Management Act
MMP	Mine Management Plan
MNES	Matters of National Environmental Significance
MP	Management Plan
NA	Not applicable
Nt	Near Threatened
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTVIS	Northern Territory Vegetation Information System
PAF	Potentially Acid Forming
PMST	EPBC Protected Matters Search Tool
PPL	Perpetual Pastoral Lease
SoBS	Sites of Botanical Significance
SoCS	Sites of Conservation Significance
TPWC Act	Territory Parks and Wildlife Conservation Act
VU	Vulnerable
WoNS	Weed of National Significance

DOCUMENT CONTROL

Disclaimer

This document has been prepared by Low Ecological Services (LES) for PNX Metals Ltd in accordance with an agreement with PNX Metals Ltd. LES has prepared this document using the skill and care expected from professional scientists to provide factual and technical information and reasonable solutions to identified risks. It does not constitute legal advice.

Acknowledgements

LES acknowledges the assistance of Brad Ermel from PNX Metals while onsite, Dennis Matthew for bat call identification, Nicholas Cuff at the Darwin Herbarium for plant identification, the Ban Ban Springs station owners for allowing access to their properties and Brett Perry and Kate Sinai from ERIAS for coordination and review of the project and documents. LES personnel involved in the project were:

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Document Details

Name of Document:	Hayes Creek Project Flora and Fauna Report
Authors:	Lauren Young, Jess Cuneo, Kate Stevens and Bill Low
Client:	PNX Metals Ltd
Name of Project:	Hayes Creek Project Gold, Silver and Zinc Project

Document Control

Approvals	Name	Signature	Date
Originator:	Low Ecological Services P/L	× 	30/04/2020
Reviewer:		×	
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Approver:		×	
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REVISION DETAILS

Date	Revision	Details	Name	Company
	Draft V1	Prepared by	Lauren Young	Low Ecological Services P/L
		Reviewed by	David Browne and Kate Sinai	ERIAS
29/03/2020	Final	Updated and Revised by	Nicola Hanrahan	Low Ecological Services P/L
		Reviewed by	David Browne and Kate Sinai	ERIAS
30/04/2020	Final	Updated and Revised by	Nicola Hanrahan	Low Ecological Services P/L

Preface

All information on proposed operations contained in this document has been supplied by PNX Metals *via* ERIAS Group.

EXECUTIVE SUMMARY

Mt Bonnie, Iron Blow and Fountain Head are existing, non-operational mine sites located near Hayes Creek, 170 km south of Darwin, Northern Territory (NT) and approximately 6 km east of the Stuart Highway. Historic mining activities have occurred at both Mt Bonnie and Iron Blow between 1912 and 1916 followed by a second phase in 1983 and 1985 when an open cut mine was established. In 2014, PNX Metals acquired the 13 mining leases (MLs) containing Iron Blow and Mt Bonnie polymetallic deposits and entered into a separate agreement with Newmarket Gold Australia to purchase the 4 MLs on which the Fountain Head site is located. PNX Metals aim to develop the Hayes Creek Project which is a Zinc, Gold and Silver mining operation (the proposal) and is comprised of the Fountain Head, Iron Blow and Mt Bonnie sites. A proposed Haul Road will link the three sites. All three sites are previously disturbed as a result of historic mining activities. This study was commissioned for the Hayes Creek Project.

PNX Metals commissioned Low Ecological Services P/L (LES) through ERIAS Group to undertake an on-ground flora and fauna survey at the Hayes Creek Project to accompany an NOI to develop the proposal in 2017. A second survey was commissioned by PNX Metals to provide further information for the Draft Environmental Impact Statement in line with the final Terms of Reference (ToR). This was undertaken in the late dry season in August 2019.

A desktop review was undertaken using data obtained from various sources to gain an understanding of the ecological context of the landscape, the physical environment, climate, vegetation and habitats. Interrogation of national and NT databases were undertaken to gain an understanding of the potential occurrence of threatened or conservation significant flora and fauna. This information was then used to assess the likelihood of occurrence of threatened or conservation significant species and their potential distribution in the survey area.

The initial on-site flora and fauna survey of the Hayes Creek Project survey area was undertaken from 15th – 18th May 2017 to assess flora and fauna presence post wet-season. This survey was designed to gain a detailed understanding of the environment of the survey areas, as well as to target survey species of conservation significance identified by the desktop review. Riparian and aquatic habitats were also surveyed in May 2017 in line with the AusRivAS methodology. The Final Terms of Reference (ToR) for the proposal (NT Environment Protection Authority, 2019) required that, while the NT EPA had concluded that there is a low likelihood of significant impacts on terrestrial flora and fauna from the proposal and did not require further field assessment (NT Environment Protection Authority, 2018), updated results of targeted surveys for threatened species in areas where vegetation is to be cleared as part of the proposal be provided. Therefore, sites surveyed and methods employed during August 2019 were chosen to target species identified as having a moderate or high likelihood of occurring within the survey area (Figure 3, Table 4, Appendix 3).

Two threatened flora species, *Acacia praetermissa* and *Stylidium ensatum* were assessed in the desktop study as having a high likelihood of occurrence in the survey area. *Acacia praetermissa* is listed as vulnerable under both the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Territory Parks and Wildlife Conservation Act 2000* (TPWC Act). *Stylidium ensatum* is listed as endangered under both the EPBC Act and TPWC Act.

Five threatened bird species were assessed as having a moderate to high likelihood of occurring in the survey area. These were the curlew sandpiper (*Calidris ferruginea*), red goshawk, Gouldian finch

(*Erythrura gouldiae*), partridge pigeon (eastern subspecies) (*Geophaps smithii smithii*) and masked owl (northern subspecies) (*Tyto novaehollandiae kimberli*). Seven threatened mammal species were assessed as having a moderate to high likelihood of occurring in the survey area. These were the fawn antechinus (*Antechinus bellus*), the northern quoll (*Dasyurus hallucatus*), ghost bat (*Macroderma gigas*), black-footed tree-rat (*Mesembriomys gouldii gouldii*), northern brush-tailed phascogale (*Phascogale pirata*), pale field rat (*Rattus tunneyi*) and bare-rumped sheath-tailed bat (*Saccolaimus saccolaimus nudicluniatus*). The threatened reptile species were assessed as having a high likelihood of occurrence in the survey area. These were Merten's water monitor (*Varanus mertensi*), Mitchell's water monitor (*Varanus mitchelli*) and the floodplain monitor (*Varanus panoptes*).

Six main habitats were surveyed during the May 2017 and August 2019 surveys of the Hayes Creek Project area. *Eucalyptus* woodland on sandstone plains and *Eucalyptus* woodland on low sandstone hills were the predominant habitats in the survey area. Overall, 143 flora taxa were recorded during on-ground surveys. No threatened flora species were identified in the survey area during May 2017 and August 2019 surveys despite targeted survey effort for *A. praetermissa* and *S. ensatum*. Twenty-four introduced species were recorded including 2 declared Weeds of National Significance (WoNS). WoNS recorded within the survey sites included gamba grass (*Andropogon gayanus*) and Olive hymenachne (*Hymenachne amplexicaulis).* Three species, *A. gayanus, Hyptis suaveolens* (Hyptis) and *Sida rhombifolia* (common sida) recorded during the surveys are class B weeds in the NT (growth and spread to be controlled). Five additional species, *H. amplexicaulis, Senna alata* (candlebush), *Sida acuta* (spiny-headed sida), *Stachytarpheta cayennensis* (snakeweed) and *Themeda quadrivalvis* (grader grass), are class B and class C (not to be introduced into the NT) in the NT, and were also recorded.

A total of 130 native fauna species consisting of five amphibian species, 107 bird species, 15 mammal species and eight reptile species were recorded across the survey area during the May 2017 and August 2019 surveys. Two threatened fauna species were recorded during targeted survey effort for 22 potential threatened species identified by the NT Fauna Atlas and PMST. The Gouldian finch (*Erythrura gouldiae*), listed as endangered under the EPBC Act, was recorded north of the Mt Bonnie site and at the south-eastern tip of the dam in the Mt Bonnie production area. Suitable nesting habitat was found through the mapped Baker landsystem while the Rumwaggon landsystem provided suitable food grass species. Merten's water monitor (*Varanus mertensi*), listed as vulnerable under the TPWC Act, was recorded through anecdotal evidence (confirmed via photograph) in the existing Iron Blow pit. No fauna species listed as migratory were recorded during the May 2017 or August 2019 on-ground surveys. Seven species listed as near-threatened under the TPWC Act were recorded during the surveys; buff-sided robin (*Poecilodryas cerviniventris*), bush-stone curlew (*Burhinus grallarius*), Australian bustard (*Ardeotis australis*), hooded parrot (*Psephotus dissimilis*), orange leaf-nosed bat (*Rhinonicteris aurantia*), Arnhem sheath-tailed bat (*Taphozous kapalgensis*) and northern ridge-tailed monitor (*Varanus primordius*). Four EPBC listed marine species were recorded within the survey area during the surveys; rainbow bee-eater (*Merops ornatus*), freshwater crocodile (*Crocodylus johnsoni*), great egret (*Ardea alba*) and cattle egret (*Ardea ibis*). Seven introduced fauna species were recorded during the survey. These were black rat (*Rattus rattus*), cane toad (*Rhinella marina*), cat (*Felis catus*), cattle (*Bos taurus*), feral pig (*Sus scrofa*), donkey (*Equus asinus*) and water buffalo (*Bubalus bubalis*).

The potential for significant impacts was assessed on 35 threatened, migratory and marine species listed under the EPBC Act and/or TPWC Act that were recorded during surveys or have a moderate to high likelihood of occurring in the survey area. These species were assessed using the criteria set out

in the *Significant Impact Guidelines 1.1-Matters of National Environmental Significance* (Department of Environment, 2013). Despite not being identified within the survey area, the proposal was deemed to have the potential of having a significant impact on an important population of *Acacia praetermissa* although this risk has been determined to be low. This is due to the presence of suitable habitat and the species ability to resprout from rootstock making it possible that individuals present were not encountered during the two surveys. Mitigation measures that are recommended for reducing the risk to *A. praetermissa* include the training of environmental staff to identify *A. praetermissa* and a requirement to report any individuals found. The proposal was also deemed to have a high risk of impacting an important population of Gouldian finches. This determination was made based on data that indicates that there is suitable habitat for the Gouldian finch throughout the survey area, but particularly around Mt Bonnie and Iron Blow. The recording of adult and juvenile Gouldian finches in May 2017 and again in August 2019 suggests that habitat in and adjacent to the survey area may be suitable somewhat continuously through time and that breeding occurs either within the survey area or close by. This risk was categorised based on the precautionary principle and may be re-evaluated subject to further targeted gouldian finch surveys that provide more information on seasonal habitat use.

The Gouldian finch is the only species for which mitigation and monitoring measures are recommended separately. Mitigation and monitoring measures will be developed for *A. praetermissa* should it be found to occur in the survey area by mine staff. Mitigation and monitoring measures for other species of national or NT significance are covered under the general mitigation measures to limit impacts to flora and fauna. Following the mitigation and monitoring measures, the risk of the proposal significantly impacting Matters of National Environmental Significance (MNES) is decreased substantially with the risks predominantly being low to very low, and medium being the highest risk rating after measures are taken into consideration.

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1 INTRODUCTION

1.1 Overview

Mt Bonnie, Iron Blow and Fountain Head are existing, non-operational mine sites located near Hayes Creek, 170 km south of Darwin, Northern Territory (NT) and approximately 12 km north east of the Stuart Highway (Figure 1). The Fountain Head, Iron Blow and Mt Bonnie production areas (hereafter refered to as the production areas), along with the proposed Haul Road are hereafter collectively referred to as the proposal area. The Fountain Head lease area falls within the Ban Ban Springs pastoral lease, and the Iron Blow and Mt Bonnie lease areas fall within the Douglas pastoral lease. Historic mining activities occurred at both Mt Bonnie and Iron Blow between 1912 and 1916 and a second phase of mining occurred between 1983 and 1985 when an open cut mine was established. In 2014, PNX Metals acquired 13 mining leases (MLs) containing Iron Blow and Mt Bonnie polymetallic deposits and in 2018 aquired from Newmarket Gold Australia four MLs on which the Fountain Head site is located. During the 2018 field season, exploration drilling was undertaken to determine additional gold resources at the Fountain Head site. PNX Metals proposes to mine and process ore at the Fountain Head site for approximately three years (the Fountain Head Gold Project) prior to mining polymetallic ore over eight years from the Hayes Creek Zinc, Gold and Silver project (hereafter referred to as the proposal). This study was commissioned for the Hayes Creek Project, which encompasses the Fountain Head Gold project area. The predominant activities are outlined in

Table 1. Unrehabilitated open pits, pit lakes, some waste rock dumps, tailings storage facilities, ore stockpiles, dams (containing freshwater and contaminated water), process plant site, associated access roads and other disturbances remain in the proposal area from previous operations. The proposal will be undertaken in three stages:

- Stage 1 - Fountain Head Gold Project (approximately three-year operation)
    - Dewatering of the existing Fountain Head pit;
    - Construction of evaporation dam;
    - Expansion of existing open pit;
    - Expansion of existing waste rock stockpile;
    - Construction of processing related leach pads, solution ponds, crushing facilities and gold processing plant;
    - Construction of supporting infrastructure i.e. workshops, power station, roads, offices and
    - Continued dewatering and evaporation of the pit and evaporation dam.
    -
- Stage 2 and 3 – Hayes Creek Project
    - Mining of polymetallic (Zinc, Gold and Silver) orebody at Mt Bonnie open cut (two-year operation);
    - Mining of polymetallic (Zinc, Gold and Silver) orebody at Iron Blow underground (six to eight-year operation);
    - Once processing of ore at the Fountain head site is complete, a separate processing plant will be established to process the ore from Mt Bonnie and Iron Blow; and
    - Deposit tailings from processing of Mt Bonnie and Iron Blow ore sub-aqueously into the Fountain Head pit.

Table 1. Proposed developments in each production area and along the Haul Road in the Hayes Creek Project survey area

production area/Haul Road	Proposed development
Stage 1 – Fountain Head Gold Project	
Fountain Head	Dewatering of existing open pit, mining of the pit, construction of the evaporation dam, expansion of the waste rock storage, construction of processing related heap leach pads, solution ponds, crushing facilities and gold processing plant, construction of supporting infrastructure e.g., workshops, power station, roads and offices
Stage 2 and 3 – Hayes Creek Project	
Fountain Head	Access roads, exploration area, core shed, waste rock storage, existing open pit, water dam, PV solar farm, gas power station, processing plant site, ROM pad
Iron Blow	Waste rock storage x 2, PFS portal, ROM pad, surface magazines, office and workshop, fuel farm, laydown area, ANE manufacturing facility
Mt Bonnie	Temporary PAF waste rock storage, NAF waste rock storage, PFS pit, SME go line, fuel farm, office and workshop
Haul Road	Upgrade and maintenance of existing Haul Road route, clearing of 12 m Haul Road corridor along new section of route, culvert at creek crossing north of Mt Bonnie, rail crossing south of Fountain Head

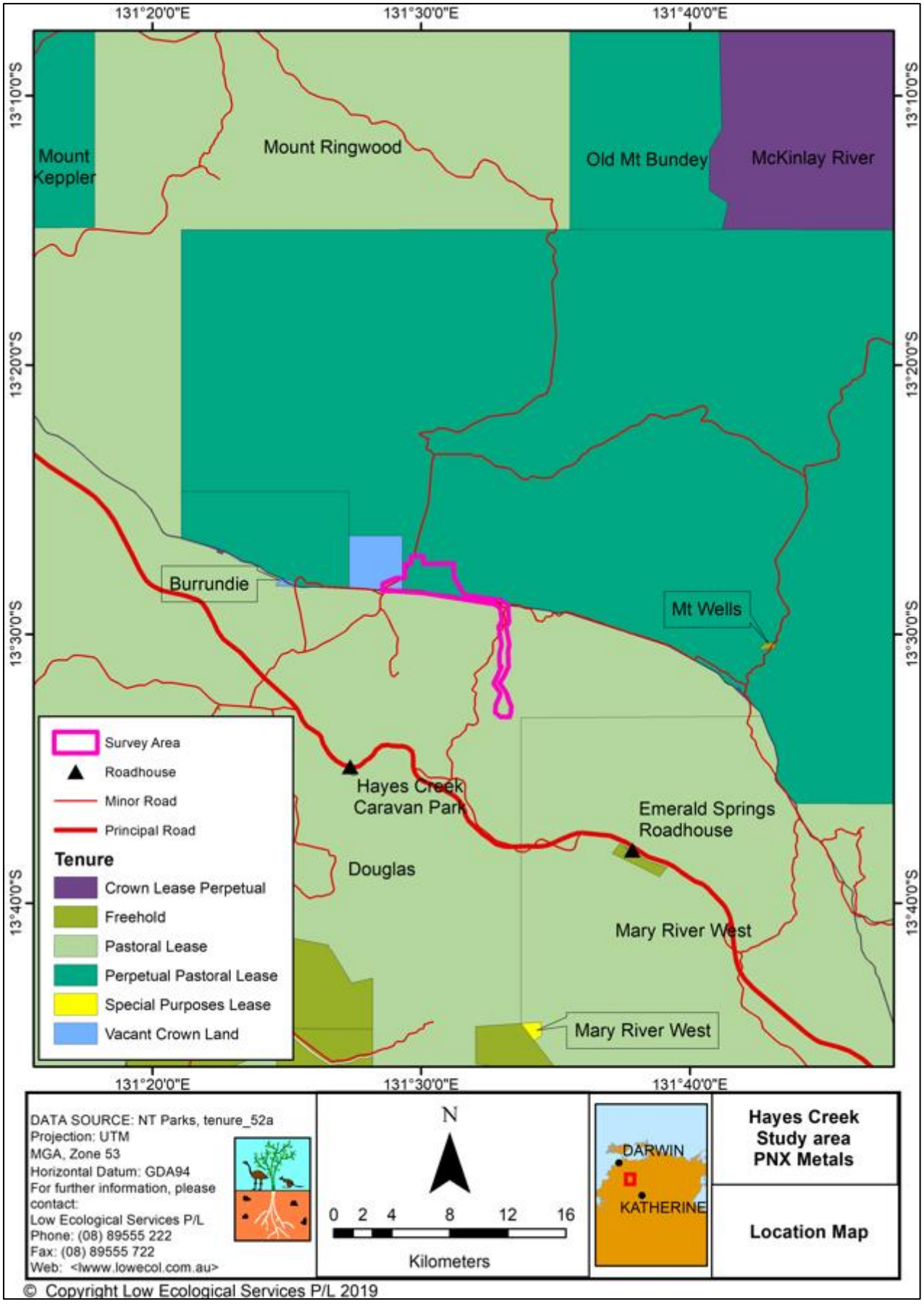

Figure 1. Location of the Hayes Creek Project survey area in relation to crown lease, freehold land, pastoral lease and vacant crown land

1.2 Purpose of This Report

PNX Metals commissioned Low Ecological Services P/L (LES) through ERIAS Group to undertake two on-ground flora and fauna surveys (to allow for seasonal variation) within and adjacent to the proposal area (hereafter referred to as the survey area) (Figure 1). The survey area covers 14.96 km^2. A desktop assessment was undertaken to provide prior information of the existing environment of the survey area and to consider the likelihood that threatened species may occur in the areas.

The May 2017 on-ground survey was based on the findings of the desktop assessment. Flora and fauna species observed in all major habitat types were recorded, and targeted surveying for threatened species identified in the desktop assessment was undertaken. Introduced flora and fauna species and existing disturbance within the survey area was also recorded. Surveys were designed in line with the NT Environment Protection Authority (NT EPA) *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT Environment Protection Authority, 2013), the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst, et al., 2007) and the Commonwealth guidelines for threatened species, including *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011) and *Survey Guidelines for Australia's Threatened Birds* (Department of Environment, Water, Heritage and the Arts, 2010).

The scope of the assessment was to:

- Characterise the vegetation and habitat types in the survey area;
- Assess the likelihood that any flora and fauna species listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or *Territory Parks and Wildlife Conservation Act 1976* (TPWC Act) will be present in the survey area;
- Identify any introduced flora and fauna in the survey area, assess their abundance and identify any potential source populations that may impact the survey area;
- Assess the impact of introduced herbivores to the survey area and outline mitigation measures;
- Assess the potential for any significant impacts on threatened flora and fauna species and communities (as classified by the EPBC Act or TPWC Act) as a result of the proposal;
- Initial assessment of aquatic ecology; and
- Recommend management and mitigation measures specific to any species at risk from the proposal as well as significant species.

An additional, late dry-season survey was undertaken in August 2019. The purpose of this survey was to undertake further targeted surveys for threatened species in the proposal footprint.

1.3 Legislative Context

1.3.1 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's key piece of environmental legislation, which commenced on July 16, 2000. The objectives of the EPBC Act are to provide for the protection of Matters of National Environmental Significance (MNES) and to promote the conservation of biodiversity. The EPBC Act focuses Australian Government interests on the protection of MNES, with the states and territories having responsibility for matters of state and local significance. The EPBC Act identifies MNES as:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (listed under the Ramsar Convention);
- Listed threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas;
- The Great Barrier Reef Marine Park;
- Nuclear actions (including uranium mines); and
- A water resource, in relation to coal seam gas development and large coal mining development.

1.3.2 State Legislation

Territory Parks and Wildlife Conservation Act 2006

The *Territory Parks and Wildlife Conservation Act* (TPWC Act) is "an Act to make provision for and in relation to the establishment of Territory Parks and other Parks and Reserves, and the study, protection, conservation and sustainable utilisation of wildlife". Under the TPWC Act, all native species are classed as protected wildlife. The Act includes 'Principles of Management', which require that threatened wildlife be managed in a manner that "maintains or increases their population and the extent of their distribution within the Territory at or to a sustainable level". `

Environmental Assessment Act 1982 and Environmental Assessment Administrative Procedures 1984

The *Environmental Assessment Act* (EA Act) and the *Environmental Assessment Administrative Procedures 1984* is administered by the NT Environmental Protection Agency (EPA). The EA Act provides a framework for the assessment of potential environmental impacts of developments. The object of the EA Act is to ensure that matters affecting the environment to a significant extent are fully examined and considered in decisions by the NT Government. The assessment process also evaluates the effectiveness of the proposed safeguards to mitigate these impacts during construction and operational phases of the development.

Mining Management Act 2001

The *Mining Management Act 2001* (MM Act) is administered by the Department of Primary Industry and Resources (DPIR). The objectives of the MM Act are to ensure that mining in the NT is conducted in accordance with best practice standards for health, safety and the environment. Under the MM Act, an application for authorisation to carry out mining activities must include a Mining Management Plan (MMP).

Weeds Management Act 2001

The *Weeds Management Act 2001* (WM Act) is administered by the NT Department of Environment and Natural Resources (DENR). The objective of the WM Act is to prevent the spread of weeds within, into and out of the NT and to ensure that the management of weeds is an integral component of land management. The WM Act is linked to the *Northern Territory Weeds Management Strategy 1996-2005* which led to a series of Statutory Plans being developed for each declared weed. Declared weeds are grouped into three categories; Schedule A (weeds to be eradicated), Schedule B (Weeds which growth and spread must be controlled) and Schedule C (weeds not to be introduced to the Territory).

Other legislation that may be applicable to the proposed mine includes:

1.3.3 Other Applicable Legislation

- General
  - *Mineral Titles Act 2016.*
  - *Northern Territory Environmental Protection Authority Act 2012.*
- Land use
  - *Planning Act 2016.*
  - *Aboriginal Land Act 2013.*
  - *Crown Lands Act 2014.*
  - *Soil Conservation and Land Utilization Act 2016.*
  - *Bushfires Act 2014.*
  - *Pastoral Land Act 2016.*
- Cultural and heritage
  - *Northern Territory Aboriginal Sacred Sites Act 2013.*
  - *Heritage Act 2016.*
- Water quality and biodiversity conservation
  - *Water Act 2016.*
  - *Biological Control Act 2016.*
  - *Public and Environmental Health Act 2016.*
  - *Weeds Management Act 2001.*
- Air quality, noise and waste management
  - *Waste Management and Pollution Control Act 2016.*
  - *Public and Environmental Health Act 2016.*
- Safety and environmental compliance
  - *Work Health and Safety (National Uniform Legislation) Act 2016.*
  - *Environmental Offences and Penalties Act 2011.*
  - *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2016.*
  - *Dangerous Goods Act 2012.*

2 METHODS

2.1 Desktop Review

Literature and database searches were undertaken to gain an understanding of the ecological context of the survey areas. Data collated from database searches provided information on the fauna and flora species known to occur in the region, particularly those of conservation significance (threatened, near threatened or data deficient). A search of Australian Bureau of Meteorology (BoM) climate data (Bureau of Meteorology, 2019) and available spatial data were undertaken to provide an overview of the climate, soils, vegetation and habitats of the lease areas and surrounds. A literature review was performed to obtain an understanding of data available and validity thereof, within and surrounding the lease areas.

2.1.1 Database Review

A database review including GIS mapping was undertaken using several data sources to provide an ecological context of the landscape, vegetation, habitats and climate of the lease areas. The sources include:

- Climate data online (Bureau of Meteorology, 2019);
- Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Cresswell, 1995);
- Australian Hydrological Geospatial Fabric (Bureau of Meteorology, 2019);
- GEODATA TOPO 250K Series 3 (Geoscience Australia, 2006);
- Directory of Important Wetlands in Australia (Environment Australia, 2001);
- Ramsar Wetlands of Australia (Department of the Environment and Energy, 2018);
- Geological Map of the Northern Territory (Ahmad, 2000);
- Digital Atlas of Australian Soils (Northcote, 1968);
- Report on the land systems of Northern Australia (Lynch, et al., 2012);
- NTVIS – NT Data Compilation for the National Vegetation Information System (ESCAVI, 2003)
- Vegetation Survey of the Northern Territory Australia: Notes to accompany 1: 100, 000 Map Sheets (Wilson, et al., 1990);
- North Australia and Rangelands Fire Information (North Australia and Rangelands Fire Information, 2019); and
- Satellite imagery.

The EPBC Protected Matters Search Tool PMST identifies MNES that may occur in a given area (see Section 1.3.1 for a description of MNES). The PMST identifies EPBC listed flora and fauna species and communities based on predicted distributions of the species and/or their habitat, rather than known records. The PMST may predict the occurrence of a species or community in an area when there are no documented records from the area.

The NT Flora Atlas (Department of Environment and Natural Resources, 2019) and NT Fauna Atlas (Department of Environment and Natural Resources, 2011) provides a list of threatened, non-threatened and introduced fauna and flora species recorded in the NT. The Species of National Environmental Significance (Public Grids) database also provided spatial information on the likelihood of species or species habitat occurrences (Department of the Environment and Energy, 2019). Interrogation of the databases of Sites of Conservation Significance (SoCS) (Department of Environment and Natural Resources, 2009) and Sites of Botanical Significance (SoBS) (Department of Environment and Natural Resources, 2000) were also undertaken to determine any SoCS or SoBS in the in the vicinity of the survey area.

Searches of the PMST and the NT Flora and Fauna Atlases within a 20 km radius of the survey area provided lists of the species of conservation significance that occur or may occur within the survey area. Species of conservation significance are those that are listed as threatened under the EPBC Act and/or TPWC Act, or as near threatened or data deficient under the TPWC Act. A search of the Fish Atlas of Northern Australia (James Cook University, 2017) also provided information on the fish species that may occur within the survey area. Threatened species identified in the desktop assessment were assessed for their likelihood of occurrence based on appraisal of NT Fauna and Flora Atlas and PMST search tool, assessment of habitat present in the survey area, literature review concerning identified threatened species and field survey results.

Geology, soil, land system and vegetation mapping provided information on habitats present within the survey area. This was then cross-referenced with information on threatened species habitat requirements obtained from the published literature and habitats in which mapped records occurred to determine if threatened species habitat was present or likely to be present. Each species listed as threatened was then given a likelihood of occurrence in the lease areas of either low, moderate or high (Table 2).

Table 2. Likelihood of occurrence ranking criteria for EPBC and TPWC listed species.

Likelihood of occurrence	Threatened flora criteria	Threatened fauna criteria
High	A search of the NT Flora Atlas identified records of the species within 20 km of the survey area and potentially suitable habitat was identified by the desktop study.	A search of the NT Fauna Atlas identified records of the species within 20 km of the survey area and potentially suitable habitat was identified by the desktop study.
Moderate	A search of the NT Flora Atlas did not identify records of the species within a 20 km radius of the survey area. However, potentially suitable habitat was identified by the desktop study.	A search of the NT Fauna Atlas did not identify records of the species within a 20 km radius of the survey area. However, potentially suitable habitat, or habitat that may occasionally be used by the species, was identified by the desktop study.
Low	A search of the NT Flora Atlas did not identify records of the species within a 20 km radius of the survey area, and no potentially suitable habitat was identified by the desktop study. Potentially suitable habitat was identified during the desktop study, but the survey area is outside of the species known range.	A search of the NT Fauna Atlas did not identify records of the species within a 20 km radius of the survey area, and no potentially suitable habitat was identified by the desktop study. Potentially suitable habitat was identified during the desktop study, but the survey area is outside of the species known range.

2.1.2 Literature Review

A literature review provided information on the species occurring or potentially occurring within the lease areas and surrounds. Information was collated to assess the potential for species of conservation significance to occur within the lease areas and surrounds, and the likelihood that proposed operations would impact on these species of conservation significance. Sources of literature reviewed include:

- Species Profile and Threats Database (Department of the Environment, 2019) for information about species listed in the EPBC Act including information sheets, survey guidelines, recovery plans, and Threat Abatement Plans for Key Threatening Processes;
- Northern Territory Threatened Species fact sheets published by DENR;
- FloraNT – Northern Territory Flora Online (Northern Territory Herbarium, 2015);

- DENR Sensitive vegetation in the Northern Territory Factsheets (Department of Environment and Natural Resources, 2018); and
- Scientific literature.

2.2 Field Surveys

Two on-site flora and fauna surveys of the survey area were undertaken. The first was undertaken between 15th-18th of May 2017 and the second between 20th -24th August 2019. The surveys were designed to gain a more detailed understanding of the environment of the survey area, as well as to survey for species of conservation significance. During the May 2017 survey, six survey sites were chosen for detailed surveying and establishment of live-trapping grids (Figure 2, Table 3, Appendix 2). Three of these sites (FH2, IB1, MB5; see Figure 2) were situated in the production areas, one in each area targeting habitat types potentially important to conservation significant species. The production areas and in particular the Fountain Head production area, were largely disturbed, as a result of extensive clearing during previous mining operations and cattle grazing. Three additional sites (HR3, HR6, HR11; see Figure 2) were established in undisturbed habitat types corresponding to those identified within production areas. The undisturbed sites were placed adjacent to the production areas identified by PNX in order to avoid habitat already disturbed by previous mining activity. Motion-sensing cameras were set up in habitats identified as potentially suitable for one or more targeted threatened species. Three were located at live-trapping sites whilst four were placed in other sites.

After the May 2017 survey, the NT EPA concluded that there is a low likelihood of significant impacts on terrestrial flora and fauna from the proposal and did not require further assessment (NT Environment Protection Authority, 2018). Despite this, the Final Terms of Reference (ToR) for the proposal (NT Environment Protection Authority, 2019) required that updated results of targeted surveys for threatened species in areas where vegetation is to be cleared as part of the proposal, be provided. Therefore, sites surveyed and methods employed during August 2019 were chosen to target species identified as having a moderate or high likelihood of occurring within the survey area (Table 12; Table 14; **Error! Reference source not found.**; **Error! Reference source not found.**; Table 17)

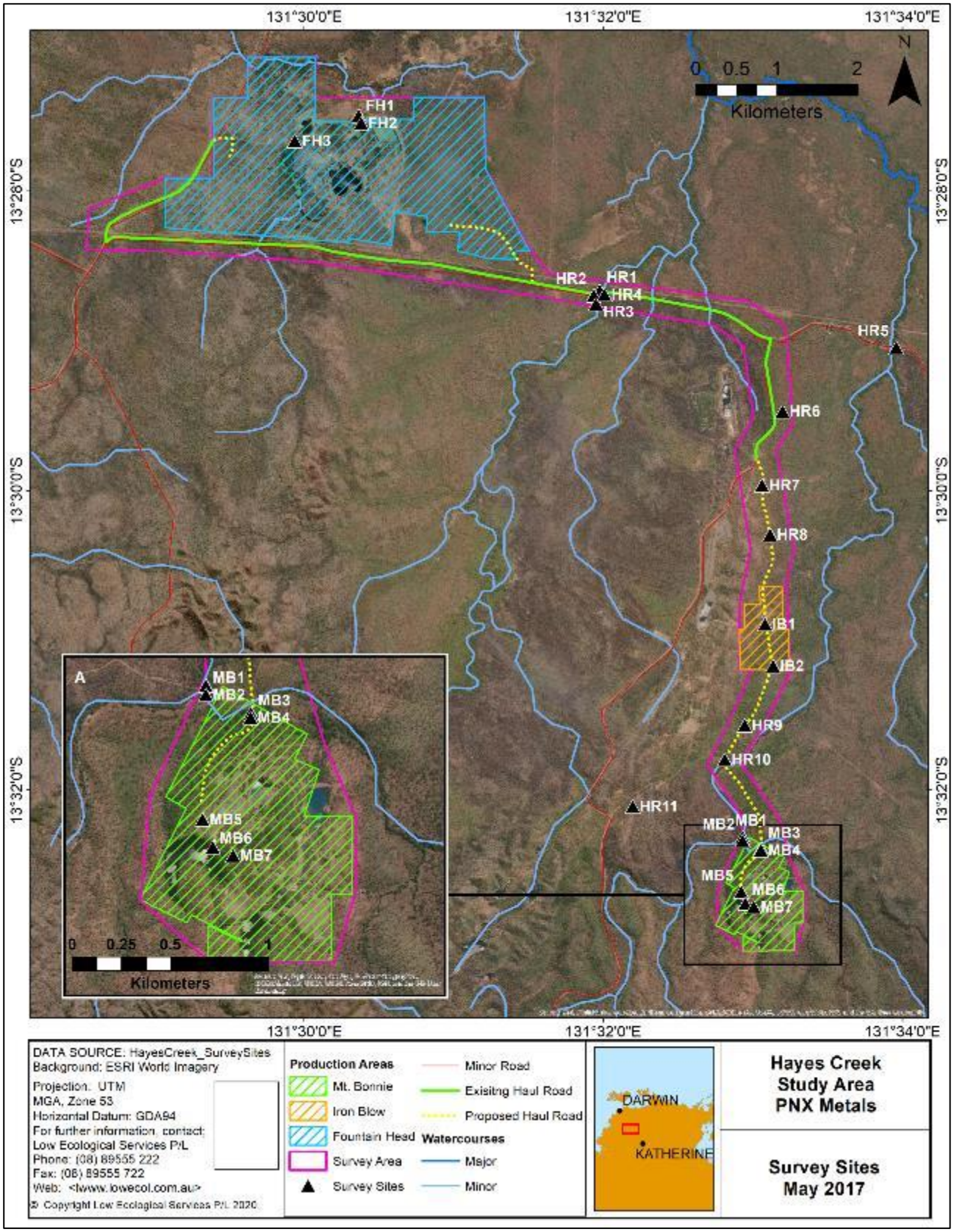

Figure 2. Location of sites surveyed during May 2017 in the Hayes Creek Project survey area. See Table 3 for survey methods used at each site. Inset A provides a closer view of the Mt Bonnie area for clarity and is identified by the black box in the main map. See Table 3 for survey methods used at each site.

Table 3. Methodology used at each survey site during the May 2017 field survey. See Figure 2 for location of survey sites.

Area	Site	Site description	Vegetation transect	Live-trapping	Bat detector	Bird survey	Secondary sign survey	Area search	Camera trap	Spotlighting	Call playback	Aquatic survey	Gouldian finch habitat survey
Fountain Head	FH1								X				
Fountain Head	FH2	X	X	X	X	X	X	X					
Fountain Head	FH3					X							
Haul Road	HR2								X				
Haul Road	HR1					X				X			
Haul Road	HR10	X				X		X	X	X	X		
Haul Road	HR11	X	X	X	X	X	X	X	X				
Haul Road	HR3	X	X	X	X	X	X	X		X	X		
Haul Road	HR4					X						X	
Haul Road	HR5					X						X	
Haul Road	HR6	X	X	X	X	X	X	X					
Haul Road	HR7	X				X		X	X	X	X		
Haul Road	HR8									X	X		
Haul Road	HR9									X	X		
Iron Blow	IB1	X	X	X	X	X	X	X		X	X		
Iron Blow	IB2									X	X		
Mount Bonnie	MB1					X	X	X					
Mount Bonnie	MB2	X										X	
Mount Bonnie	MB3							X	X				
Mount Bonnie	MB4	X				X	X	X	X	X			
Mount Bonnie	MB5	X	X	X	X	X	X	X	X	X			
Mount Bonnie	MB6					X							
Mount Bonnie	MB7						X	X					X

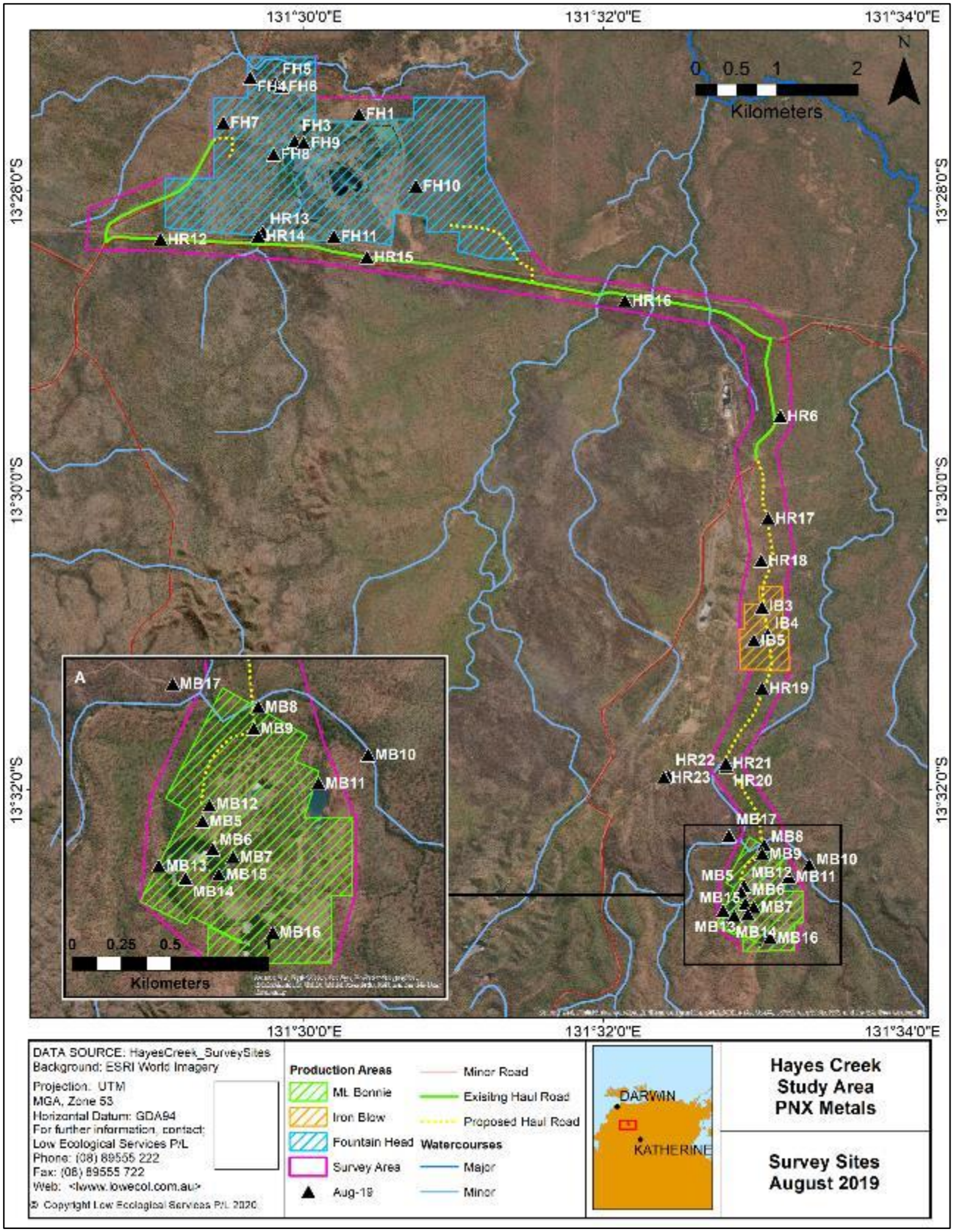

Figure 3. Location of sites surveyed during August 2019 in the Hayes Creek Project survey area. Inset A provides a closer view of the Mt Bonnie area for clarity and is identified by the black box in the main map. See Table 4 for survey methods used at each site.

Table 4. Methodology used at each survey site during the August 2019 field survey. See Figure 3 for location of survey sites. X: conducted at site, A: active bat survey with portable bat detector, P: passive bat survey with static bat detector.

Footprint area	Site	Site description	Vegetation transect	Live-trapping	Bat detector	Bird survey	Secondary sign survey	Area search	Camera trap	Spotlighting	Call playback	Aquatic survey	Gouldian finch habitat survey
Fountain Head	FH1			X									
Fountain Head	FH3					X							
Fountain Head	FH4				X A								
Fountain Head	FH5				X P								
Fountain Head	FH6					X							
Fountain Head	FH7				X A								
Fountain Head	FH8	X											
Fountain Head	FH9					X							
Fountain Head	FH10	X											
Fountain Head	FH11	X		X		X							
Haul Road	HR6	X		X	X P								
Haul Road	HR12				X A								
Haul Road	HR13					X		X					
Haul Road	HR14								X				
Haul Road	HR15				X A								
Haul Road	HR16					X							X
Haul Road	HR17												X
Haul Road	HR18												X
Haul Road	HR19				X A								
Haul Road	HR20	X		X	X A	X							X
Haul Road	HR21								X				
Haul Road	HR22								X				

Footprint area	Site	Site description	Vegetation transect	Live-trapping	Bat detector	Bird survey	Secondary sign survey	Area search	Camera trap	Spotlighting	Call playback	Aquatic survey	Gouldian finch habitat survey
Haul Road	HR23				X P								
Haul Road	HR24	X											X
Iron Blow	IB3				X A					X			
Iron Blow	IB4			X									
Iron Blow	IB5	X				X							X
Mount Bonnie	MB5					X							
Mount Bonnie	MB6					X		X					
Mount Bonnie	MB7												X
Mount Bonnie	MB8	X				X							X
Mount Bonnie	MB9				X P								
Mount Bonnie	MB10					X		X					X
Mount Bonnie	MB11				X A					X			
Mount Bonnie	MB12				X A					X			
Mount Bonnie	MB13												X
Mount Bonnie	MB14												X
Mount Bonnie	MB15					X							X
Mount Bonnie	MB16	X		X		X		X					

2.2.1 Landscape, Vegetation and Flora surveys

Characterisation of vegetation communities across the site was undertaken using a combination of vegetation quadrats, transects, driving transects or walking meanders across survey sites according to standard survey requirements.

A site description was carried out within a 50 m x 50 m quadrat at ten survey sites during the May 2017 survey and nine sites during the August 2019 survey (Table 3, Table 4). Site descriptions provided an overall snapshot of the landscape, geology, soil, dominant flora species and vegetation structure and density at each site. The presence of termite mounds, woody debris and previous disturbance, weeds were also noted. Photographs were taken at each site representative of the landscape and vegetation community, facing north, south, east and west. A complete list of all flora species present within each quadrat was collated by doing a walkover of the quadrat during May 2017. Comprehensive flora lists were not collected during August 2019 as this survey effort targeted threatened species and their habitat in line with the ToR. Voucher specimens were taken where plants could not be identified in the field. Botanists at the Northern Territory Herbarium, Darwin, identified voucher specimens.

During the May 2017 survey, 100 m point-intercept vegetation transects were conducted at the six live-trapping sites and species present were recorded at 1 m intervals to increase the likelihood that flora secies present were detected.

2.2.2 Fauna Surveys

General survey methodology follows the NT EPA *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT Environment Protection Authority, 2013).

Survey methods used to determine the presence of threatened species follow those suggested in the *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011) *Survey Guidelines for Australia's Threatened Bats* (Department of the Environment, Water, Heritage and the Arts, 2010)*, Survey Guidelines for Australia's threatened reptiles* (Department of Sustainability, Environment, Water, Population and Communities, 2011) and *Survey Guidelines for Australia's Threatened Birds* (Department of the Environment, Water, Heritage and the Arts, 2010). Targeted searches were conducted during May 2017 and August 2019 for threatened species identified by the EPBC PMST or NT Flora and Fauna Atlases as occurring or potentially occurring within the survey area, that were assessed as having a moderate or high likelihood of occurring within the survey area (Table 5; see also Section 3.11.2).

Habitat types consistent with those required by the Gouldian finch were identified during the desktop assessment (discussed in Section 3.11) and during the May 2017 survey (Section 4), i.e. areas of stony hill woodlands dominated by *Eucalyptus tintinnans* and *E. brevifolia* (Brazill-Boast, et al., 2011; Dostine, et al., 2001). These tree species are hollow bearing, providing critical nesting sites for the Gouldian finch (Tidemann, et al., 1992). In the post-breeding season (late dry season and early wet season), the birds disperse locally to surrounding lowlands to feed on a variety of grass species and availability to standing water bodies (Tidemann, et al., 1992; Tidemann, et al., 1999; Collins & McNee, 1992; Dostine, et al., 2001; Lewis, 2007; Liedloff, et al., 2009), also potentially present in the survey area. Therefore, additional habitat assessments were undertaken at 12 survey sites during the August 2019 survey to better describe the distribution of Gouldian finch (*Erythrura gouldiae*) habitat within the survey area. Data collected included landscape type, distance to closest water, disturbance variables (climate, fire, weeds, introduced herbivores), vegetation

community structure, dominant flora species and hollow attributes, including quantity, size class (1-4 cm, 4-8 cm, 8-10 cm and >10 cm) and average hollow height (placement within the tree), within a 1 ha quadrat.

Table 5. Type of survey undertaken to target species listed as threatened under the EPBC Act and TPWC Act potentially occurring within the survey areas

Scientific name	Common name	Habitat search	Live trapping	Bat detector	Secondary sign	Area search	Camera trap	Spotlighting	Call playback
Erythrotriorchis radiatus	Red goshawk	X				X			
Erythrura gouldiae	Gouldian finch	X				X	X		
Geohaps smithii	Partridge pigeon	X				X	X		
Rostratula australis	Australian painted snipe	X				X			
Tyto novaehollandiae kimberli	Masked owl	X						X	X
Antechinus bellus	Fawn antechinus	X	X				X	X	
Dasyurus hallucatus	Northern quoll	X	X		X		X	X	
Macroderma gigas	Ghost bat	X		X					
Mesembriomys gouldii gouldii	Black-footed tree-rat	X	X		X		X	X	
Phascogale pirata	Northern brush-tailed phascogale	X	X				X	X	
Rattus tunneyi	Pale field-rat	X	X				X	X	
Saccolaimus saccolaimus nudicluniatus	Bare-rumped sheath-tailed bat	X		X					
Varanus mertensi	Merten's water monitor	X	X			X	X		
Varanus mitchelli	Mitchell's water monitor	X	X			X	X		
Varanus panoptes	Floodplain monitor	X	X			X	X		

Habitat Search

Searches for potentially suitable habitat for threatened species (in addition to the Gouldian finch referenced in Section 2.1.1) were undertaken while traversing the survey area.

Live-trapping

Varying combinations of Elliott, cage and funnel traps were used at six live-trapping sites during both the May 2017 and August 2019 surveys. Sites consisted of 25 Elliott traps set at 10 m intervals around the perimeter of a 0.25 ha quadrat, a cage trap at each corner of the quadrat (where these were available), 2-8 funnel traps and 2 pitfall traps where possible. Funnel traps and pitfall traps were centred on 10 m drift fences. Rocky substrates precluded the use of pitfall traps at some sites. Layout of Elliott traps was modified slightly at sites falling within the alluvial floodplain areas (Fountain Head site and control site 1). A grid pattern replaced the standard box pattern in order to incorporate more of the site variation including creek banks, creek beds and floodplain areas. Elliott traps were baited with a mixture of peanut butter and oats. Cage traps were baited with sardines or tuna. All traps were checked each morning and animals processed (i.e. noting species, sex, reproductive status, body length and tail length) and released at the point of capture. Elliott traps were closed during the day and then opened in late afternoon when pitfall and funnel traps were re-checked.

Bat detectors

In May 2017, two bat detectors were deployed at six sites encompassing the six trapping survey areas. During the August 2019 survey, 13 sites were surveyed for bats; nine sites were surveyed by walking transects (active survey) and four using passive detectors deployed at sites for between 1 night (MB9, HR23) and 3 nights (FH5, HR6). The bat detectors were used to identify the bat species using each habitat and to determine if the threatened species, bare-rumped sheath-tailed bat and ghost bat were present. Echolocation calls recorded were identified for each species when possible and assigned to a species group when echolocation call structure overlapped. Bats were identified from the recordings by bat expert, Dennis Matthews.

Secondary sign surveys

Searches for secondary sign of fauna species (e.g. tracks and scats) were undertaken within a 250 m x 250 m quadrat at each site. Secondary sign was also recorded opportunistically during the surveys. Secondary sign included tracks, scats, scratchings and diggings.

Area search

Area searches were undertaken at each of the trapping sites and camera sites while vegetation surveys were being undertaken and opportunistically while checking and setting traps. Additional targeted area searches were conducted in habitat types identified for a number of target threatened species (Table 5).

Camera traps

Camera-traps were deployed at seven sites during the May 2017 survey and eight sites during the August 2019 survey to increase the likelihood of recording species not detected by other methods or to verify species presence. Camera-traps were either baited either peanut butter and oats or sardines or not baited depending on the targeted species. Six camera-traps were set facing horizontally (forwards), and one was set facing vertically (downwards/nadir) during the May 2017 survey. Horizontally oriented camera-traps are useful for the detection of larger animals including dingoes, cats and monitors whilst vertically oriented camera-traps target smaller animals where body measurements are required for identification purposes. All camera-traps were set horizontally during the August 2019 survey.

Spotlighting

Between two and three hours of spotlighting were conducted on each night of the survey during both May 2017 and August 2019, by vehicle and on foot. Vehicle spotlighting was undertaken along road transects throughout the survey area (utilising existing tracks only). Spotlighting on foot was undertaken at 9 sites within the survey areas. At each site, a walkover was undertaken while searching for eye-shine or movement of animals with a torch.

Call-playback

Call-playback was undertaken for masked owls following the method of Ward (2010), whereby:

1. The call of the masked owl is broadcast
2. For the first five minutes after the broadcast, surveyors listen for calls of masked owls and watch for silhouettes of birds flying in the area around the speaker without a spotlight
3. In the second five minutes, surveyors keep listening for owl calls but use a spotlight to look for owls in the trees around the site
4. When spotlighting, the surveyors do an initial scan of all the nearby trees, then spend the rest of the five minutes doing a more-careful search of the trees for owls and small mammals (potential prey)

In August 2019, call-playback was also undertaken for the ghost bat using methods developed by Nicola Hanrahan, whereby:

1. Ghost bat social vocalisations were broadcast for a period of 1-minute at a time.
2. Playback was conducting shortly after sunset when ghost bats would be expected to be leaving the roost.
3. During and after the broadcast surveyors scanned the sky for any ghost bats drawn to the calls and listened for any ghost bat low frewuency social calls.

Incidental observations

Incidental observations of fauna species were always recorded and all habitats during the field surveys.

2.2.3 Aquatic and Riparian Habitat Assessments

Aquatic and riparian habitat assessments were undertaken during the May 2017 survey but not the August 2019 survey. Streams and waterbodies within the survey area were categorised according to stream order (Department of Environment and Natural Resources, 2018). The Strahler stream classification system was utilised where waterways are given an ‘order’ according to the number of additional tributaries associated with each waterway (Department of Land Resource Management, 2016) (Figure 4). Stream order was then used to determine recommendations for riparian zone buffers around affected waterways within the survey area (Table 6).

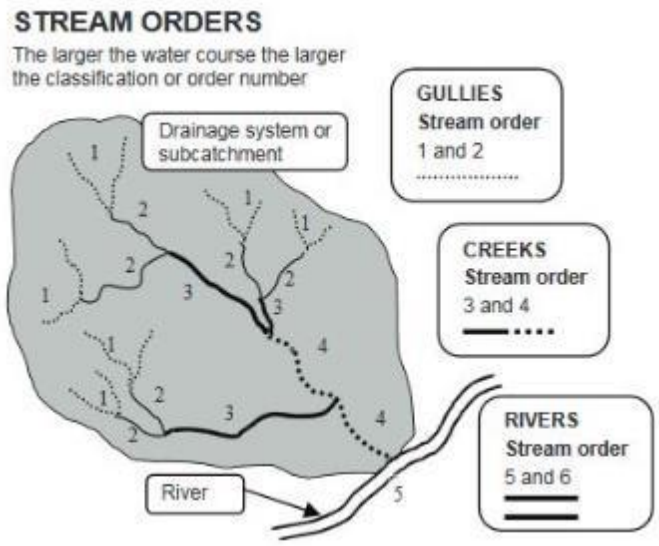

Figure 4. Stream orders as defined by the Straler stream classification system (Department of Environment and Natural Resources, 2018)

Table 6. Waterway buffers according to stream order (Department of Environment and Natural Resources, 2018).

Waterway	Stream order	Minimum buffer width (m)	Measure from
Drainage area	Not applicable	25	The outer edge of the seepage zone
Intermittent streams	First	25	The outer edge of riparian vegetation, where mapped otherwise the primary bank of the outer stream channel where there is more than one channel, or the stream is braided
Intermittent streams	Second	50	As above
Creeks	Third and fourth	100	As above
Rivers	Fifth and sixth	250	As above
Wetlands (e.g. swamps, lakes, billabongs) and mangroves	Not applicable	200	The outer edge of areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, brackish or salt, including areas of coastal marine waters.

Aquatic habitat assessments followed relevant sections extracted from the NT AusRivAS Manual (Lloyd & Cook, 1998). The assessment considered the suitability of habitats in terms of habitat diversity and extent, suitability for aquatic fauna groups, existing disturbances/modifications and riparian condition. Specific habitat features were recorded including substrate characteristics, habitat attributes and variety, vegetation and streamside cover, bank stability and presence of erosion. One site was assessed in the south (MB2 – Mt Bonnie Creek) and north (HR4 – Yam Creek) of the survey area and a downstream site (HR5 – Downstream Creek) was assessed for comparison (Figure 2, Table 3).

2.2.4 Other

GPS locations and extent of weed infestations were recorded.

2.2.5 Calculation of Habitat Loss

The survey area and disturbance areas within the three production areas and the Haul Road were overlayed on habitat mapping refined following the field surveys. The area of each habitat within the survey area, and the area of habitat within each of the disturbance areas was calculated in ArcGIS. Areas previously disturbed within the three production areas were mapped as a distinct habitat type in the habitat mapping. Field survey results also indicated that areas that were previously disturbed provided habitat for fauna, including the threatened Gouldian finch and near threatened buff-sided robin. Therefore, calculation of previously disturbed habitat (including heavily disturbed pastoral areas) to be re-developed, along with habitat that was not previously disturbed was undertaken.

2.2.6 Limitations of the Surveys

Records obtained from the NT Fauna and Flora Atlases display records from areas which have been surveyed previously. The lack of records at a locality commonly represents a lack of survey effort as opposed to the absence of various species in the area.

While invertebrates captured in traps were recorded, there are limited existing data and identification tools available for terrestrial invertebrates in the Top End. Therefore, only casual attempt was made to identify any trapped invertebrates to group, genus or species level. No targeted survey for invertebrates was undertaken during the on-ground survey, as this was not a part of the scope of works and no threatened invertebrate species were identified by the EPBC PMST or NT Flora and Fauna Atlases.

LES has attempted to carry out surveys at an appropriate spatial scale for the proposed development. While this will increase the chances of obtaining sufficient data required to detect the presence of threatened species, it cannot be guaranteed that the species lists are complete.

Surveys were aimed at detecting appropriate landscapes and assessing the potential presence of threatened species within the survey areas. Surveys to assess population abundance and density were not conducted within the survey areas and surrounds.

As the August 2019 survey was undertaken in the late dry season following period of rainfall deficit and a wet season with below average rainfall, many plants did not have characteristics that allowed identification to species level.

3 EXISTING ENVIRONMENT

3.1 Climate

The survey area has a tropical monsoonal climate, with distinct wet and dry seasons. The closest Australian Bureau of Meteorology (BoM) climate station to the survey area with consistent records of both rainfall and temperature (recorded between 1968-1979 and 1995-2019) is the Douglas River Research Farm, located approximately 50 km south-west of the survey area. Annual rainfall recorded at Douglas River Research Farm is variable and averages 1,245.83 ± 246.04 mm, with a wet season from December to March and dry season from May to September (Figure 5). Average temperatures vary little over the year, with mean maximum temperatures being 34.42 ± 0.66 °C (Figure 5) and warmest months September to December. Coolest temperatures are during the driest months of June to August with the mean minimum being 19.89 ± 0.70 °C.

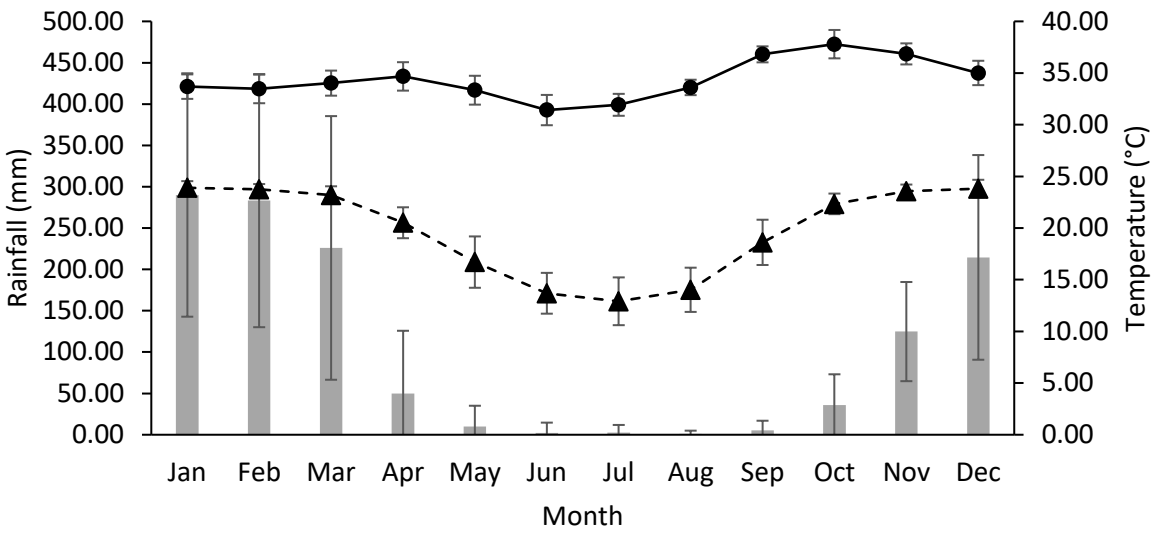

Figure 5. Monthly average rainfall (grey bars) and average monthly minimum (black triangles and dashed line) and maximum (black circles and solid line) temperature (°C) at Douglas River Research Farm based on data from the BoM's Climate Data Online (Bureau of Meteorology, 2019). Error bars indicate standard deviation.

3.2 Bioregion

The Interim Biogeographic Regionalisation of Australia (IBRA) provides a division of Australia into geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information (Department of Sustainability, Environment, Water, Population and Communities, 2012a). The survey area lies within the Pine Creek bioregion (Figure 6).

The Pine Creek Bioregion consists mainly of rugged ridges with undulating plains (Bastin & ACRIS Management Committee, 2008). Land use types in the bioregion include conservation, pastoralism, intensive rural freehold blocks, horticulture and mining. The bioregion also contains Aboriginal land (Bastin & ACRIS Management Committee, 2008). The Pine Creek bioregion is characterised by extensive and high frequency fire (Bastin & ACRIS Management Committee, 2008).

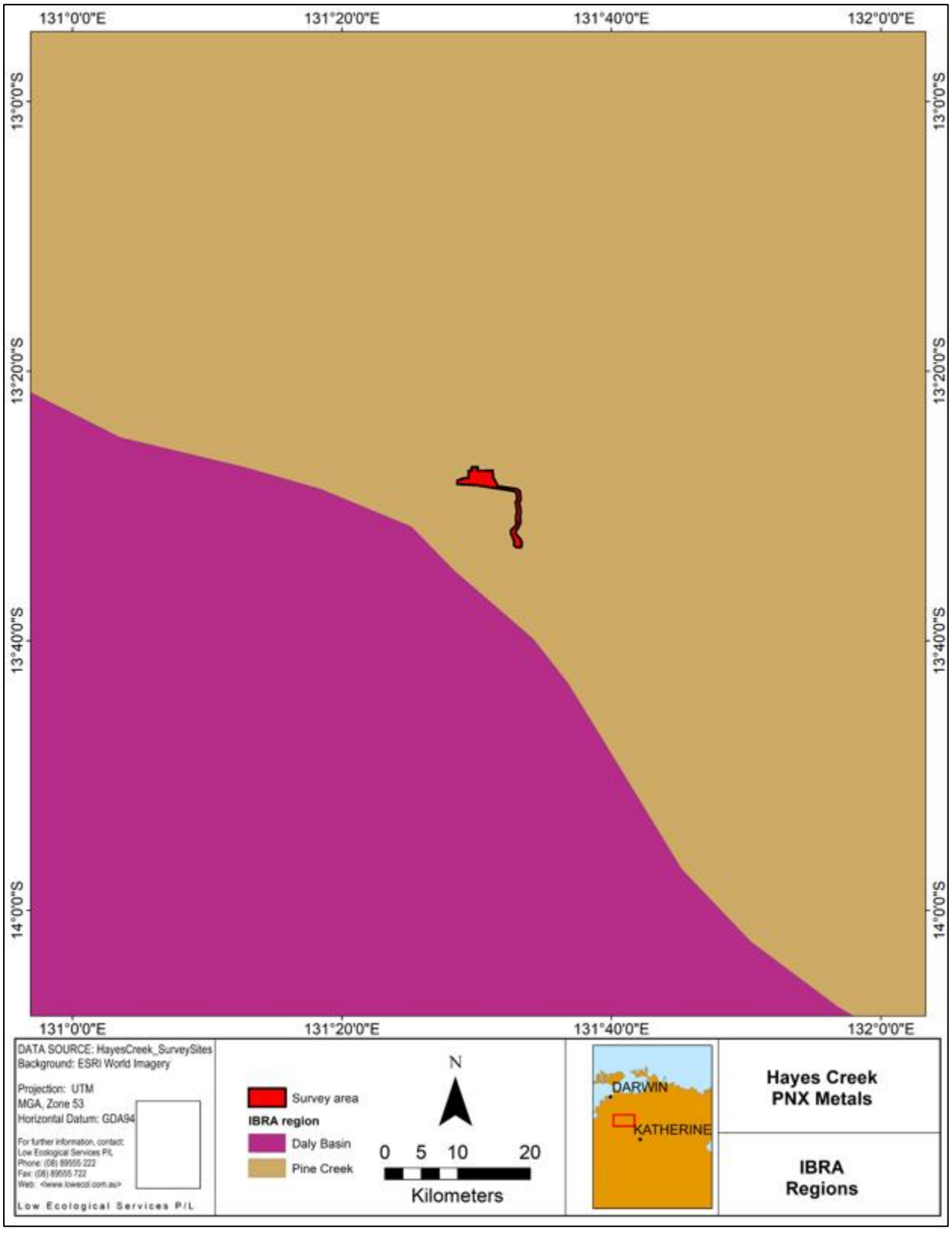

Figure 6. Interim Biogeographic Regionalisation for Australia (IBRA) bioregions in relation to Hayes Creek Project survey area (Department of Sustainability, Environment, Water, Population and Communities, 2012a).

3.3 Hydrology

The surface hydrology of the survey area consists of ephemeral watercourses and waterbodies as well as several man-made areas of permanent standing water. All three production areas fall within the Adelaide River catchment area (Bureau of Meteorology, 2019). The Margaret River, a large tributary of the Adelaide River, is situated within 1 km of the north-east corner of the survey area (Figure 7). Tributaries of the Margaret River pass through the survey area at multiple points along the existing Haul Road (the existing east-west Haul Road south of the Fountain Head site) and north of the Mt Bonnie site. These smaller watercourses are ephemeral and can result in large scale flows and associated flooding onto surrounding flood outs during high rainfalls, primarily during the wet season (November to April). Smaller creek lines, drainage depressions and ephemeral standing water bodies within the survey area provide important water sources for biodiversity during wet periods.

There are no Nationally Important Wetlands within the survey area. The nearest Nationally Important Wetland is Kakadu National Park 42 km east and the Daly River Middle Reaches 49km south-west of the survey area. There are no Ramsar Wetlands or Wetlands of National Significance located within the survey area. The nearest Ramsar Wetland is Kakadu National Park, located 42 km east of the survey area.

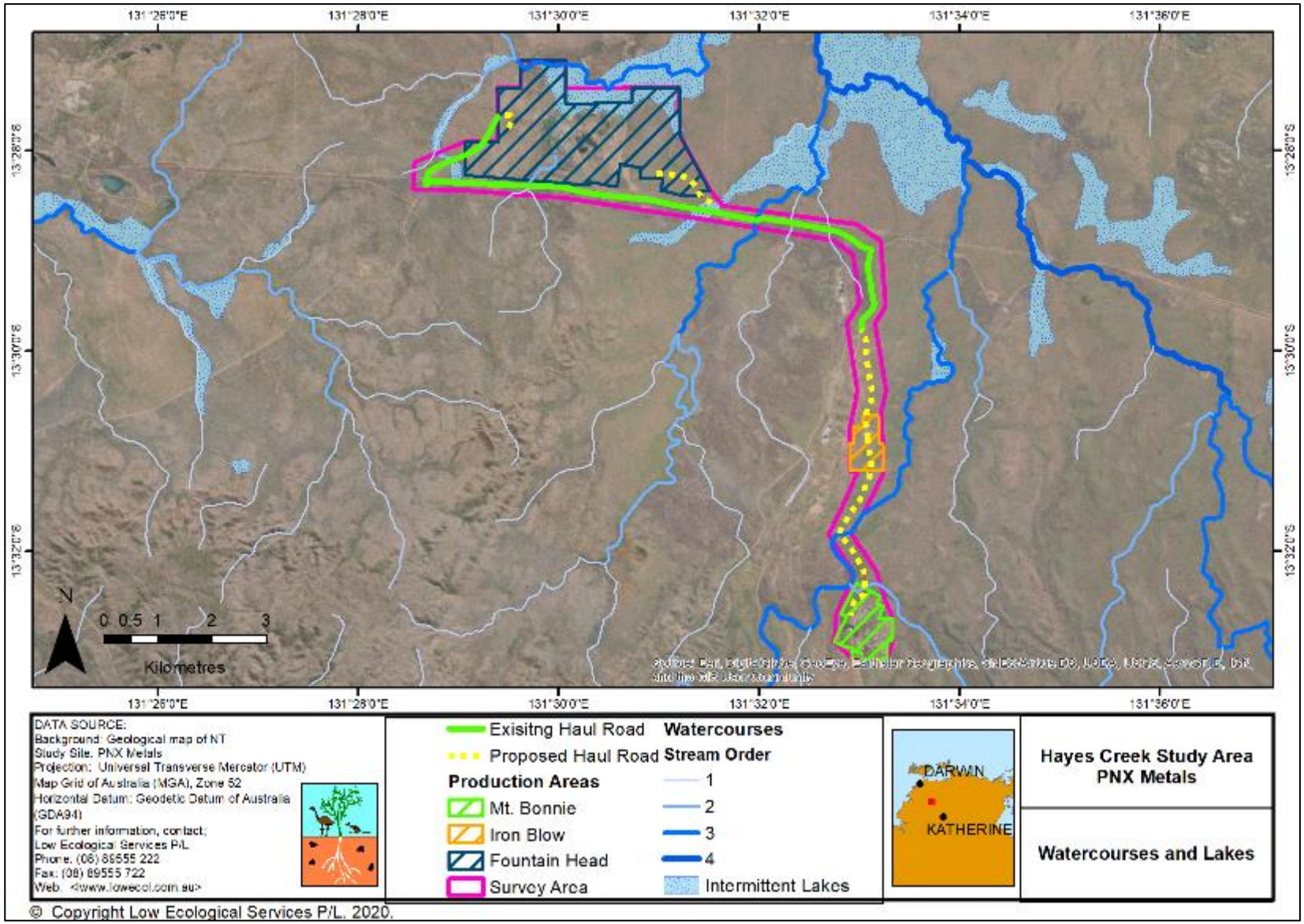

Figure 7. Location of Hayes Creek Project survey area in relation to watercourses.

3.4 Geology

The geological units of the survey area are described in Table 7 and mapped in Figure 8. The Fountain Head area is within geological unit P4. The Iron Blow and Mt Bonnie production sites are within geological unit P3. The proposed Haul Road passes through units P4 and P3.

Table 7. Description of geological units within the Hayes Creek Project survey area as described by Ahmad (2000).

Map unit	Rock type	Description
P3	Sedimentary	Greywacke, shale, siltstone, tuff, phyllite, chert, carbonaceous shale, banded iron formation (BIF), dolostone
P4	Sedimentary	Greywacke, shale, siltstone, sandstone
d4	Igneous	Mafic intrusive
g5	Igneous	Granite

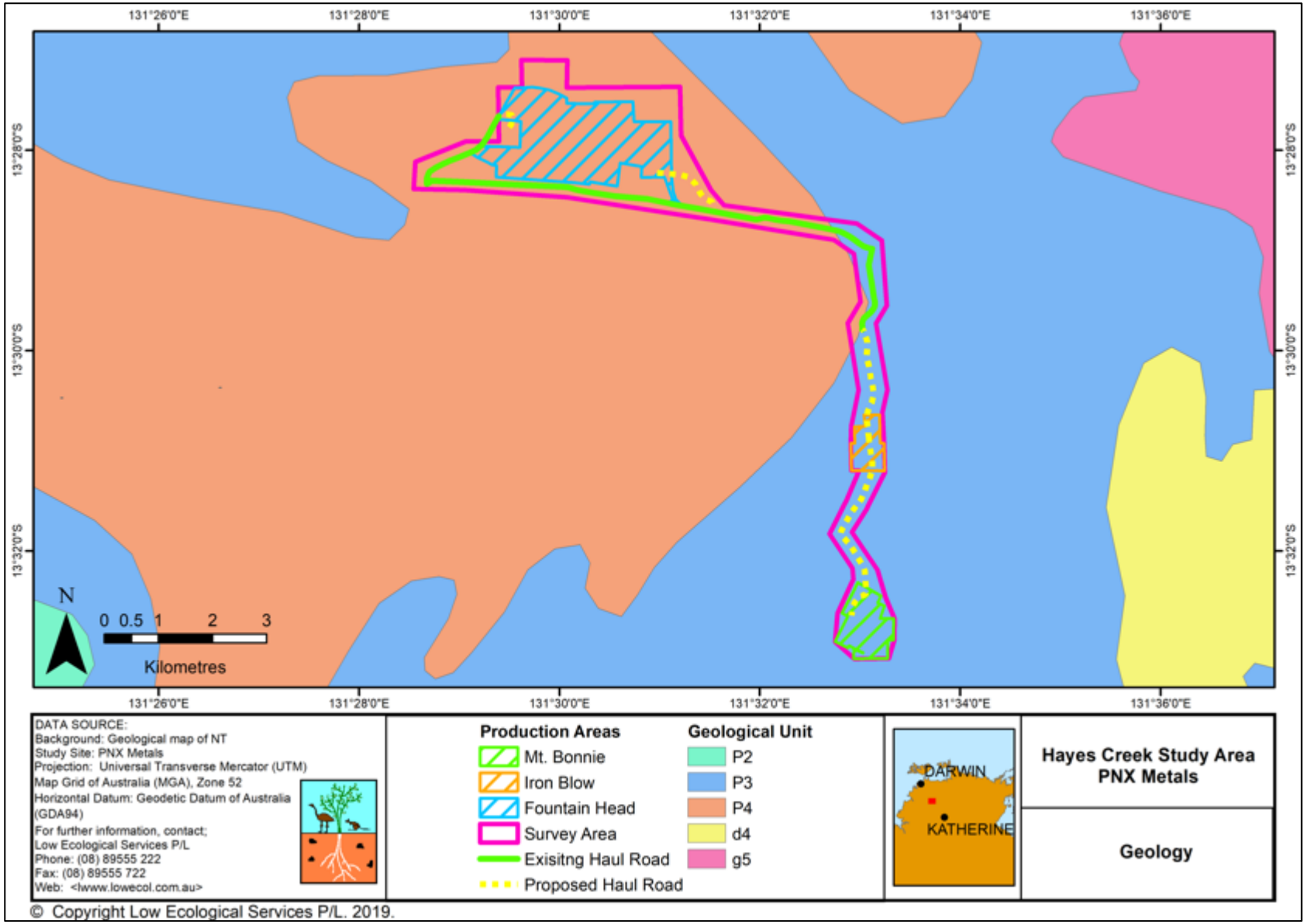

Figure 8. The Geological Map of the Northern Territory (Ahmad 2000) within and surrounding the Hayes Creek Project survey area. Geological units within the area are described in Table 7.

3.5 Soils

Soil types in the survey area have been mapped using the Atlas of Australian Soils (mapped by Bureau of Rural Sciences after Commonwealth Scientific and Industrial Research Organisation, 1991; described by Northcote et al., 1968). However, because the currently accepted classification system is the Australian Soil Classification (ASC) (Isbell & National Committee on Soil and Terrain, 2016) a conversion from the Atlas of Australian Soils to Australian Soil Classification was developed by (Ashton & McKenzie, 2001). Soil units within the survey area include Tb134 and JJ28. The soil units are described along with the ASC conversion in Table 8 and mapped in relation to the survey area in Figure 9. The Fountain Head and Iron Blow production areas and the proposed Haul Road are within the JJ28 and Tb134 soil units and the Mt Bonnie production area is entirely within the JJ28 soil unit.

Table 8: Description of soil types in the Hayes Creek Project survey area, including Australian Soils Atlas Description by Northcote (1968) and Australian Soil Classification conversion by Ashton & McKenzie (2001)

Soil unit	Australian Soils Atlas Description	ASC Conversion
Tb134	Strongly undulating to hilly lands on greywacke, siltstones, and sandstones with rock outcrops, and interspersed with gently sloping to flat-floored valleys of variable size and extent: soil dominance varies markedly between the valleys and the hilly portions. Chief soils of the basal hill slopes and the valleys are hard acidic, and also neutral, yellow mottled soils, including hard settling bleached acid and neutral soils, sometimes alkaline and usually in association with yellow and grey earths such as non-calcareous yellow acid earths and grey bleached neutral earths. Chief soils of the hill slopes are shallow stony and gravelly loams including pale grey-brown and firm shallow siliceous loams and sands such as hard-settling red duplex soils and yellow and yellow grey acid soils; and yellow earths such as acid bleached and acid mottled yellow bleached massive earths. Small areas of other soils, such as red acid massive earths, occur on included andesites and dolerite sills.	Sodosol: Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic and not strongly acidic. Hydrosols and soils with strongly subplastic upper B2 horizons are excluded.
JJ28	Low to steep hills, ridges and cuestas intersperse with small sandy plain areas, mainly on sandstones, with some shales; rock outcrops common; narrow valleys: chief soils are probably shallow stony sands pale sands without B-horizons, firm siliceous sand with pale sands with colour b horizons. Associated are slopes and plains of yellow earth sands with coherent earth subsoils, with gravelly ironstone and red non-calcareous massive earths, yellow neutral massive earths and mottled yellow earth soils; and narrow valley plains of yellow earths	Tenosol: Soils with generally only weak pedologic organisation apart from the A horizons. Encompasses a diverse range of soils that do not fit the requirements of any other soil orders and generally with one or more of the following: i. A peaty horizon. ii. A lumose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlays a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite or unconsolidated mineral materials. iii. A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or

Soil unit	Australian Soils Atlas Description	ASC Conversion
	such as mottled yellow bleached acid soils. Small areas of adjoining units may be included.	other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. iv. A1 horizons which have a more than weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. v. An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. vi. Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less, or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate). vii. A ferric or bauxitic horizon >0.2 m thick. viii. A calcareous horizon >0.2 m thick.
Wd13	Undulating to rolling and hill terrain on granites; many rock outcrops and tors on crests and upper slopes. Chief soils are sandy acidic yellow mottles soils.	Tenosol: Soils with generally only weak pedologic organisation apart from the A horizons. Encompasses a diverse range of soils that do not fir the requirements of any other soil orders and generally with one or more of the following: ix. A peaty horizon. x. A lumose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlays a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite or unconsolidated mineral materials. xi. A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xii. A1 horizons which have a more than weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xiii. An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xiv. Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less, or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate). xv. A ferric or bauxitic horizon >0.2 m thick. xvi. A calcareous horizon >0.2 m thick.

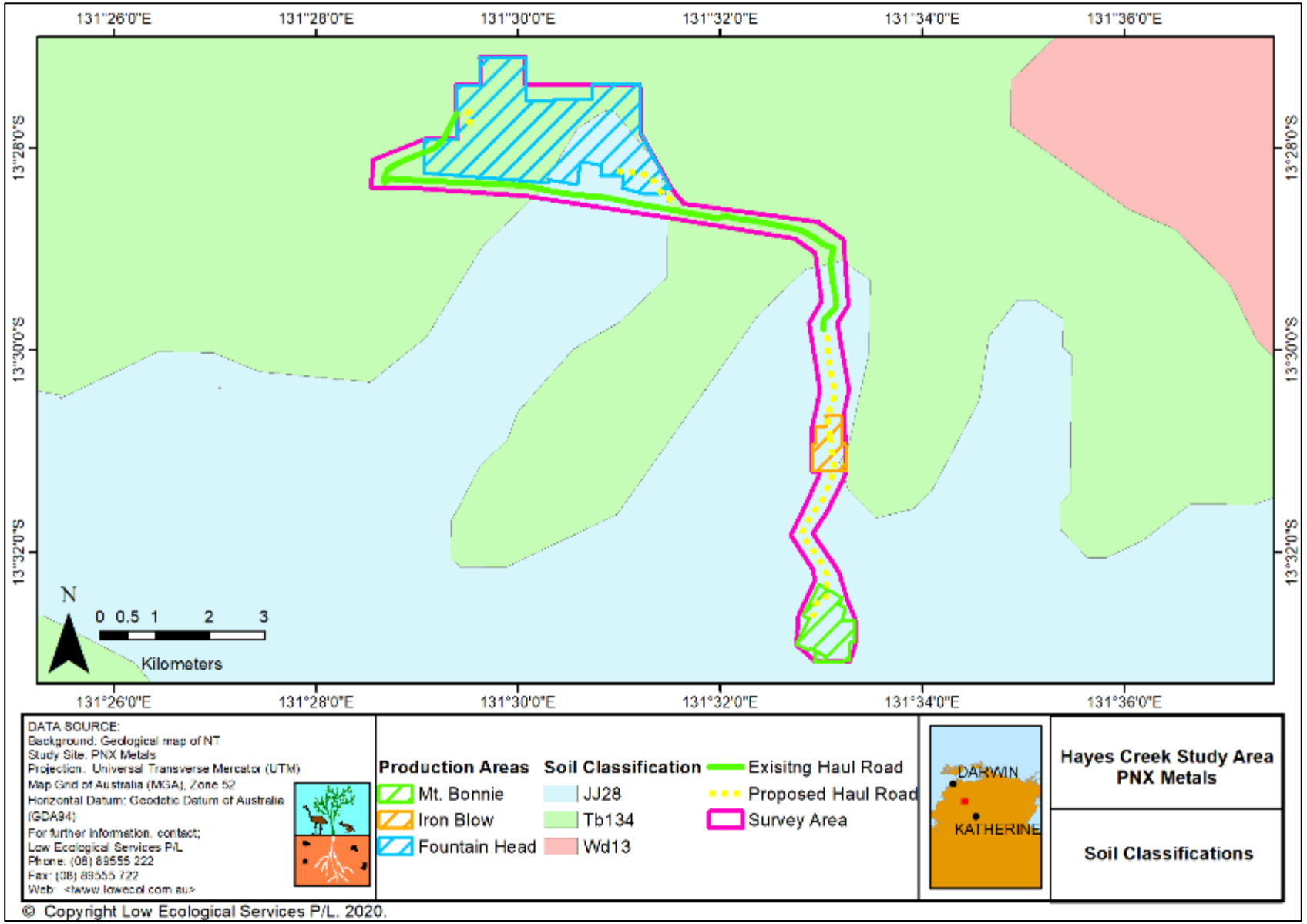

Figure 9. Soil Atlas classifications within and around the Hayes Creek Project survey area (Northcote, 1968)

3.6 Land Systems

Land system mapping of the area by (Lynch, et al., 2012) is available at a scale of 1:250,000. Land systems in the Hayes Creek Project survey area are described in Table 9 and mapped in Figure 10. The Fountain Head production area is predominantly within the Rumwaggon land system and extends slightly into the McKinlay land system. The Iron Blow production area is within the Baker and Rumwaggon land systems. The Mt Bonnie production area is predominantly within the Baker land system, but also extends into the Rumwaggon land system. The Haul Road passes through the Rumwaggon land system for the majority of the proposed route, but also falls within the Baker and McKinlay land systems in the south and north of the survey area, respectively.

Table 9. Description of land units within the Fountain Head (FH), Iron Blow (IB) and Mt Bonnie (MB) survey areas of the Hayes Creek Project survey area (Lynch, et al., 2012).

Land Unit	Landform	Soil description	Vegetation
Baker	Rugged hills and strike ridges with intervening narrow valleys and short lower slopes on folded Burrels Creek greywacke, sandstone and siltstone	Skeletal soils and outcrop with minor sandy red and yellow gradational soils	Mid-high woodland of *C. dichromophloia, E. miniata, C. bleeseri, E. tectifica* and *C. terminalis* over *Sorghum spp., Themeda triandra* and *Chrysopogon spp.*
McKinlay	Alluvial floodplains, swamps, drainage depressions and alluvial fans; sandy, silty and clay soils on Quaternary alluvium	Siliceous sands, silty brown and yellow earths, yellow podzolics	Mid-high grassland of *Chrysopogon spp., Themeda triandra, Cyperus spp.* with minor areas of woodland (*C. papuana, C. polycarpa, Pandanus sp., Melalueca spp., E. apodophylla*)
Rumwaggon	Low rounded hills and low gravelly ridges with intervening broad alluvial flats; developed on highly weathered rocks of Lower Proterozoic age.	Lithosols on rises, yellow pozolics on alluvial areas.	Mid-high open woodland of *E. polysciadia, C. ferruginea, C. foelscheana, E. tectifica, Xanthostemon paradoxus* over *Chrysopogon spp., Sorghum spp., Eriachne triseta*

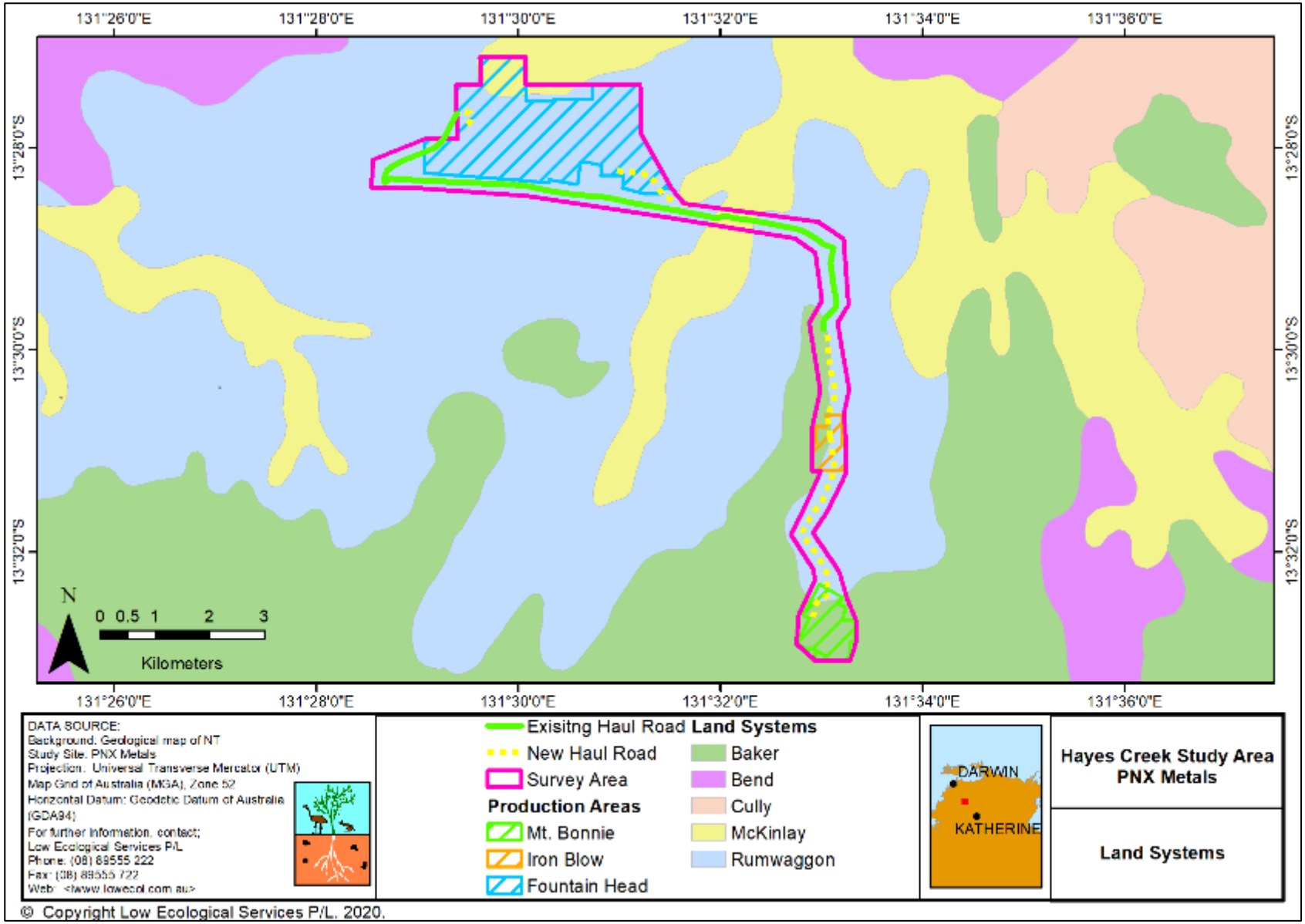

Figure 10. Land system mapping for the Hayes Creek Project survey area (Lynch, et al., 2012). Descriptions of each land system are provided in Table 9.

3.7 Vegetation Types

Vegetation in the survey area has been mapped at a scale of 1: 100 000 in the Vegetation Survey of the Northern Territory (Wilson, et al., 1990). There are four vegetation types occurring within the survey areas and these are described in Table 10 and mapped in Figure 11. The Fountain Head production area is within vegetation units 316, 572 and 1064. The Iron Blow production area is within vegetation units 572 and 1064. The Mt Bonnie production area is within vegetation units 333 and 1064. The proposed Haul Road passes through vegetation units 572, 1064, 316 and 333.

Table 10. Description of vegetation types within the Hayes Creek Project survey area as mapped by Wilson et al. (1990)

Vegetation unit	Broad vegetation classification	Structural formation	Fine vegetation description
316	Melaleuca woodland	Woodland	*Melaleuca viridiflora/leucadendra* +/- *Melaleuca argentea, Barringtonia acutangula, Pandanus aquaticus, Chysopogon fallax, Heteropoon contortus, Pseudoraphis spinescens*
320	Melaleuca low woodland	Woodland	*Melaleuca viridiflora, Melaleuca cajupati, Melaleuca dealbata, Pandanus spiralis, Barringtonia acutangula, Eleocharis brassi, Eleocharis sphacelata, Hymenachne acutigluma*
333	Eucalyptus low woodland	Woodland	*Eucalyptus tintinnans, Corymbia dichromophloia, Erythrophleum chlorostachys, Livistonia humilis, Gardenia megasperma, Sorghum stipoideum, Heteropogon triticeus, Sorghum plumosum*
572	Eucalyptus woodland	Woodland	*Eucalyptus tectifica, Erythrophleum chlorostachys, Corymbia latifolia, Terminalia ferdinandiana, Petalostigma pubescens, Sorghum* spp., *Heteropogon triticeus, Chrysopogon fallax*
1061	Canarium (mixed) mid closed forest	Mid closed forest	*Canarium australianum* +/1 *Diospyros* spp.
1064	Pastoral/ Horticultural/Roads	-	-

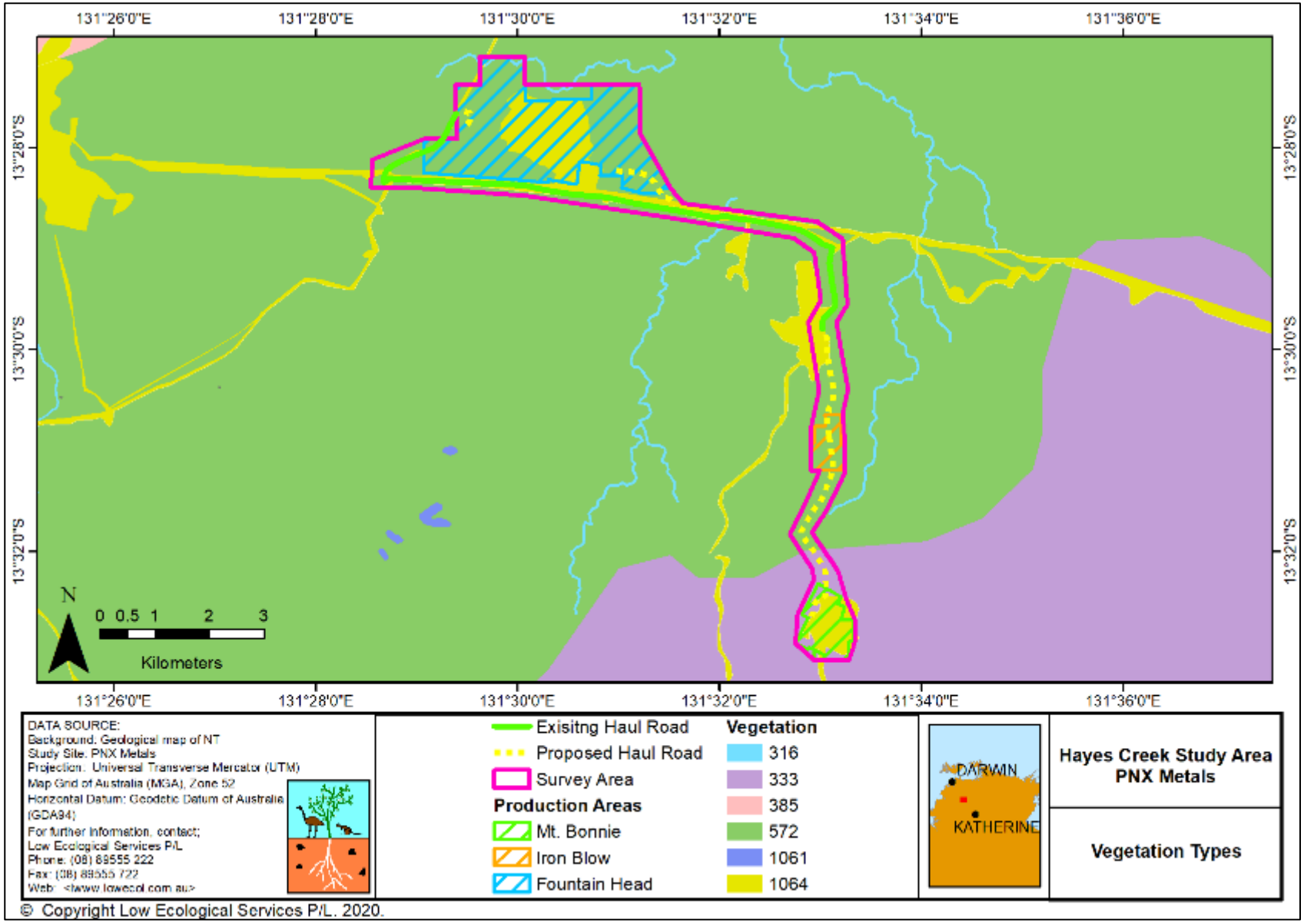

Figure 11. Vegetation types within Mt Bonnie, Iron Blow and Fountain Head mapped by Wilson et al. (1990). Vegetation types are described in Table 10.

3.8 Sites of Conservation Significance

Sites of Conservation significance (SoCS) are 67 sites in the Northern Territory identified as the most important for biodiversity, and that require further protection (Department of Land Resource Management, 2019). Sites of Botanical Significance (SoBS) are defined as areas that have botanical features distinguishing them from the surrounding landscape, and that are important for general plant conservation and for specifically mentioned species (White, et al., 2000a). There are no SoCs or SoBs within 20 km of the survey area. The nearest SoCs are the Daly River middle reaches, Western Arnhem Plateau and Yinberrie Hills; located approximately 40 km south-west, 40 km west and 60 km south-east of the survey area, respectively. SoCs are mapped below however no further descriptions are provided as these areas are considered outside the impacts of the proposal (Figure 12).

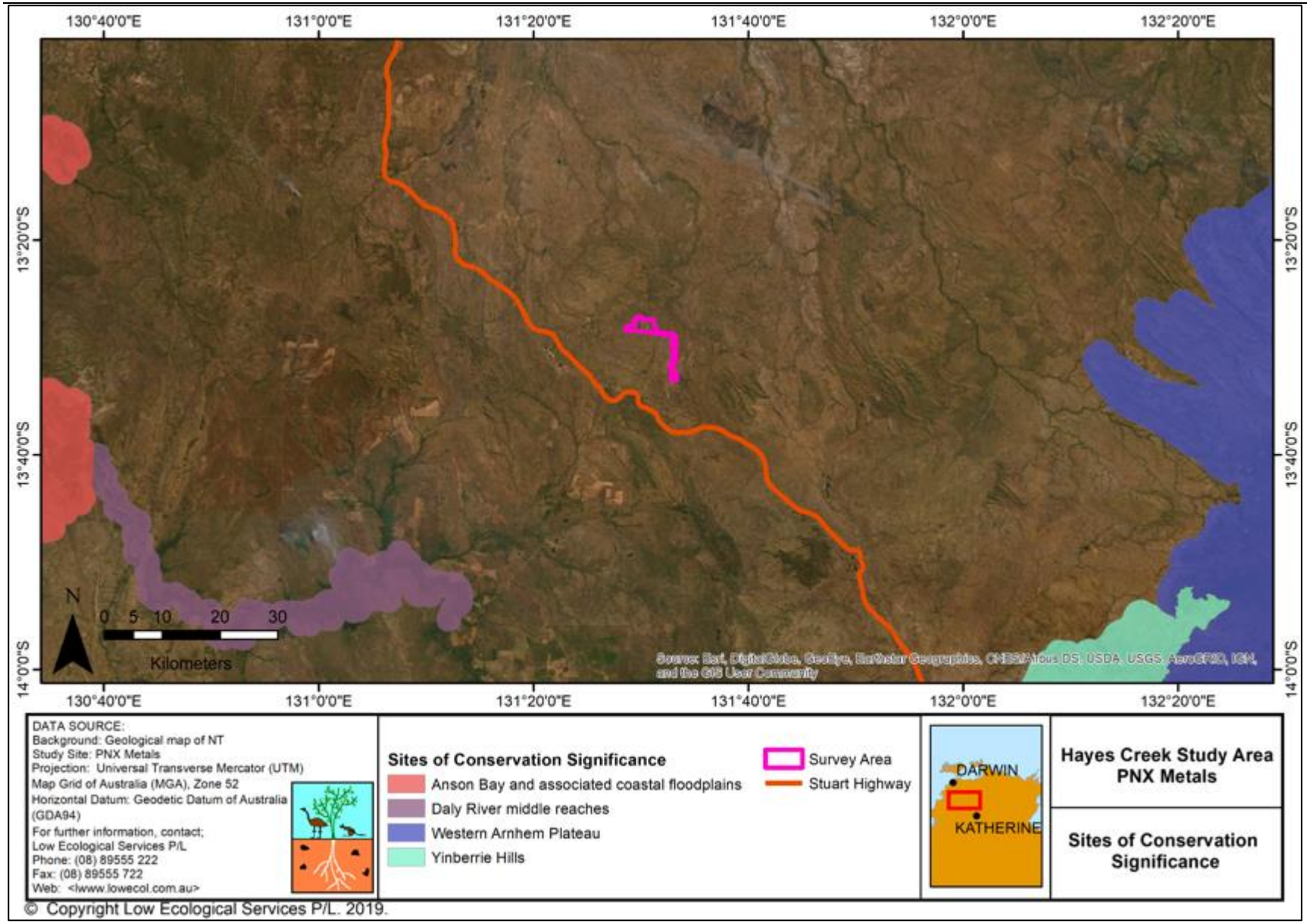

Figure 12. Sites of conservation significance in the area surrounding Hayes Creek Project survey area.

3.9 Fire History

Mapping obtained from the North Australia Fire Information (NAFI) website indicates that fire (the contribution of wildfires and prescribed burns are not available) occurs within the survey area on an annual basis (Table 11, Figure 13) (North Australia and Rangelands Fire Information, 2019). An average of 64% of the survey area is affected by fire every year. Fire frequency mapping from NAFI indicates that fire is more frequent in the Iron Blow and Mt Bonnie production areas than in the Fountain Head production area (Figure 14), possibly due to a larger proportion of cleared area in this area. The propensity of fire across the survey area may have detrimental effects on vegetation assemblage and may impact the detection of flora species during the survey.

Table 11. Fires occurring in the survey area between 2010 and July 2019, with the survey area (km^2) and percentage of the survey area burnt (%) during those years (North Australia and Rangelands Fire Information, 2019).The total size of the survey area is 15,000m^2.

Year	Area km²	%
2010	9.45	65.39
2011	8.40	56.33
2012	10.42	72.11
2013	9.51	65.81
2014	8.88	61.45
2015	4.42	30.58
2016	7.22	49.97
2017	12.32	85.26
2018	11.73	81.18
2019 – to July	8.90	61.59

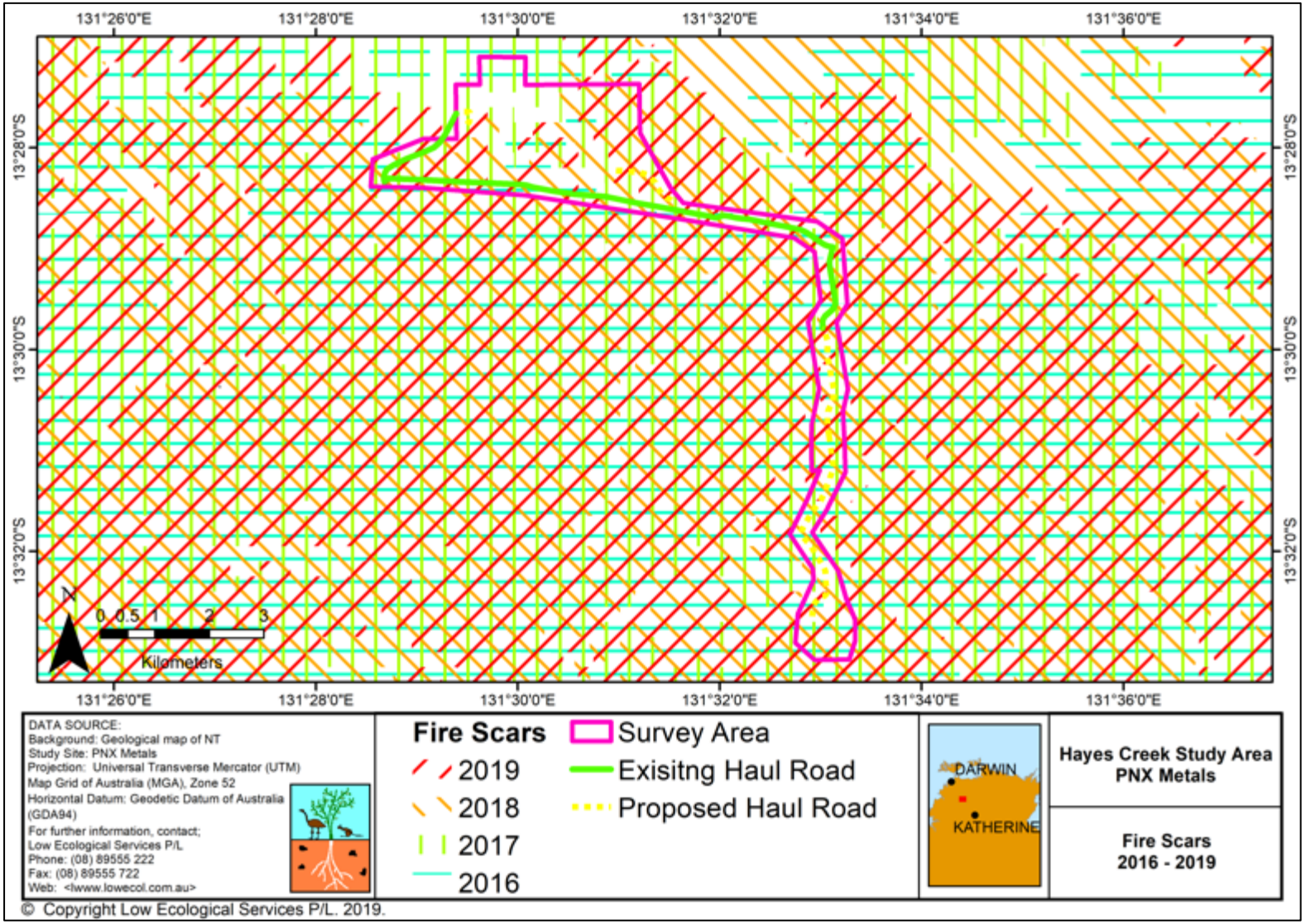

Figure 13. Fire history for the years 2016 – 2019 in the Hayes Creek Project survey area (North Australia and Rangelands Fire Information, 2019)

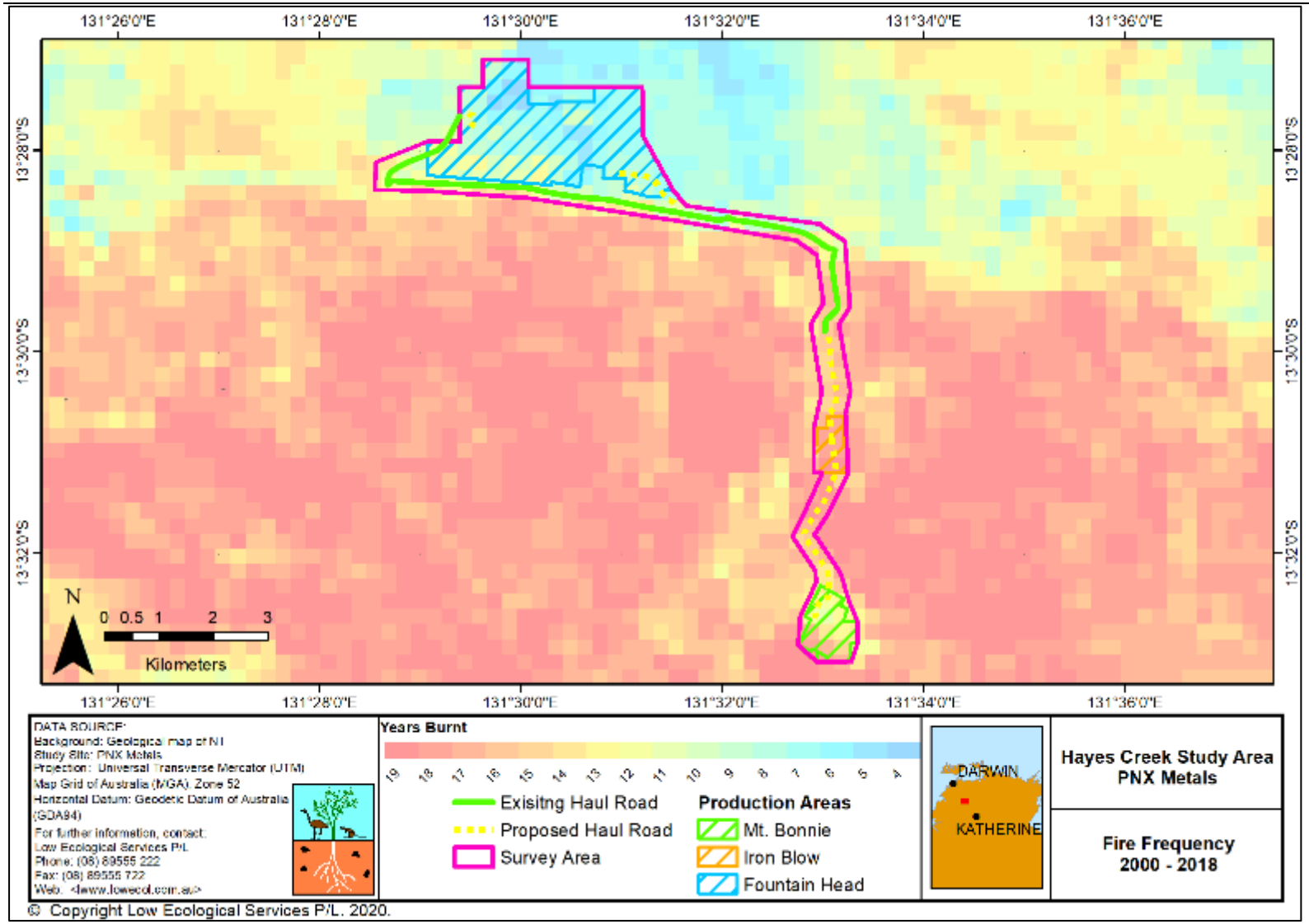

Figure 14. Fire frequency in the survey area and surrounds between 2000-2018 (North Australia and Rangelands Fire Information, 2019)

3.10 Flora

3.10.1 Flora Records

The NT Flora Atlas identified 2777 records of 362 flora species within 20 km of the survey area.

3.10.2 Flora Species of Conservation Significance

The NT Flora Atlas found 4281 records of 661 species within a 20 km buffer of the survey area. Two species of conservation significance were identified by the EPBC PMST or TWPC Flora Atlas as occurring or potentially occurring within a 20 km radius of the survey area (Table 12, Figure 15). The EPBC PMST identified one endangered flora species, *Stylidium ensatum*, and one vulnerable flora species, *Acacia praetermissa*, as potentially occurring within 20 km of the survey area. Interrogation of the NT Flora Atlas identified 222 records of *A. praetermissa* within the same search area. Further descriptions of these threatened species and assessment of their likelihood of occurrence are provided below. Four species listed as near threatened and eight species listed as data deficient under the TPWC Act were also previously recorded within 20 km of the survey area (Table 12).

Table 12. Flora species of conservation significance identified by the EPBC PMST and/or the NT Flora Atlas as previously recorded or potentially occurring within a 20 km radius of the Hayes Creek Project survey area. En: Endangered, Vu: Vulnerable, NT: Near threatened, DD: Data deficient

Family	Scientific Name	Status		PMST	NT Flora Atlas	Likelihood of occurrence
		TPWC	EPBC			
Fabaceae	*Acacia praetermissa*	VU	VU	X	X	High
Fabaceae	*Alysicarpus suffruticosus*	DD			X	Moderate
Centrolepidaceae	*Centrolepis curta*	NT			X	Moderate
Malvaceae	*Decaschistia byrnesii* subsp. *byrnesii*	NT			X	High
Cyperaceae	*Eleocharis acutangula*	DD			X	Moderate
Amaranthaceae	*Gomphrena involucrata*	DD			X	High
Goodeniaceae	*Goodenia glandulosa*	NT			X	Moderate
Pittosporaceae	*Pittosporum moluccanum*	NT			X	Moderate
Cyperaceae	*Scleria pergracilis*	DD			X	Moderate
Cyperaceae	*Scleria psilorrhiza*	DD			X	High
Fabaceae	*Senna procumbens*	DD			X	Moderate
Stylidiaceae	*Stylidium ensatum*	EN	EN	X	X	High
Santalaceae	*Viscum whitei* subsp. *flexicaule*	DD			X	Moderate
Poaceae	*Whiteochloa multiciliata*	DD			X	Moderate

Acacia praetermissa - *Acacia praetermissa* is known from two general locations in the Northern Territory, near Emerald Springs and Hayes Creek Project. The species is known to have an extremely restricted area of occupancy, approximately 2.5 ha (Northern Territory Herbarium, 2015). *Acacia praetermissa* is a shrub, often multi-stemmed with stems 50 cm – 2 m high (Northern Territory

Herbarium, 2015). The species grows on upper to lower slopes with various aspects in stoney skeletal or sandy soils on sandstone or laterite substrates. Associated dominant vegetation includes *Eucalyptus tetrodonta/Corymbia dichromophloia* woodland (Northern Territory Herbarium, 2015). The foliage is bluish and narrow (Northern Territory Herbarium, 2015). Flowers are in bright yellow spikes on simple axillary stalks, mostly two per axil (Northern Territory Herbarium, 2015). Flowering occurs from January – September and fruiting in January, March, July and October (Northern Territory Herbarium, 2015). The known population of *A. praetermissa* occurs along the Stuart Highway, near Emerald Springs and Hayes Creek Project. The Hayes Creek Project population is approximately 10 km south-south-east of the survey area. Slopes with various aspects on sandstone exist within the survey area. Therefore, there is a high likelihood that *A. praetermissa* occurs within the survey area.

Stylidium ensatum - *Stylidium ensatum* is an annual herb to 22 cm tall with broad sessile leaves on a short basal stem (Northern Territory Herbarium, 2015). The flowers are pink, with both upper and lower petals bilobed at the apex (Northern Territory Herbarium, 2015). *Stylidium ensatum* flowers and fruits from June to August (Northern Territory Herbarium, 2015). *Stylidium ensatum* is associated with low-lying, poorly drained, low-nutrient, sandy soils (sandy wetlands) where free-water or saturated soil moisture conditions at/near the land surface persist into the mid-late dry season (Green & Cuff, 2016). It is often found with *Eriachne burkitii, Pandanus* spp., *Osbeckia* spp. and *Fimbristylis furva* (Northern Territory Herbarium, 2015). There are records of *S. ensatum* approximately 13 km south-west of the survey area (Department of Environment and Natural Resources, 2019). There is potential habitat for this species in a small section of alluvial floodplains along the existing section of the Haul Road and along the southern part of the new section of Haul Road close to Mt Bonnie. However, it is unclear how long these areas stay inundated past the end of the wet season. Given that this species has been recorded within 20 km of the survey area previously and potentially suitable habitat exists here, there is a high likelihood that *S. ensatum* occurs within the survey areas.

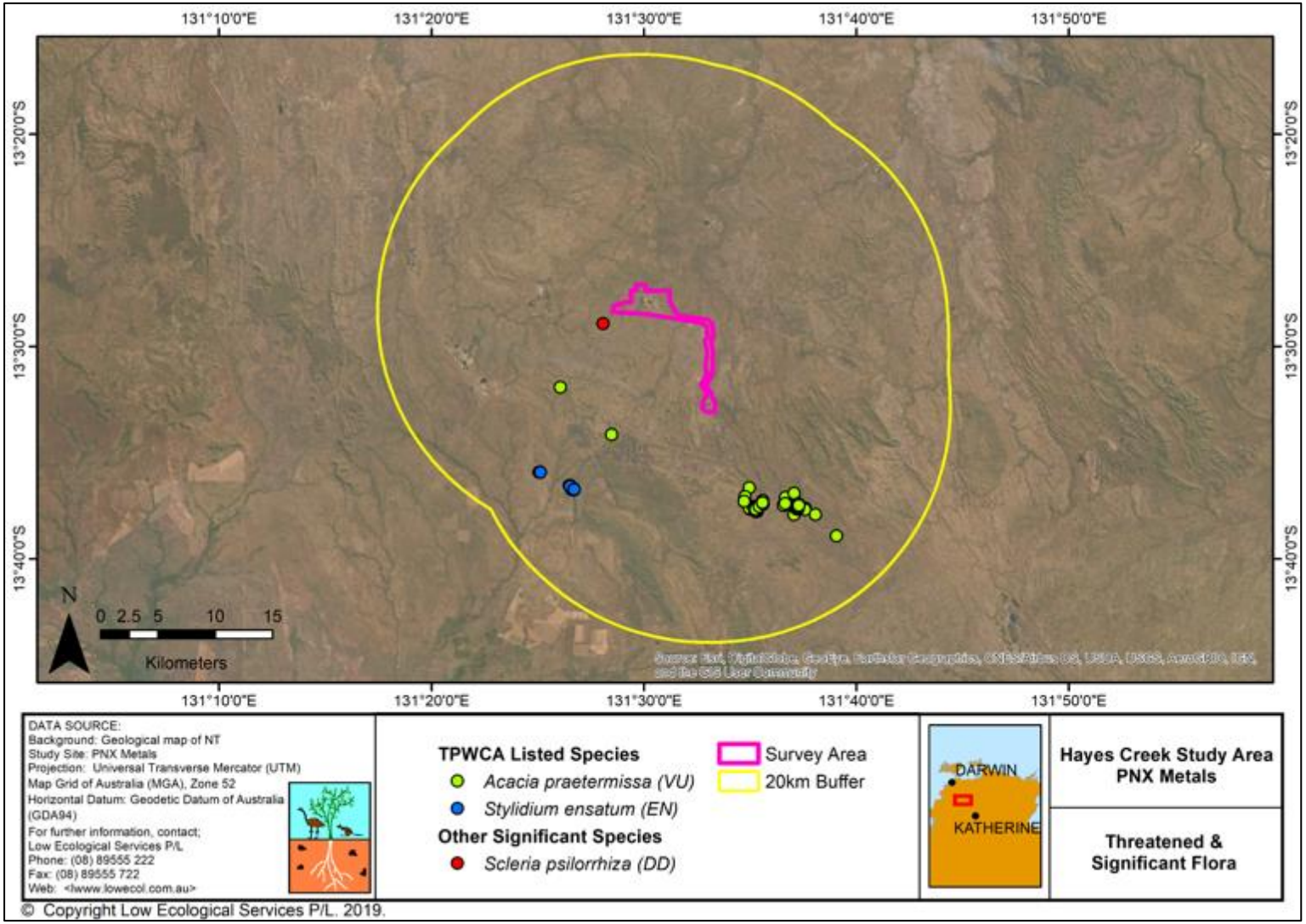

Figure 15. Location of records of flora species of conservation significance listed under the TPWC Act within 20 km of the Hayes Creek Project survey area (Department of Environment and Natural Resources, 2019)

3.10.3 Threatened Ecological Communities

The EPBC SPRAT system identifies two threatened ecological communities with the Northern Territory, 'Arnhem Plateau Sandstone Shrubland Complex' and 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' (Department of Agriculture, Water and the Environment, 2019). Neither of these communities overlap with the proposal area with the closest threatened ecological community located more than 90 km from the proposal area.

3.10.4 Introduced and Weed Species

Weeds of National Significance (WoNS) are declared based on invasiveness, potential for spread and environmental, social and economic impacts. Strategic plans for WoNS are developed as a result of their declaration, which define responsibilities and identifies strategies and actions to control the species. Landholders and managers are ultimately responsible for managing WoNS, and the state/territory government is responsible for overall legislation and administration (Department of Sustainability, Environment, Water, Population and Communities, 2012).

In the NT, a plant is declared a weed if it has been identified for control, eradication or prevention of entry into the NT. All landholders, land managers and land users must comply with the declaration classification. Based on the risk of harm they could cause and how difficult they are to control; weeds are placed into the following classes:

- Class A – to be eradicated
- Class B – growth and spread to be controlled
- Class C – not to be introduced into the NT

Records of fifty introduced flora species were identified in the NT Flora Atlas within a 20 km radius of the survey area (Figure 16 and Table 13). Eight species, all classified WoNS, were identified as occurring or potentially occurring within 20 km of the survey area (Table 13) and are described in further detail below, including information on identification and habitat. Two of these WoNS have been recorded within 20 km of the survey area (Figure 17). Other weeds known to occur in the Pine Creek bioregion are *Barleria prionitis,* cabomba (*Cabomba caroliniana*), creeping lantana (*Lantana montevidensis*), giant rats-tail grass (*Sporobolus natalensis* and *S. pyramidalis*), grader grass (*Themeda quadrivalvis*), *Senna tora* and snakeweed (*Stachytarpheta* spp.) (Bastin & ACRIS Management Committee, 2008).

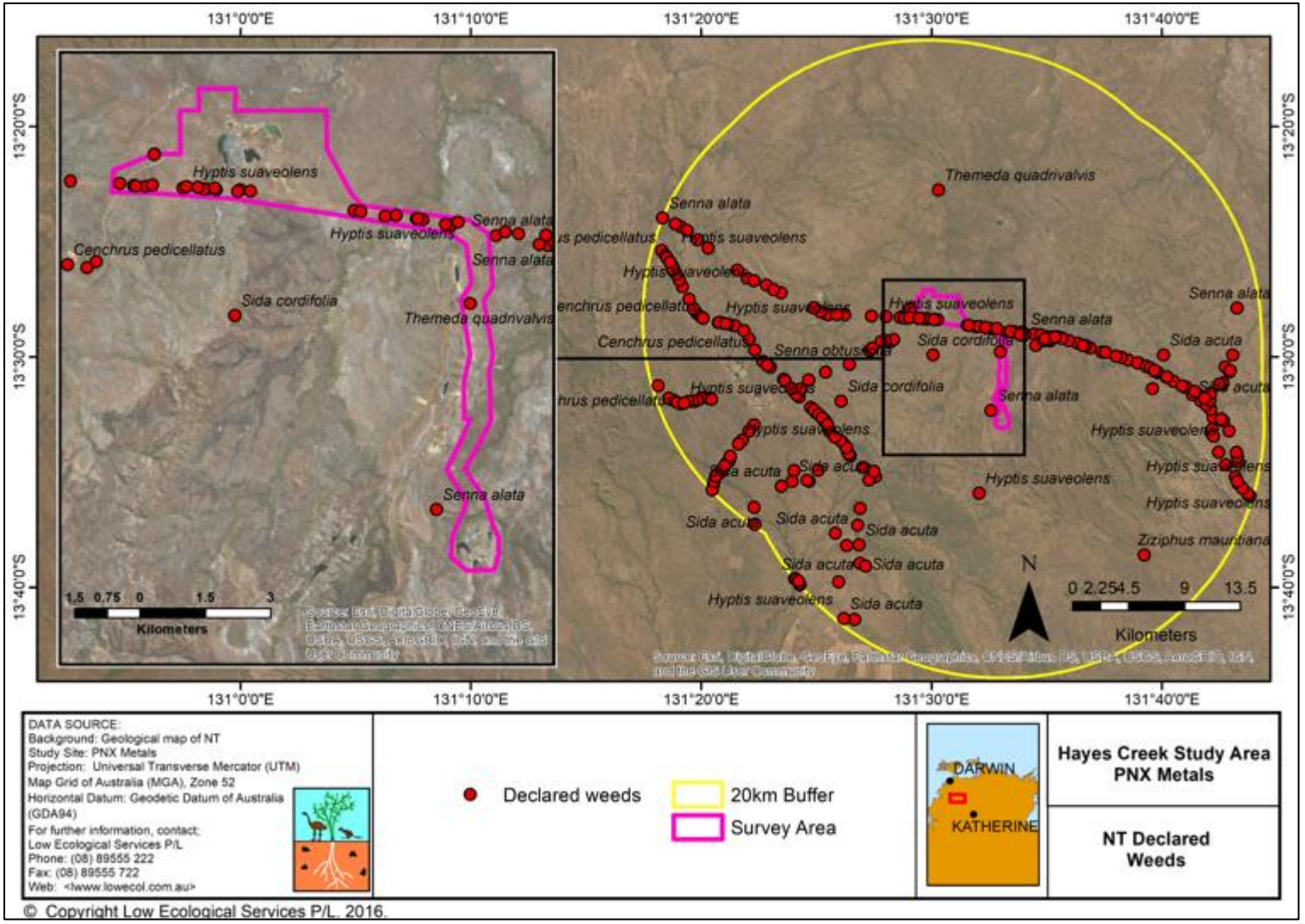

Figure 16. Location of introduced flora species identified in the NT Flora Atlas within a 20 km radius of the Hayes Creek Project survey area (Department of Environment and Natural Resources, 2019). Inset: Introduced species identified within the survey area.

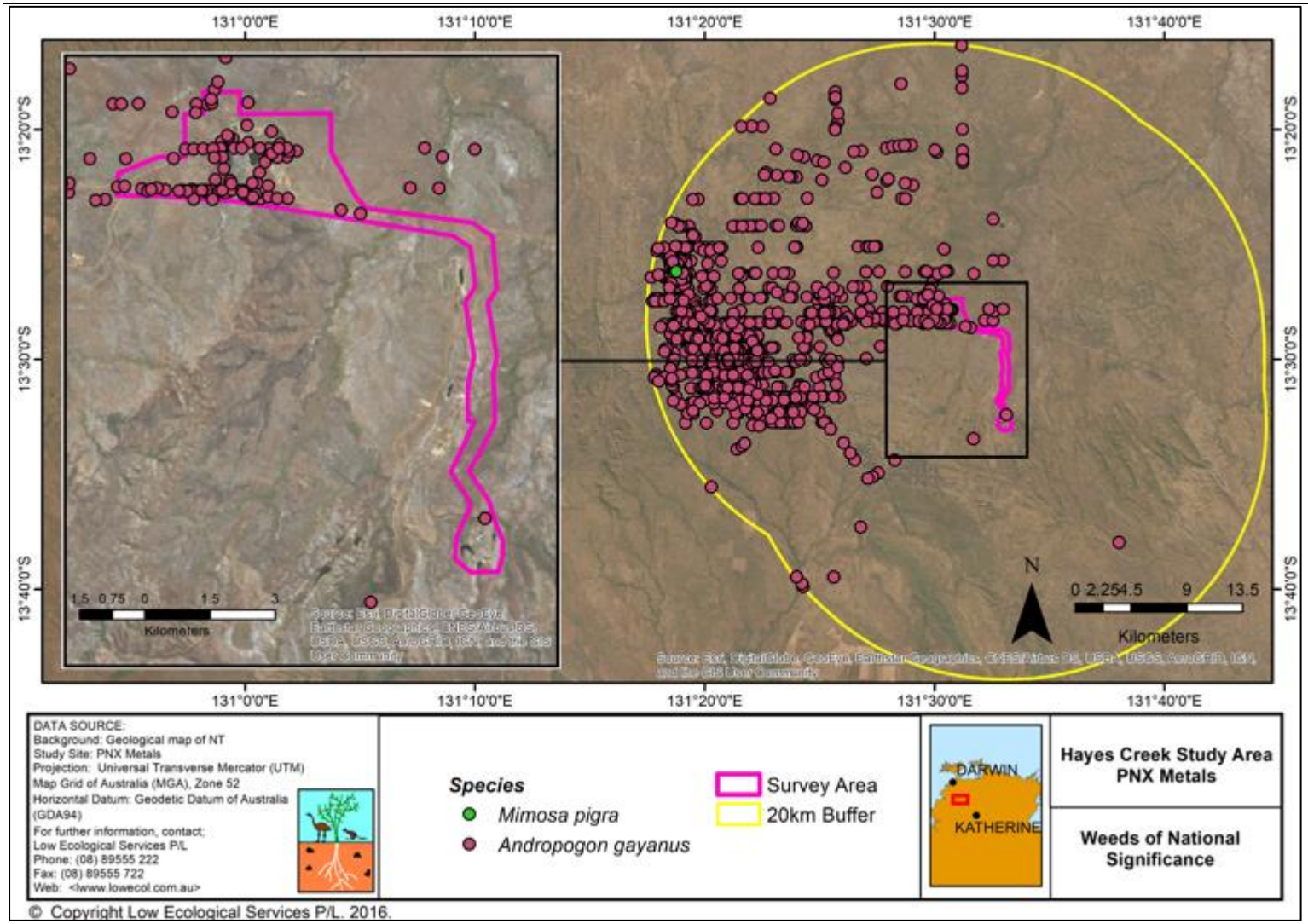

Figure 17. Location of Weeds of National Significance identified during the desktop assessment within a 20 km radius of the Hayes Creek Project survey area (Department of Environment and Natural Resources, 2019). Inset: Introduced species identified within the survey area.

Table 13: Introduced flora species identified by the EPBC PMST and/or NT weeds public database and/or recorded during the May 2017 on-ground survey, including if the species is a WoNS and the class it is declared under in the NT within. NT classification: A – to be eradicated, B – growth and spread to be controlled, C – not to be introduced into the NT

Species name	Common name	Status			PMST	NT Flora Atlas
		NT class	EPBC	WoNS		
Aeschynomene villosa						X
Ageratum conyzoides	Billygoat weed					X
Alysicarpus vaginalis						X
Andropogon gayanus	Gamba grass	B,C	Inv	X	X	X
Antigonon leptopus	Coral vine					X
Azadirachta indica	Neem	B,C				X
Brachiaria mutica	Para grass				X	
Bidens pilosa	Cobblers peg					X
Calopogonium mucunoides	Calopo					X
Calotropis procera	Rubber bush					X
Cabomba caroliniana	Carolina fanwort	A,C	Inv	X	X	
Cenchrus pedicellatus	Mission grass (annual)					X
Cenchrus polystachios	Mission grass (perennial)	B				X
Corchorus olitorius	Bush okra					X
Crotalaria goreensis	Gambia pea					X
Cynodon dactylon	Couch grass					X
Dactyloctenium aegyptium						X
Digitaria bicornis	Crab grass					X
Digitaria ciliaris	Summer grass					X
Echinocloa colona	Barnyard grass					X
Euphorbia heterophylla						X
Euphorbia hirta						X
Grewia asiatica						X
Gomphrena celosioides						X
Heliotropium indicum						X
Hibiscus sabdariffa						X
Hymenachne amplexicaulis	Olive hymenachne	B, C	Inv	X	X	
Hyptis suaveolens	Hyptis	B,C				X
Jatropha curcas	Physic nut	A,C				X
Jatropha gossypifolia	Bellyache bush	A,B,C	Inv	X	X	
Lantana camara	Common lantana	B,C	Inv	X	X	
Leonotis nepetifolia	Lions tail	B,C				X

Species name	Common name	Status			PMST	NT Flora Atlas
		NT class	EPBC	WoNS		
Martynia annua	Devils claw					X
Melinis repens	Red natal grass					X
Merremia aegyptia	Hairy merremia					X
Mimosa pigra	Mimosa	A	Inv	X	X	X
Mitracarpus hirtus						X
Murdannia nudiflora						X
Passiflora foetida						X
Paspalum dilatatum						X
Rottboellia cochinchinensis	Itch grass					X
Salvinia molesta	Giant salvinia	B,C	Inv	X	X	
Scoparia dulcis						X
Senna alata	Candle bush	B				X
Senna obtusifolia	Sicklepod	B,C				X
Senna occidentalis	Coffee senna	B,C				X
Sida acuta	Spinyhead sida	B,C				X
Sida cordifolia	Flannel weed	B,C				X
Stachytarpheta jamaicensis	Snakeweed	B,C				X
Stylosanthes hamata	Stylo					X
Stylosanthes scabra	Shrubby stylo					X
Themeda quadrivalvis	Grader grass	B,C				X
Trianthema portulacastrum						X
Triumfetta rhomboidea						X
Urochloa mutica						X
Vachellia nilotica	Prickly acacia	A,C	Inv	X	X	
Ziziphys mauritiana	Chinee apple	A,C				X

Weed species that are listed as WoNS and may be present within the proposal area:

Gamba grass (*Andropogon gayanus*) - Gamba grass is a perennial tussock grass that grows up to 70 cm diameter and 4 m tall (Department of the Environment, 2013). The leaf blades are up to 60 cm long and 1.5-5 cm wide with a prominent white midrib (Department of the Environment, 2013). The flowering stems have up to six groups of 2-18 loosely branched primary branches (Department of the Environment, 2013). The flower spikelets are arranged in pairs, with one spikelet sessile and the other stalked (Department of the Environment, 2013). The seeds of gamba grass are light brown to brownish-black, 2-3 mm long and 1 mm wide (Department of the Environment, 2013). Gamba grass mostly grows in pastures and along roads but can be invasive in other habitats such as savanna (Department of the Environment, 2013). Gamba grass invasion leads to dramatically increased fire intensity, that is harder to control and can result in a reduction in the woody component of a

vegetation community (Department of the Environment, 2013). Gamba grass seed is dispersed by wind or water, and can also be spread during hay transport or in mud attached to vehicles and machinery (Department of the Environment, 2013). Gamba grass can be controlled by herbicide application of young and regrowing plants before seed maturity (Department of the Environment, 2013).

Carolina fanwort (*Cabomba caroliniana*) - Carolina fanwort is fast growing, perennial aquatic weed that grows from 1-2 m long and is usually rooted to the water body floor (Department of Environment and Heritage, 2003). Cabomba grows quickly and produces a large amount of plant material, with branched stems that have white or reddish brown hair growing on them (Department of Environment and Heritage, 2003). The plant is fully submerged, except for the occasional floating leaves and flowers (Department of Environment and Heritage, 2003). The underwater leaves are divided into fine branches giving them a feather-fan appearance (Department of Environment and Heritage, 2003). Cabomba is sensitive to drying out and requires permanent shallow water, usually less than 3 m but up to 10 m deep. The plant does not produce fertile seed or fruit but reproduces and spreads by movement of small plant pieces (Department of Environment and Heritage, 2003). Plant fragments may survive in water for 6 – 8 weeks with pieces as short as 10 mm potentially viable (Department of Environment and Heritage, 2003). Infestations have been recorded in the Darwin region. Whilst distribution is currently isolated to relatively few water bodies, the potential for spread is high based on climate and the availability of water. Current strategies for control include physical cutting and removal, hand pulling and drying or shading cabomba (Department of Environment and Heritage, 2003). Chemical control is in most cases considered problematic due to the associated difficulties of applying chemicals in water and the potential to affect non-target species (Department of Environment and Heritage, 2003).

Hymenachne (*Hymenachne amplexicaulis*) - Hymenachne is a perennial grass, usually growing to 1-2.5 m tall, but occasionally to 3.5 m tall. Its above ground stems are upright or semi-upright from a creeping base or floating on shallow water, are up to 12 mm or more thick and regularly produce roots at the joints (Department of Sustainability, Environment, Water, Population and Communities, 2013). The leaf blades are 10-45 cm long and 2-6 cm wide, hairy or hairless and partially enclose the stem, and are large and spreading (Department of Sustainability, Environment, Water, Population and Communities, 2013). The inflorescence is elongated, dense and spike like, and is 10 -50 cm long and 8-20 mm wide (Department of Sustainability, Environment, Water, Population and Communities, 2013).

Hymenachne occurs in swamps, wetlands, seasonally flooded areas, waterways, riverbanks, drainage channels and other water bodies in wetter tropical and sub-tropical environments (Department of Sustainability, Environment, Water, Population and Communities, 2013). Hymenachne can block waterways, potentially causing flooding and threatening drinking water, block drainage and irrigation channels in cropping areas, displace native plants and increase the density of vegetation, which can alter habitat suitability for biodiversity (Department of Sustainability, Environment, Water, Population and Communities, 2013). Hymenachne can reproduce by seed or vegetatively, with spread being attributed to flooding, mud attached to animals and vehicles, in contaminated agricultural produce and by birds (Department of Sustainability, Environment, Water, Population and Communities, 2013).

Bellyache bush (*Jatropha gossypiifolia*) - Bellyache bush a shrub or small tree 1-3 m tall (Department of Sustainability, Environment, Water, Population and Communities, 2011). Older stems of bellyache

bush are relatively thick and contain a watery or soapy sap (Department of Sustainability, Environment, Water, Population and Communities, 2011). Younger stems and growing points are purplish in colour and have a dense covering of hairs (Department of Sustainability, Environment, Water, Population and Communities, 2011). The leaves are alternately arranged, purplish and covered in sticky hairs when immature, bright or dark green as they are, 4.5-10 cm long and 5-13 cm wide and have three or five deep lobes (Department of Sustainability, Environment, Water, Population and Communities, 2011). The flowers are arranged in clusters with 2-8 female and 27-54 male flowers in each cluster (Department of Sustainability, Environment, Water, Population and Communities, 2011). The flowers are deep purple to bright red (Department of Sustainability, Environment, Water, Population and Communities, 2011). The fruit is slightly three lobed and faintly hairy (Department of Sustainability, Environment, Water, Population and Communities, 2011). Bellyache bush occurs in degraded pastures, open woodlands, monsoon vine forests, grasslands, waterways, coastal foreshores, roadsides, disturbed sites, waste areas and old or abandoned gardens (Department of Sustainability, Environment, Water, Population and Communities, 2011). It occurs mainly in drier tropical environments, but also sometimes in sub-tropical and semi-arid regions (Department of Sustainability, Environment, Water, Population and Communities, 2011). Bellyache bush can form dense thickets, which reduces the productivity of pastures, displaces native vegetation, and may reduce biodiversity, preventing the regeneration of trees and shrubs (Department of Sustainability, Environment, Water, Population and Communities, 2011). Bellyache bush reproduces by seed and vegetatively (Department of Sustainability, Environment, Water, Population and Communities, 2011). Seeds may be dispersed in water and mud, and by ants (Department of Sustainability, Environment, Water, Population and Communities, 2011). Bellyache bush is Declared Class A in the NT outside of designated Class B zones.

Lantana (*Lantana camara*) - Lantana is a sprawling or climbing shrub or vine 1-3 m high, sometimes to 6 m high in favourable conditions (Department of Sustainability, Environment, Water, Population and Communities, 2011). The stems and branches often have recurved prickles and sometimes glands or glandular hairs (Department of Sustainability, Environment, Water, Population and Communities, 2011). The leaves are in opposite pairs, are ovate to oblong-ovate, often covered with coarse hairs on the upper surface, strongly aromatic and 4-10 cm long and 3-6 cm wide (Department of Sustainability, Environment, Water, Population and Communities, 2011). The inflorescence consists of 20-40 flowers ranging from yellow, orange-yellow, deep orange, deep red, pink, rose-pink to white (Department of Sustainability, Environment, Water, Population and Communities, 2011). Lantana occurs in disturbed sites such as roadsides, cultivated pastures and fence lines on rich organic soils and well-drained clay and basalt soils (Department of Sustainability, Environment, Water, Population and Communities, 2011). Lantana forms dense thickets, which changes the structure of native bushland and pasture, increases fuel loads and adversely affects the species richness of soil biodiversity (Department of Sustainability, Environment, Water, Population and Communities, 2011). Lantana can reproduce vegetatively and by seed, which can be spread by animals (Department of Sustainability, Environment, Water, Population and Communities, 2011).

Mimosa (*Mimosa pigra*) - Mimosa is a shrub 5-6 m tall with touch sensitive compound leaves 12-22 cm long with up to 45 pairs of leaflets (Department of Sustainability, Environment, Water, Population and Communities, 2011). Mimosa has thorns 5-12 mm long scattered along the stems and branches (Department of Sustainability, Environment, Water, Population and Communities, 2011). The flower

heads are round, 10-20 mm diameter and comprised of about 100 pink or mauve flowers (Department of Sustainability, Environment, Water, Population and Communities, 2011). The seed pods are flat, 30-120 mm long, 7-14 mm wide and densely hairy (Department of Sustainability, Environment, Water, Population and Communities, 2011). Mimosa occurs in moist areas such as riverbanks, coastal plains and floodplains, particularly in humid and sub-humid tropical regions (Department of Sustainability, Environment, Water, Population and Communities, 2011). Mimosa produces copious amounts of seed, which are dispersed by water, humans, animals, mud on vehicles and movement of contaminated soils (Department of Sustainability, Environment, Water, Population and Communities, 2011). Mimosa forms dense monoculture stands, replacing all native vegetation (Department of Sustainability, Environment, Water, Population and Communities, 2011). The invasion of mimosa threatens productive industry and cultural and conservation values of wetlands, including nationally and internationally significant wetlands, where it reduces biodiversity by out-competing native plants and reducing habitat suitability for native fauna (Department of Sustainability, Environment, Water, Population and Communities, 2011). Mimosa is a class A weed in the NT.

Salvinia (*Salvinia molesta*) - Salvinia is a free-floating aquatic fern, which forms a thick mat of vegetation (Department of Sustainability, Environment, Water, Population and Communities, 2011). The fronds of salvinia are arranged along the stem in three, with two fronds being leaf like and the third frond being root-like and submerged in the water (Department of Sustainability, Environment, Water, Population and Communities, 2011). The leaf-like fronds are round in shape, 4-40 mm long and 7-25 mm wide, covered in hairs pale green to greenish brown and folded along the mid-rib (Department of Sustainability, Environment, Water, Population and Communities, 2011). The root-like fronds are up to 30 cm long and covered with fine brown hairs (Department of Sustainability, Environment, Water, Population and Communities, 2011). Salvinia occurs in still or slow-moving water bodies with high nutrient levels (Department of Sustainability, Environment, Water, Population and Communities, 2011). Salvinia modifies aquatic fauna habitats, excludes light and reduces oxygen levels leading to water stagnation and pollution, impedes water flow, and can harbour mosquitoes (Department of Sustainability, Environment, Water, Population and Communities, 2011).

Prickly acacia (*Vachellia nilotica*) - Prickly acacia is a thorny shrub or spreading tree, which grows to 4-7 m high and occasionally to 10 m (Department of Sustainability, Environment, Water, Population and Communities, 2011). Young trees have bark with a tinge of orange and/or green, and usually have long white straight spines 10-50 mm long in pairs at the base of each leaf (Department of Sustainability, Environment, Water, Population and Communities, 2011). Older trees have dark, rough bark and lose most of their thorns (Department of Sustainability, Environment, Water, Population and Communities, 2011). Prickly acacia has compound leaves 30-40 mm long, with 10-25 pairs of leaflets along their length (Department of Sustainability, Environment, Water, Population and Communities, 2011). Flowerheads are globular, golden-yellow, about 10 mm diameter and in groups of 2-6 in the leaf axils (Department of Sustainability, Environment, Water, Population and Communities, 2011). The seed pods are a distinguishing feature, being grey-green, covered in fine hairs, 100-200 mm long and having deep constrictions between the seeds to give them a necklace like appearance (Department of Sustainability, Environment, Water, Population and Communities, 2011). Prickly acacia occurs on cracking clay soils with high water holding capacity but can also occur on sandy soils in areas of higher rainfall (Department of Sustainability, Environment, Water, Population and Communities, 2011). It grows best around waterways and on seasonally inundated floodplains with 350-1500 mm of annual

rainfall (Department of Sustainability, Environment, Water, Population and Communities, 2011). Established stands of prickly acacia form impenetrable dense thorny thickets, reducing primary productivity, interfering with stock mustering and access to water, and changing the structure and composition of grasslands which impacts the overall ecology of the system (Department of Sustainability, Environment, Water, Population and Communities, 2011). Prickly acacia reproduces only by seeds, which are dispersed by flowing water and consumption by cattle (Department of Sustainability, Environment, Water, Population and Communities, 2011).

3.11 Fauna

3.11.1 Fauna Records

The NT Fauna Atlas identified 4389 records of 301 species within 20 km of the survey areas.

3.11.2 Fauna Species of Conservation Significance

The EPBC PMST identified 20 fauna species listed as threatened under the EPBC Act as occurring or potentially occurring within 20 km of survey area (Figure 18). Records of three species listed as endangered and three species listed as vulnerable under the EPBC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. The NT Fauna Atlas also identified records of an additional four species listed as vulnerable under the TPWC Act, but not listed under the EPBC Act, within a 20 km radius of the survey areas (Figure 18). Records of an additional 16 species listed as near threatened and seven listed as data deficient under the TPWC Act, were identified in the NT Flora Atlas within 20km of the survey area.

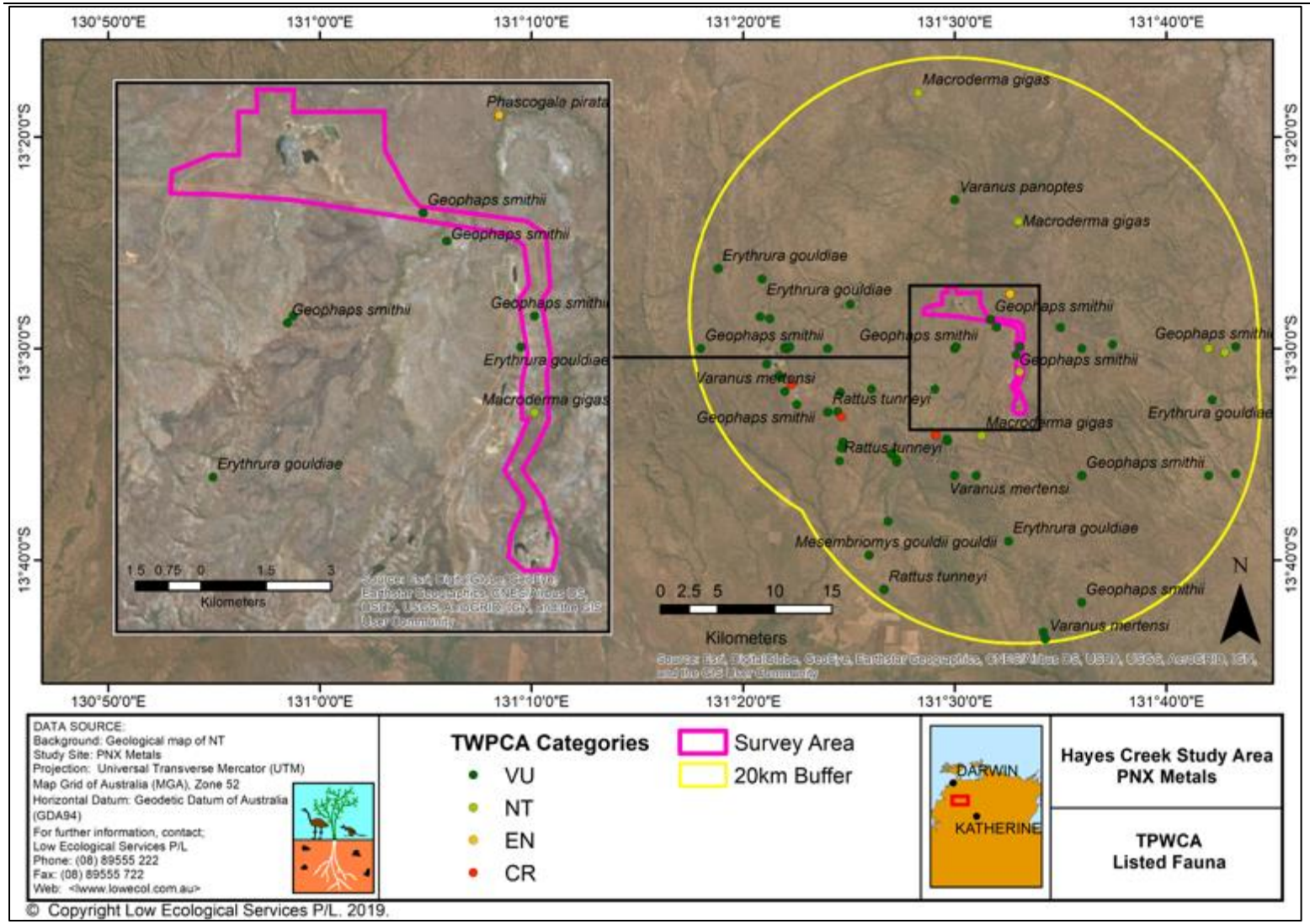

Figure 18. Location of records of fauna species of conservation significance listed under the TPWC Act with records in the NT Fauna Atlas within 20 km of the Hayes Creek Project survey area; CR: critical, EN: endangered, VU: vulnerable, NT: near threatened, DD: data deficient

Bird species of conservation significance

Fifteen bird species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring or potentially occurring within a 20 km radius of the survey area (Table 14). Eight of these species are listed as threatened under the EPBC Act; two as critically endangered, two as endangered and four as vulnerable. Three of these species listed as threatened under the EPBC Act , red goshawk (*Erythrotriorchis radiatus*), Gouldian finch (*Erythrura gouldiae*) and partridge pigeon (*Geophaps smithii smithii*), were identified by the NT Fauna Atlas within a 20 km radius of the survey area (Figure 18). Records of a further six species listed as near threatened and one species listed as data deficient under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. Further information about identified threatened bird species and a discussion of their likelihood of occurrence in the survey areas is provided below.

Table 14: Bird species of conservation significance identified by the EPBC PMST and NT Fauna Atlas as previously recorded or potentially occurring within a 20 km radius of the Hayes Creek Project survey area. Cr: critically endangered, En: endangered, Vu: vulnerable, NT: near threatened, DD: data deficient.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood of Occurrence
		TPWC	EPBC			
Ardeotis australis	Australian bustard	NT			X	High
Burhinus grallarius	Bush stone-curlew	NT			X	High
Calidris ferruginea	Curlew sandpiper	Vu	Cr	X		Moderate
Erythrotriorchis radiatus	Red goshawk	Vu	Vu	X	X	High
Erythrura gouldiae	Gouldian finch	Vu	En	X	X	High
Falcunculus frontatus whitei	Crested shrike-tit (northern)	NT	Vu	X		Low
Geophaps smithii smithii	Partridge pigeon (eastern)	Vu	Vu	X	X	High
Lonchura flaviprymna	Yellow-rumped Mannikin	NT			X	High
Neochmia ruficauda	Star Finch	NT			X	High
Numenius madagascariensis	Eastern curlew	Vu	Cr	X		Low
Poecilodryas cerviniventris	Buff-sided robin	NT			X	High
Psephotus dissimilis	Hooded parrot	NT			X	High
Rostratula australis	Australian painted snipe	Vu	En	X		Low
Turnix castanotus	Chestnut-backed button-quail	DD			X	Moderate
Tyto novaehollandiae kimberli	Masked owl (northern)	Vu	Vu	X		High

Bird species that are listed in threatened categories (Critically Endangered, Endangered, Vulnerable) that potentially use habitat within the proposal area:

Curlew sandpiper (*Calidris ferruginea*) – The curlew sandpiper is a small to medium sized shorebird that is present in Australia during the non-breeding season from late August to April and is listed as vulnerable under the TPWC Act and critically endangered under the EPBC Act (Department of the Environment, 2019). In Australia, the curlew sandpiper inhabits coastal and brackish lagoons, intertidal mud and sand flats, estuaries, saltmarshes and occasionally inland freshwater wetlands (Ward, 2012). The closest record of this species to the survey areas is approximately 117 km west of the survey area. There is a moderate likelihood that this species will be present in the survey areas during annual migration.

Red goshawk (*Erythrotriorchis radiatus*) – The red goshawk is a large reddish-brown hawk with conspicuous dark streaks from chin to belly and barring on the underwing and tail (Woinarski, 2006b) It is listed as vulnerable under the TPWC Act and EPBC Act. It occurs across much of northern Australia where it generally occurs in tall open eucalypt forest and riparian areas characteristic of higher rainfall areas (Woinarski, 2006b). The closest record of the red goshawk to the survey areas is 32 km north-west of Fountain Head. Given the large territory size of this species (up to 200 km^2) (Woinarski, 2006b) and the relatively close proximity of prior records, there is a high likelihood that this species occurs in the survey areas.

Gouldian finch (*Erythrura gouldiae*) – The Gouldian finch is an easily recognised colourful finch that is restricted to isolated areas of tropical savannas in the NT and the Kimberley (Department of Environment and Natural Resources, 2017). It is listed as vulnerable under the TPWC Act and endangered under the EPBC Act. In the late wet season and dry season (February to October) the Gouldian finch inhabits wooded hills containing a group of eucalypts called snappy or salmon gums, with hollows for nesting sites (Department of Environment and Natural Resources, 2017). In the wet season, the Gouldian finch inhabits lowland drainages to feed on seeds on perennial grasses (Department of Environment and Natural Resources, 2017). The closest record of the Gouldian finch to the survey areas is 3 km south of Fountain Head. Given the proximity of prior records and potentially suitable habitat in the survey areas, there is a high likelihood that the Gouldian finch is present in the survey areas.

Crested shrike-tit (northern) (*Falcunculus frontatus whitei*) – The crested shrike-tit is a distinctive medium-sized bird that occurs between the south-west Kimberley east to Borroloola and north into north-east Arnhem Land (Woinarski & Ward, 2012). It is listed as near threatened under the TPWC Act and vulnerable under the EPBC Act. This subspecies inhabits a range of eucalypt and melaleuca woodlands, from relatively wet to strongly seasonal areas in Arnhem Land to semi-arid woodland in the southern Victoria River District (Woinarski & Ward, 2012). The closest record of the crested shrike-tit to the surveys areas is 78 km south-west of the survey area. There is a low likelihood of the species occurring within the survey area.

Partridge pigeon (*Geophaps smithii smithii*) – Partridge pigeons are a medium-sized ground dwelling pigeon listed as vulnerable under both the TPWC Act and EPBC Act (Woinarski, 2006a). It is distributed across the Top End NT and Kimberley but has disappeared from the lower rainfall parts of its range (Woinarski, 2006a). Partridge pigeons mainly inhabits lowland eucalypt open forest and woodland with grassy understorey (Woinarski, 2006a). This species has been recorded within the Hayes Creek Project survey area, during a 2006 survey of the survey area. Therefore, there is a high likelihood of it occurring in the survey areas.

Eastern curlew (*Numenius madagascariensis*) – The eastern curlew is a very large shorebird that is a non-breeding migrant in Australia for the austral summer (Ward, 2012c). It is listed as vulnerable under the TPWC Act and critically endangered under the EPBC Act. The species has been recorded along the coast and offshore islands of the NT, and are most common in mangrove areas but can also be found on intertidal flats and saltmarshes (Ward, 2012c). The closest record of this species to the survey areas is 113 km north-east of Iron Blow. Given that this species inhabits coastal areas there is a low likelihood that it occurs within the survey areas.

Australian painted snipe (*Rostratula australis*) – The Australian painted snipe is a wading bird that is found throughout Australia, though mostly recorded in south-east Australia (Taylor, et al., 2013). It is listed as vulnerable under the TPWC Act and endangered under the EPBC Act. The species inhabits shallow, vegetated, freshwater swamps, claypans or inundated grassland (Taylor, et al., 2013). The closest record of the Australian painted snipe to the survey areas is 127 km north-east of Fountain Head. There are few other records of the Australian painted snipe in the NT, and most of these are from the northern interior (Marchant & Higgins, 1993; Atlas of Living Australia, 2019). Therefore, there is a low likelihood that the Australian painted snipe occurs in the survey area.

Masked owl (northern) (*Tyto novaehollandiae kimberli*) – The masked owl is a large dark owl occurring on the north Australian mainland (Woinarski & Ward, 2012). It is listed as vulnerable under the TPWC Act and EPBC Act. The species occurs mainly in eucalypt tall open forest, but also roosts in monsoon rainforests and forages in more open vegetation types including grasslands (Woinarski & Ward, 2012). The closest record of the masked owl to the survey areas is 8 km west of Fountain Head. As there is potentially suitable habitat for the masked owl present in the survey areas and a record close by, there is a high likelihood that this species is present.

Mammals of conservation significance

Sixteen mammal species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (**Error! Reference source not found.**). Ten mammal species are listed as threatened under the EPBC Act; four as endangered and six as vulnerable. Eight of these species are also listed as threatened under the TPWC Act, and the remaining two are listed as near threatened or vulnerable. Three of these EPBC listed species were identified by the NT Fauna Atlas within a 20 km radius of the survey area. An additional four species listed as near threatened under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. All NT Fauna Atlas records of conservation significant mammals within 20km of the survey areas are mapped in Figure 18. Further information about identified threatened mammal species and a discussion of their likelihood of occurrence in the survey areas is provided below.

Table 15. Mammal species of conservation significance identified by the EPBC PMST and NT Fauna Atlas as previously recorded or potentially occurring within 20 km of the Hayes Creek Project proposal area. Cr: critically endangered, En: Endangered, Vu: vulnerable, NT: near threatened, DD: data deficient.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
Antechinus bellus	Fawn antechinus	En	Vu	X		Moderate
Conilurus penicillatus	Brush-tailed rabbit-rat	En	Vu	X		Low
Dasyurus hallucatus	Northern quoll	Cr	En	X	X	Moderate

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
Hipposideros inornatus	Arnhem leaf-nosed bat	Vu	En	X		Low
Hipposideros stenotis	Northern leaf-nosed bat	NT			X	Moderate
Isoodon macrourus	Northern brown bandicoot	NT			X	High
Macroderma gigas	Ghost bat	NT	Vu	X		High
Mesembriomys gouldii gouldii	Black-footed tree-rat	Vu	En	X	X	High
Mesembriomys macrurus	Golden-backed tree rat	Cr	Vu			Low
Petrogale concinna canescens	Nabarlek (Top End)	Vu	En	X		Low
Phascogale pirata	Northern brush-tailed phascogale	En	Vu	X	X	Moderate
Pseudomys nanus	Western chestnut mouse	NT			X	High
Rattus tunneyi	Pale field-rat	Vu			X	High
Rhinonicteris aurantia	Orange leaf-nosed bat	NT			X	High
Saccolaimus saccolaimus nudicluniatus	Bare-rumped sheath-tailed bat	DD	Vu	X		Moderate
Trichosurus vulpecula arnhemensis	Common brushtail possum (Top End)	NT			X	Moderate

Mammal species that are listed in threatened categories (Critically Endangered, Endangered, Vulnerable) that potentially use habitat within the proposal area:

Fawn antechinus (*Antechinus bellus*) – The fawn antechinus is a small dasyurid marsupial found in the savannah woodland and tall open forest on the Top End NT (Young, 2012). It is listed as endangered under the TPWC Act and vulnerable under the EPBC Act. The closest record of the fawn antechinus to the survey areas is 30 km north-east of Fountain Head. Given the proximity of prior records, and the presence of potentially suitable habitat, there is a moderate likelihood that the fawn antechinus occurs within the survey areas.

Brush-tailed rabbit-rat (*Conilurus penicillatus*) –The brush-tailed rabbit ratis a moderate-sized, partly arboreal rat, only known to currently persist in the NT on the Cobourg Peninsula, Bathurst, Melville and Inglis Islands, and Groote Eylandt (Woinarski & Hill, 2012). It is listed as endangered under the TPWC Act and vulnerable under the EPBC Act. The preferred habitat of the species is eucalypt tall-open forest, but, at least on the Cobourg Peninsula, it also occurs on coastal grasslands (Woinarski & Hill, 2012). The closest record of this species is 66 km west of Fountain Head; however this was before 1971. Given the high survey effort for this species in recent years and associated observed declines in populations (see Woinarski & Hill, 2012), and a lack of recent records within the immediate area surrounding the survey areas, there is a low likelihood that the brush-tailed rabbit rat occurs within the survey areas.

Northern quoll (*Dasyurus hallucatus*) – Northern quolls are distinctive carnivorous marsupials, about the size of a small cat, occurring across much of northern Australia (Woinarski & Hill, 2012b). It is listed as critically endangered under the TPWC Act and endangered under the EPBC Act. The northern quoll occurs in a wide range of habitat, but rocky areas appear to be most suitable (Woinarski & Hill, 2012b). It was common in many eucalypt open forests (Woinarski & Hill, 2012b). In Kakadu National Park, open

forest and woodlands on plains dominated by *E. tetrodonta, E. miniata* and *E. tectifica,* open woodland on low rocky hills dominated by *E. setosa* and *E. bleeseri* and riparian areas with flowing water dominated by *M. viridiflora* and *P. spiralis* consitute habitat for the northern quoll (Department of the Environment, 2019). Large scale declines and local extinctions have been recorded in Kakadu National Park since the invasion of cane toads (*Rhinella marinusi*) and similar declines are assumed across the rest of the species range (Woinarski, et al., 2010). A northern quoll was recorded in a 2006 survey of the survey area, 5 km north-east of the survey area at the North Point mine site. However, taking into account broad-scale decline of the species since this observation as a result of cane toads moving into the region there is a moderate likelihood of the northern quoll being present in the survey areas.

Arnhem leaf-nosed bat (*Hipposideros inornatus*) – The Arnhem leaf-nosed bat is a moderately large insectivorous bat (Threatened Species Scientific Committee, 2015). It's distribution is one of the most limited of any Australian bat taxon, known only from the Kakadu escarpment on the western edge of the Arnhem land plateau (Threatened Species Scientific Committee, 2015). In 1978 a population was discovered in a cave at Tolmer Falls, Litchfield National Park; 81 km north-west of the survey area (Threatened Species Scientific Committee, 2015). However no bats have been recorded in this cave or the surrounding area since 1983. Based on the lack of current records near the proposal, there is a low likelihood that the Arnhem leaf-nosed bat is present within the survey area.

Ghost bat (*Macroderma gigas*) – Ghost bats are a large species of bat, currently distributed across northern Australia (Ward & Milne, 2016). It is listed as near threatened under the TPWC Act and vulnerable under the EPBC Act. The distribution is influenced by the availability of suitable caves and mines for roost sites, with one of the largest colonies occurring in gold mine workings at Pine Creek NT (Ward & Milne, 2016). Ghost bats were recorded in the survey areas in 1988 and 5 km north-east of the survey area in 2007. There is the potential for caves and suitable disturbed mining areas to be present in the rocky areas within the survey areas, therefore there is a high likelihood that ghost bats are present.

Black-footed tree-rat (*Mesembriomys gouldii gouldii*) – The black-footed tree-rat is one of the largest rodents in Australia and is found in the Top End NT (Hill, 2012). The species inhabits tropical woodlands and open forests in coastal areas, sheltering in tree hollows and pandanus stands during the day (Hill, 2012). The closest record of *M. g. gouldii* is 14 km south-east of Mt Bonnie. Given the proximity of prior records and potentially suitable habitat in the area, there is a high likelihood that this species occurs in the survey areas.

Golden-backed tree rat (*Mesembriomys macrurus*) – The golden-backed tree-rat is a large rodent, midway in size between the Territory's other two semi-arboreal species (Woinarski, et al., 2012). It is known only from three records in the Northern Territory; at "Balanbrinni" in the upper McArthur in 1901; from Nellie Creek (in the upper Mary) in 1903; and from Deaf Adder Gorge in 1969 (Department of Environment and Natural Resources, 2019). It is listed as critically endangered under the TPWC Act and vulnerable under the EPBC Act. Whilst there is a record 5 km east of the survey area, the record is from prior to 1970. Given that the species is considered possibly extinct in the wild, there is a low likelihood this species occurs in the survey area.

Nabarlek (Top End) (*Petrogale concinna canescens*) – The nabarlek is a very small rock-wallaby that has been recorded in scattered populations from the Arafura Swamp in the east to the Daly River catchment in the west (Ward & Woinarski, 2012). The species is restricted to rocky sandstone or

granite areas, especially on steep slopes, with large boulders, caves and crevices, and may move to forage in adjacent flat areas (Ward & Woinarski, 2012). The closest record of a Nabarlek is 38 km west of Fountain Head. However given the lack of suitable habitat within the survey area, there is a low likelihood that this species is present.

Northern brush-tailed phascogale (*Phascogale pirata*) – The northern brush-tailed phascogale is a mid-sized carnivorous marsupial restricted to the Top End NT (Woinarski & Ward, 2012b). Little is known of the ecology of *P. pirata*, but most records are from tall open forest dominated by *E. miniata* and *E. tertodonta* (Woinarski & Ward, 2012b). The closest record of this *P. pirata* to the survey areas is 2.5 km east of survey area at Yam Creek. However, this record is dated 1878. The next closest record to the survey area is 10.5 km south-west from 2000. Given the potentially suitable habitat in the survey areas and the proximity of the 2000 record, there is a moderate likelihood that this species occurs in the survey area.

Pale field-rat (*Rattus tunneyi*) – The pale field rat is a medium sized rodent found in higher rainfall areas of northern Australia (Young & Hill, 2012). It is listed as vulnerable under the TPWC Act. *Rattus tunneyi* inhabits dense vegetation along creeks (Young & Hill, 2012). The closest record of the species is 6 km south-west of Mt Bonnie. Given the potentially suitable habitat and the proximity of prior records, there is a high likelihood that this species is present in the survey areas.

Bare-rumped sheath-tailed bat (*Saccolaimus saccolaimus nudicluniatus*) – The bare-rumped sheath-tailed bat is a large, high-flying, insectivorous bat distributed across north-eastern Australia, including Top End NT (Milne & Woinarski, 2006). It is listed as data deficient under the TPWC Act and vulnerable under the EPBC Act. The species has been recorded in open pandanus woodland and eucalypt tall open forests (Milne & Woinarski, 2006). The closest record of this species to the survey areas is greater than 60 km outside the survey area. Given the difficulty associated with recording the species and potentially suitable habitat, there is a moderate likelihood that this species occurs within the survey areas.

Reptile species of conservation significance

Eleven reptile species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (**Error! Reference source not found.**). One of these species is listed as vulnerable under the EPBC Act. An additional three reptile species listed as vulnerable under the TPWC Act, were also identified by the NT Fauna Atlas within a 20 km radius of the survey areas. Records of a further two species listed as near threatened and five species listed as data deficient under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. All NT Fauna Atlas records of conservation significant reptiles within 20km of the survey areas are mapped in Figure 18. Further information about identified threatened reptile species and a discussion of their likelihood of occurrence in the survey areas is provided below.

Table 16. Reptile species of conservation significance identified by the EPBC PMST and NT Fauna Atlas as previously reported or potentially occurring within 20 km of the Hayes Creek Project survey area. Vu: vulnerable, NT: near threatened, DD: data deficient.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
Acanthophis hawkei	Plains death adder	Vu	Vu	X		Low

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
Demansia olivacea	Olive whip snake	DD			X	High
Dendrelaphis punctulatus	Green tree snake	DD			X	High
Pseudechis australis	King brown snake	NT			X	High
Tiliqua scincoides	Common blue-tongued lizard	DD			X	Moderate
Varanus glebopalma	Long-tailed rock monitor	DD			X	Low
Varanus mertensi	Mertens' water monitor	Vu			X	High
Varanus mitchelli	Mitchell's water monitor	Vu			X	High
Varanus panoptes	Floodplain monitor	Vu			X	High
Varanus primordius	Northern ridge-tailed monitor	NT			X	High
Varanus scalaris	Spotted tree monitor	DD			X	High

Reptile species that are listed in threatened categories (Critically Endangered, Endangered, Vulnerable) that potentially use habitat within the proposal area:

Plains death adder (*Acanthophis hawkei*) – The plains death adder has a disjointed distribution on the floodplains of the Adelaide, Mary and Alligator Rivers, and the Barkly Tableland (Ward & Phillips, 2012). It is listed as vulnerable under the TPWC Act and EPBC Act. *Acanthophis hawkei* inhabits flat, treeless, cracking soil plains of northern Australia (Ward & Phillips, 2012). The closest record of the plains death adder to the survey areas is 80 km north the survey area. As any potentially suitable habitat is likely to be limited in extent in the survey areas, there is a low likelihood of this species occurring.

Merten's water monitor (*Varanus mertensi*) – Merten's water monitor is a medium- to large-sized semi-aquatic monitor found across far north Australia from the Kimberley to the west side of Cape York Peninsula (Ward, et al., 2006). It is listed as vulnerable under the TPWC Act. Merten's water monitor inhabits coastal and inland waters in all river systems of the Top End (Ward, et al., 2006). The closest record of this species to the survey areas is 6 km south of Mt Bonnie. Given the presence of potentially suitable habitat, there is a high likelihood that the species occurs within the survey areas.

Mitchell's water monitor (*Varanus mitchelli*) – Mitchell's water monitor is a slender, medium-sized monitor found across the Kimberley and the Top End, and an isolated population in north-western Queensland (Ward, 2012d). It is listed as vulnerable under the TPWC Act. Mitchell's water monitor inhabits margins of watercourses, swamps and lagoons (Ward, 2012d). The closest record of the species to the survey areas is 10 km south-east of Mt Bonnie. Given the presence of potentially suitable habitat, there is a high likelihood that Mitchell's water monitor occurs in the survey areas.

Floodplain monitor (*Varanus panoptes*) – The Floodplain monitor is a large, heavy-built terrestrial monitor with a broad geographic range across far northern Australia (Ward, et al., 2012b). It is listed as vulnerable under the TPWC Act. The species occurs in a variety of habitats, including coastal beaches, floodplains, grasslands and woodlands (Ward, et al., 2012b). The nearest record of a

floodplain monitor is 8 km north of the Fountain Head site. Given the presence of suitable habitat and proximity of records, there is a high likelihood that the species occurs within the survey areas.

Fish and shark species of conservation significance

One fish and shark species of conservation significance was identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (

Table 17). This species is listed as vulnerable under both the EPBC Act and TPWC Act. One fish species listed as near threatened under the TPWC Act was identified as occurring within a 20 km radius of the survey area. Further information about identified threatened reptile species and a discussion of their likelihood of occurrence in the survey areas is provided below.

Table 17. Fish and shark species of conservation significance identified by the EPBC PMST and NT Fauna Atlas as previously recorded or potentially occurring within 20 km of the Hayes Creek Project survey area. Vu: vulnerable

Species name	Common name	Status		NT Fauna Atlas	PMST	Likelihood
		TPWC	EPBC			
Mogurnda larapintae	Desert Mogurnda	NT		X		High
Pristis pristis	Largetooth sawfish	Vu	Vu		X	Low

Fish or shark species that are listed in threatened categories (Critically Endangered, Endangered, Vulnerable) that potentially use habitat within the proposal area:

Largetooth sawfish (*Pristis pristis* (*microdon*)) – The largetooth sawfish is a medium-sized sawfish known from several drainages in northern Australia from Western Australia to Queensland (Larson, et al., 2006). It is listed as vulnerable under both the TPWC Act, as *P. microdon*, and the EPBC Act, as *P. pristis*. The largetooth sawfish prefers muddy bottoms of freshwater areas and upper reaches of estuaries, but has been reported to be primarily a marine/estuarine species that spends its first 3-4 years in freshwater (Larson, et al., 2006). The closest record of the species to the survey areas is more than 60 km away. The creeks running through the survey areas are relatively small and probably do not provide habitat for an animal as large as the largetooth sawfish. Therefore, there is a low likelihood that it occurs within the survey areas.

3.11.3 Migratory & Marine Species

The EPBC PMST and NT Fauna Atlas identified 21 species listed as both migratory and marine under the EPBC Act, seven species listed as marine only and one species listed as migratory only as occurring or potentially occurring within 20 km of the survey areas (Table 18). Species were determined to have a high likelihood of being found in the survey area if commonly encountered within 20 km of the site and suitable habitat I known to occur in the survey area. A moderate likelihood was assigned if suitable habitat was likely to be present, but the species was not recently recorded within 20 km of the survey area. A low likelihood was assigned if records of the species in the vicinity of the survey area were lacking and/or habitat within the survey area was deemed unsuitable.

Table 18. Fauna species listed as migratory under the EPBC Act as identified by the PMST and the NT Fauna Atlas as previously recorded or having potentially suitable habitat within 20 km of the Hayes Creek Project survey area, their status, listing under international agreements and likelihood of occurrence (Likelihood) in the survey area. Mi: migratory, Ma: marine, J: Japan-Australia Migratory Bird Agreement, C: China-Australian Migratory Bird Agreement, B: Bonn Convention

Scientific name	Common name	EPBC	PMST	NT Fauna Atlas	International agreement	Likelihood
Acrocephalus orientalis	Oriental reed-warbler	MiMa	X		J, C, B	Low
Actitis hypoleucos	Common Sandpiper	MiMa	X	X	J, C, R, B	Moderate
Anseranas semipalmata	Magpie goose	Ma	X			High
Apus pacificus	Fork-tailed swift	MiMa	X	X	J, C, R	High
Ardea alba	Great egret	Ma	X			High
Ardea ibis	Cattle egret	Ma	X			High
Calidris acuminata	Sharp-tailed sandpiper	MiMa		X	J, C, R, B	Moderate
Calidris ferruginea	Curlew sandpiper	MiMa	X		J, C, R, B	Moderate
Calidris melanotos	Pectoral sandpiper	MiMa	X		J, B, R	Moderate
Cecropis daurica (Hirundo daurica)	Red-rumped swallow	MiMa	X		J, C, R	Moderate
Charadrius veredus	Oriental plover	MiMa	X		J, C, R, B	Moderate
Chrysococcyx osculans	Black-eared Cuckoo	Ma	X			High
Crocodylus johnstoni	Freshwater crocodile	Ma	X	X		High
Crocodylus porosus	Saltwater crocodile	MiMa	X	X	B	Low
Cuculus optatus	Oriental cuckoo	MiMa	X	X	J, C, R	Moderate
Glareola maldivarum	Oriental pratincole	MiMa	X		J, C, R	Moderate
Haliaetus leucogaster	White-bellied sea eagle	Ma	X			Moderate
Hirundo rustica	Barn swallow	MiMa	X		J, C, R	Moderate
Merops ornatus	Rainbow bee-eater	Ma	X			High
Motacilla cinerea	Grey wagtail	MiMa	X		J, C, R	Moderate
Motacilla flava	Yellow wagtail	MiMa	X		J, C, R	Moderate
Numenius madagascariensis	Eastern curlew	MiMa	X		J, C, R, B	Low
Numenius minutus	Little Curlew	MiMa		X	J, C, R, B	Moderate
Pandion haliaetus	Osprey	MiMa	X		B	Low
Plegadis falcinellus	Glossy Ibis	MiMa		X	B	High
Pristis pristis	Largetooth sawfish	Mi	X		B	Low
Rhipidura rufifrons	Rufous fantail	MiMa	X		B	Low
Tringa nebularia	Common Greenshank	MiMa		X	J, C, R, B	Moderate

3.11.4 Other Aquatic Fauna

Creeks within the survey area primarily consist of small tributaries of the Margaret River, a larger river of the Adelaide River catchment. An interrogation of the Fish Atlas of Northern Australia (James Cook University, 2017) list of fish species found in the Adelaide river catchment found 32 species potentially occurring in the 7,470 km^2 catchment area. The majority of waterways passing through the area categorised as Stream order 3 and 4. Like most waterways in the top end, they are highly seasonal in nature with flows mostly ceasing between May and November each year (Department of Environment and Natural Resources, 2018). Streams of the order 3 and 4 are classed as minimal to moderate fish habitat. Most streams are ephemeral and dry into a series of pools by the end of the dry season. As such the species likely present within the waterway would vary significantly depending on the time of year, stream flow and associated depth and width of the habitat. A full list of potential species present in the wider Adelaide River catchment is summarised below in Table 19. None of these species are species of conservation significance, listed under the EPBC Act, TPWC Act or protected under regulations of the NT Fisheries Act.

Table 19. Fish species identified by the North Australian Fish Atlas as potentially occurring in the wider Adelaide River Catchment (James Cook University, 2017).

Species	Common Name	Species	Common name
Ambassis agrammys	Sailfin Glassfish	*Melanotaenia nigrans*	Black-banded Rainbowfish
Ambassis macleayi	Macleay's Glassfish	*Melanotaenia splendida inornata*	Chequered Rainbowfish
Ambassis sp.	Glassfish	*Melanotaenia* sp.	Rainbowfish
Amniataba percoides	Barred Grunter	*Mogurnda mogurnda*	Northern Trout Gudgeon
Anodontigglanis dahli	Toothless Catfish	*Mugil* sp.	Mullet
Arius leptaspis	Triangular Shield Catfish, Salmon Catfish	*Nematalosa erebi*	Bony Bream
Arius sp.	Fork-talked Catfish	*Neosilurus ater*	Black Catfish, Butter Jew, Narrow-Fronted Tandan
Aseraggodes klunzingeri	Tailed Sole	*Neosilurus Hyrtlii*	Hyrtl's Tandan
Craterocephalus stercusmuscarum	Fly-specked Hardyhead	*Neosilurus* sp.	Catfish
Denariusa bandata	Pennyfish	*Oxyeleotris lineolatus*	Sleepy Cod
Glossamia aprion	Mouth Almighty	*Oxyeleotris selheimi*	Giant Gudgeon
Glossogobius giurus	Flathead Goby	*Pseudomugil tennellus*	Delicate Blue-eye
Hephaestus fuliginosus	Sooty Grunter	*Scleropages jardinii*	Gulf Saratoga
Lates calcarifer	Barramundi	*Strongylura krefftii*	Freshwater Longtom
Leiopotherapon unicolor	Spangled Perch	*Syncomistes butleri*	Butler's Grunter
Megalops cyprinoides	Oxeye Herring	*Toxotes chatareus*	Seven-spot Archerfish

3.11.5 Introduced Fauna Species

Twelve introduced fauna species were identified by the EPBC PMST as occurring or potentially occurring within 20 km of the survey area (Table 20). Eight introduced fauna species were identified by the NT Fauna Atlas within 20 km of the survey area.

Table 20. Introduced fauna species identified as previously recorded or potentially occurring within 20 km of the Hayes Creek Project survey area by the EPBC PMST or NT Fauna Atlas.

Scientific name	Common name	PMST	NT Fauna Atlas
Bos Taurus	Cattle	X	X
Bubalus bubalis	Water buffalo	X	X
Canis lupis familiaris	Domestic dog	X	
Columba livia	Rock dove	X	X
Equus asinus	Donkey	X	X
Equus caballus	Horse	X	
Felis catus	Cat	X	X
Hemidactylus frenatus	Asian house gecko	X	X
Mus musculus	House mouse	X	
Ramphotyphlops braminus	Flowerpot Blind Snake	X	
Rattus rattus	Black rat	X	
Rhinella marina	Cane toad	X	X
Sus scrofa	Pig	X	X

3.12 State and Territory Reserves

No Territory reserves were identified in the area surrounding the Hayes Creek Project survey area.

4 FIELD SURVEY RESULTS

4.1 Survey Conditions

The May 2017 survey was conducted after the 2016/2017 wet season, from May 15th – 18th. Climatic conditions during the survey were warm and mildly humid. Rainfall at the Douglas River weather station in the month preceding the survey (April 2017) was 64.4 mm, which is slightly higher than the April average for this site (49.9 mm) (Bureau of Meteorology, 2019). Rainfall in the preceding wet season (November 2016 to April 2017) at the Douglas River weather station totalled 1719.6 mm, which is higher than the average wet season rainfall at this station (1188.4 mm) (Bureau of Meteorology, 2019). Minimum temperatures during the May 2017 survey ranged between 12.6°C and 16.6°C, and maximum temperatures ranged between 33.1°C and 34.8°C (Bureau of Meteorology, 2019).

The August 2019 survey was conducted in the late dry season from 20th-24th August 2019. No rain fell at the Douglas River weather station in the month preceding the August 2019 survey (average July rainfall = 2.4 mm), and the last prior rainfall was in May 2019 (Bureau of Meteorology, 2019). Rainfall during the wet season preceding the August 2019 survey was below average, with 955.8 mm falling between November 2018 and April 2019 (Bureau of Meteorology, 2019). Minimum temperatures during the August 2019 survey ranged between 11.2°C and 16.5°C, and maximum temperatures ranged between 31.6°C and 35.1°C (Bureau of Meteorology, 2019).

4.2 Habitat Types in the survey area

Six habitats were identified during the on-ground survey. These habitat types are described in detail in the table below (Table 21). Habitat areas identified during the on-ground survey correlated with existing land classifications by Lynch et al. (2012) and the vegetation classes described by (Wilson & Brocklehurst, 1990) for the Hayes Creek Project survey area. The three land system classifications and four vegetation classes were ground truthed and combined resulting in a total of six key habitats within the survey area (Figure 19). A detailed description of each habitat type identified in the survey area is provided in sections 4.2.1 to 4.2.5.

Table 21. Habitat types identified during the on-ground survey broken down by production area and corresponding Northern Land System and/or NVIS vegetation class. Breakdown of areas to be disturbed by each production area footprint is provided in 6.4.1

Northern Land systems (Lynch, et al., 2012)	**Vegetation class (Wilson et al. 1990)**	**Habitat and land classification**	**Survey sites**	**Primary vegetation recorded**	**Extent of habitat type – production area**							
					Fountain Head		Mt. Bonnie		Iron Blow		Haul Rd	
					ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
McKinley	-	Open forest on alluvial floodplain	FH2, HR3	*Melaleuca viridiflora, Corymbia polycarpa, Eucalyptus confertiflora, Corymbia apodophylla, Lophostemon lactifluus, Acacia auriculiformis*	45.14	7.08	0	0	0	0	21.48	2.98
Rumwaggon	572	Open woodland on sandstone plain	IB1, HR6, FH11, FH10, FH8	*Corymbia latifolia, Erythrophleum chlorostachys, Eucalyptus tectifica, Eucalyptus miniata* and *Eucalyptus tintinnans*	370.57	58.16	11.24	11.90	30.14	59.97	438.6	60.91
Baker	333	Woodland on low sandstone hills	MB5, HR11, IB5, MB16, MB17	*Erythrophleum chlorostachys, Eucalyptus tintinnans and Eucalyptus clavigera, Erythrophleum chlorostachys* (mid-storey) and *Corymbia bleeseri*	0	0	14.87	16.65	16.74	33.31	63.62	8.84
-	320	Creek lines and riparian zones	HR4, HR5, HR20, MB8	*Nauclea orientalis, Bambus arnhemica, Ficus* sp. and *Melaleuca leucadendra*	14.59	2.29	4.37	4.63	0	0	42.37	5.88
		Pit lakes and tailings dams	MB15	Pit lakes and tailings dams holding substantial amounts of water.	26.24	4.12	7.2	7.62	0.2	0.40	1.26	0.18
	1024	Disturbed areas (pastoral/mining/ tracks)		Disturbed areas were a combination of cleared tracks, pits and gravel patches with little to no vegetation and revegetated areas consisting of *Eucalyptus tectifica, Acacia holosericea* and *Calytrix* sp.	180.51	28.33	56.74	60.10	3.18	6.33	152.79	21.22

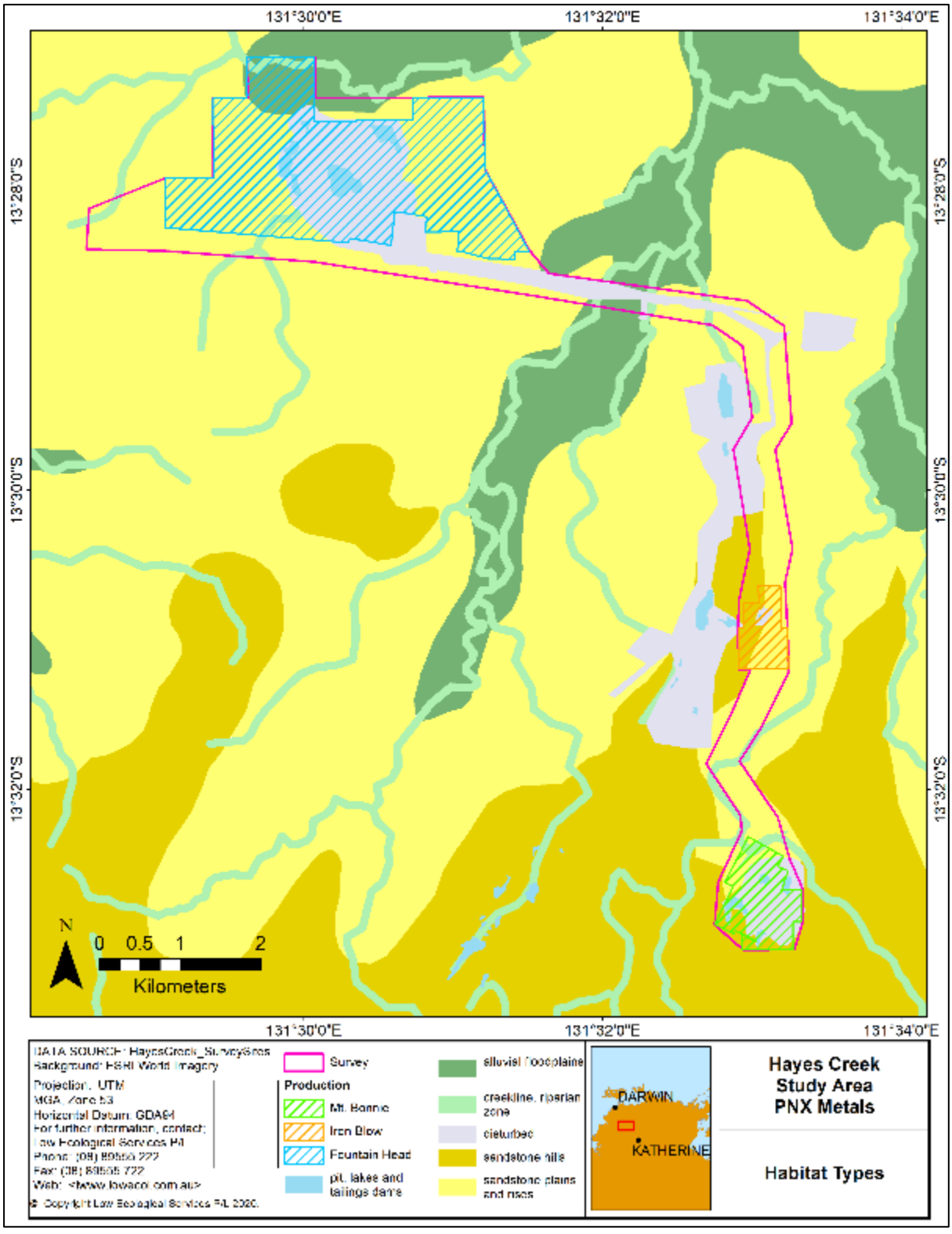

Figure 19. Habitat types identified in the Hayes Creek Project survey area, classified according to vegetation community (Wilson, et al., 1990), soil class (Northcote, 1968) and ground truthed floristic composition and landscape attributes.

4.2.1 McKinley - Open Forest on Alluvial Floodplain

Habitat – Open forest on alluvial floodplain

Structure/Characteristics (Table , Figure 20) – Open woodland of Broad-leaved Paperbark (*Melaleuca viridiflora*), Long-fruited Bloodwood (*Corymbia polycarpa*), Broad-leaved Carbeen (*Eucalyptus confertiflora*), (*Corymbia calophylla*) to 12 metres in height. Dense lower storey vegetation community consisted primarily of grasses including *Eriachne burkittii, Heteropogon* sp., *Fimbristylis sp*., and *Cynodon sp.* as well forbs including *Spermacoce sp.* and *Stylidium sp.* Soils were grey/brown and yellow with a texture of clay loam with a relatively deep soil depth (>40 cm). Stones were up to 6 cm in size.

Table 22. Distribution of open forest on alluvial plain within each project area.

production area	Extent (ha)
Fountain Head	43.05
Mt Bonnie	0
Iron Blow	0

Condition and presence of weeds – Weeds were moderately common at both the disturbed and control alluvial floodplain sites. Weeds within the control alluvial site were attributed to adjacent creek lines and existing Haul Roads.

Table 23. Vegetation community structure and dominant overstorey, midstorey and understorey species in the open forest on alluvial floodplain habitat in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	19.5	<10	*C. polycarpa, E. apodophylla, Acacia auriculiformis*
Midstorey	15.5	10-30	*Melaleuca viridiflora, A. auriculiformis*
Understorey	2	>70	*Themeda triandra, Cynodon* sp.*, Eriachne burkittii*

A)

B)

Figure 20. Open forest on alluvial floodplain at A) FH2 and B) HR3

4.2.2 Rumwaggon - Open Woodland on Sandstone Plain

Habitat – Open woodland on sandstone plain

Structure/Characteristics (Table 25, Figure 21) – Sandstone plains with low rounded hills and open woodland. A sparse overstorey dominated by Darwin stringybark (*Eucalyptus tectifica)* and/or *Eucalyptus foelscheana*, *Eucalyptus tintinnans* and ironwood (*Erythrophleum chlorostachys)* over a midstorey of round-leaf bloodwood (*Corymbia latifolia*), green plum (*Buchanania obovata)* and billygoat plum (*Terminalia ferdinandiana)* and a dense understorey of *Heteropogon* sp., kangaroo grass (*Themeda triandra*) and *Chrysopogon fallax* with mixed forbs and sedges. Soils were light brown to grey loamy clay with a moderate to deep depth (40 to >40 cm) with black to clear crust. Sandstone rocks were likely dug up and dumped on site, small stones were up to 10 cm in size.

Table 24. Distribution of open woodland on sandstone plain within each project area.

production area	Extent (ha)
Fountain Head	367.00
Mt Bonnie	10.59
Iron Blow	29.40

Condition and presence of weeds – A moderate level of disturbance by weeds was recorded at the Iron Blow site whilst a negligible presence of weeds was recorded in other areas of similar habitat type along the Haul Road and at control site 2.

Table 25. Vegetation community structure and dominant overstorey, midstorey and understorey species in the open woodland on sandstone floodplain habitat in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	12	15	*E. tectifica, E. tintinnans, Erythrophleum chlorostachys, E. miniata and E. foelscheana*
Midstorey	4.9	10-30	*Buchanania obovata, Terminalia ferdinandiana, Corymbia latifolia* and *Erythrophleum chlorostachys*
Understorey	1.8	>70	*Themeda triandra, Heteropogon* sp., *Chrysopogon fallax, Stylidium* sp., *Goodenia* sp., *Spermacoce* sp.

Figure 21. Open woodland on sandstone floodplain at HR6

4.2.3 Baker - Woodland on Low Sandstone Hills

Habitat – Woodland on low sandstone hills

Structure/Characteristics (Table 27, Figure 22 – Low rounded hills with rock outcrop. Woodland community consisting of sparse overstorey dominated by *Eucalyptus tintinnans, E. foelscheana, E. clavigera* and *Erythrophleum chlorostachys* over a Midstorey dominated of *Cochlospermum fraseri, Buchanania obovata* and *Erythrophleum chlorostachys*. Dense grassy understorey comprised predominantly of *Heteropogon* sp.*, Themeda triandra* and a range of forbs and sedges.

Table 26. Distribution of woodland on low sandstone hills within each project area.

production area	Extent (ha)
Fountain Head	0
Mt Bonnie	14.74
Iron Blow	16.74

Condition and presence of weeds – Weeds at all sites in this habitat type were recorded as negligible (1 on a scale of 0-5).

Table 27. Vegetation community structure and dominant overstorey, midstorey and understorey species in the woodland on low sandstone hills habitat in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	12.5	10-30	*E. foelscheana, E. tintinnans, E. clavigera, Erythrophleum chlorostachys*
Midstorey	3.1	10-30	*Cochlospermum fraseri, Buchanania obovata, Erythrophleum chlorostachys*
Understorey	1	>70	*Heteropogon* sp.*, Themeda triandra*

Figure 22. Woodland on low sandstone hills at A) MB1 and B) HR11

4.2.4 Creek line and Riparian Zone

Habitat – Creek line and riparian zone

Structure/Characteristics (Table 29, Figure 23) – Open forest with overstorey dominated by *Nauclea orientalis, Ficus racemosa* and *Melaleuca leucadendra* over a dense Midstorey characterised by *Lophostemon lactifluus, Pandanus aquatic* and *Bambusa arnhemica* with an understorey predominantly made up of weed species including snakeweed (*Stachytarpheta* sp.*),* hyptis (*Hyptis suaveolens*) and grader grass (*Themeda quadrivalvis*) interspersed with *Heteropogon contortus* and *Themeda triandra*.

Table 28. Distribution of creekline and riparian zones within each project area.

production area	Extent (ha)
Fountain Head	14.59
Mt. Bonnie	4.37
Iron Blow	0

Condition and presence of weeds – Weeds disturbance was recorded as high in most riparian zone vegetation communities recorded within the survey area

Table 29. Vegetation community structure and dominant overstorey, midstorey and understorey species in the creekline and riparian habitat in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	Up to 20m	10.30	*Melaleuca leucadendra, Nauclea orientalis, Ficus racemosa*
Midstorey	1.5	30-70	*Bambus arnhemica, Lophostemon lactifluus*
Understorey	0.5	10	Snakeweed *(Stachytarpheta* sp.*),* Grader grass (*Themeda quadrivalvis*), *Heteropogon contortus*

Figure 23. Creekline and riparian habitat A) at HR5 and B) snakeweed (*Stachytarpheta* sp.) and candle bush (*Senna alata*) adjacent to HR5.

4.2.5 Pit lakes and tailings dams

Habitat – Lakes and tailings dams constructed for mining activities holding large quantities of water year-round.

Structure/Characteristics (Table 31, Figure 25) – Where water persists at the shallow edges of these water bodies dense, low vegetation can form. Sedgeland vegetation consists of *Typha* sp. and *Cyperus javanica*. Habitat type surrounding dams are as described in other habitat types above.

Table 30. Distribution of pit lakes and tailings dams within each project area.

production area	Extent (ha)
Fountain Head	26.24
Mt. Bonnie	7.07
Iron Blow	0.2

Table 31. Vegetation community structure and dominant overstorey, midstorey and understorey species in the pit lakes and tailings dams in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	-	-	
Midstorey	2	60	*Typha* sp. *Cyperus javanica*
Understorey	-	-	

A)  B) 

Figure 24. A) Tailings dam in the Mt Bonnie production area and B) *Cyperus javanica* vegetation at the edge of a tailings dam in the Mt Bonnie production area

4.2.6 Pastoral/Disturbed Areas

Habitat – Areas disturbed by pastoralism, mining, existing Haul Roads and tracks

Structure/Characteristics (Table 33, Figure 25) – Primarily no vegetation (some areas of rehabilitation), some waste rock dumps, erosion, open cut pits, tailings dams etc.

Table 32. Distribution of pastoral/disturbed areas within each project area.

Production Area	Extent (ha)
Fountain Head	180.51
Mt. Bonnie	56.98
Iron Blow	3.18

Condition and presence of weeds – Weeds disturbance was observed to be moderate – high, predominantly in the Fountain Head disturbed area, along the Mt Wells Road (running E-W, south of Fountain Head), along existing tracks through the survey area and patchily in the Iron Blow and Mt Bonnie disturbed areas.

Table 33. Vegetation community structure and dominant overstorey, midstorey and understorey species in the creekline and riparian habitat in the Hayes Creek Project survey area.

Stratum	Height (m)	% cover	Dominant species
Overstorey	-	-	
Midstorey	Varied	Varied	*Acacia holosericea, Calytrix* sp.
Understorey	Varied	Varied	Gamba grass (*Andropogon gayanus*) hyptis (*Hyptis suaveolens*), mission grass (*Cenchrus pedicellatus*)

A)

B)

Figure 25. Pastoral and mining impacted habitat at A) the Fountain Head lease area and B) adjacent to IB1

4.3 Flora Species

Overall, 143 flora taxa were recorded during on-ground surveys. 152 flora taxa from 104 genera were recorded during the May 2017 survey. This included 111 taxa that could be identified to species level and 38 taxa that could be identified to genus level. Ten further taxa could not be identified to genus level. During the August 2019 survey 83 flora taxa from 56 genera were recorded. This included 63 taxa that could be identified to species level and 16 that could be identified to genus level. A further three taxa could not be identified to genus level.

4.3.1 Threatened Flora Species

No threatened flora species were identified in the survey area during May 2017 and August 2019 surveys despite targeted survey effort for *A. praetermissa* and *S. ensatum*.

Fountain Head

Potential habitat for *S. ensatum* was identified within the open forest on alluvial plains but no individuals were identified in this area. This habitat type is found in the northern part of the Fountain Head production area. *Stylidium sp.* samples were collected at two sites (FH1 and FH2) during the May 2017 survey and sent to the herbarium. These samples could not be identified to species due to a lack of fruit or flowers.

Mt Bonnie

Sandstone hill habitat that would be suitable for *A. praetermissa* was identified in the Mt Bonnie production area in the western half of the boundary. Despite this, no individuals were located.

Iron Blow

Sandstone hill habitat is in a small section in the south-west corner of the production area boundary and may provide suitable habitat for *A. praetermissa* although no individuals were identified. A *Stylidium sp.* sample was collected at Iron Blow but could not be identified to species by the herbarium.

Haul Road

The open forest on alluvial plains habitat crosses one small section of the existing Haul Road south of the Fountain Head production area. This area has potential to support *S. ensatum.* Stylidium samples were collected at two sites along the Haul Road (HR1 and HR2) in May 2017 but could not be identified to species by the herbarium.

4.3.2 Conservation Significant Flora Species

No flora species of conservation significance were recorded in the survey areas during the May 2017 on-ground survey. Several flora species could not be identified to species level. However, all were determined not to be threatened species due to their identified genus, description or and/or location.

4.3.3 Introduced Flora Species

Twenty-four introduced flora species were recorded in the survey area overall (Table 34). Two of these were recorded in May 2017 but could not be identified to species level (Table 34). The first, *Ipomoea* spp. could be identified far enough to ascertain introduced status. The second was Cynodon sp. and *Cynodon* is a genus for which there are no native species in the NT. Of the 24 introduced species recorded in the survey area, 20 were recorded during May 2017 and 13 during August 2019. Four species, *A. gayanus, C. procera, Hyptis suaveolens* (Hyptis) and *Sida rhombifolia* (common sida) are class B weeds in the NT (growth and spread to be controlled). However, *C. procera* is only a class B weed in the NT south of 16° 30'. Hayes Creek Project is north of this latitude, therefore *C. procera* is not a class B weed in the survey area. Five species, *H. amplexicaulis, Senna alata* (candlebush), *Sida acuta* (spiny-headed sida), *Stachytarpheta cayennensis* (snakeweed) and *Themeda quadrivalvis* (grader grass), are class B and class C (not to be introduced into the NT) in the NT. Both *A. gayanus* and *H. amplexicaulis* are also listed as WoNS. Many of the introduced species observed were within or immediately adjacent to riparian zones around creek lines in the south and north of the survey areas. Dominant introduced species in these areas included snakeweed and hyptis with scattered patches of candlestick bush, spinyhead sida, gambia pea, morning glory vine, red natal grass, couch grass and stylo.

Fountain Head

Five weed species were identified within the Fountain Head production area, two of which are listed weeds in the NT, Gamba grass which is a class B weed and Grader grass which is a class B and C weed (Table 34). Gamba grass was prevalent around most of the edge of the existing pit and scattered throughout the disturbed area. Grader grass was identified at site FH2 in May 2017.

Mt. Bonnie

Sixteen species of weed were identified in the Mt. Bonnie area, 2 of which are classed at class B weeds while six as listed as class B and C weeds. (Table 34). One patch of olive hymenachne (*Hymenachne amplexicaulis*), a WoNS, was observed on a creek bank in the south-east of the survey area, just north of the Mt. Bonnie production area. of note was an infestation of *C. procera* in the Mt Bonnie area close to where the new Haul Road route is proposed.

Iron Blow

Only one weed, Stylo was identified in the Iron Blow production area and is not a listed weed in the NT.

Haul Road

Thirteen species of weeds were identified along the existing and proposed Haul Road sections, 3 that are listed as Class B weeds and 3 that are listed as Class B and C weeds. Significant areas of weed growth were noted along the existing Haul Road in the north of the survey area where gamba grass, a WoNS, and mission grass (*Cenchrus pedicellatus/polystachios*) were prevalent (Figure 26).

Table 34. Introduced flora species recorded in the Hayes Creek Project survey area during the May 2017 and August 2019 surveys, including classification under the NT Weeds Act (see section 3.10.4 for description of classes), EPBC Act and inclusion on the WoNS list. NT classes: A – to be eradicated, B – growth and spread to be controlled, C – not to be introduced into the NT, zoned – class restricted to part of the NT.

Scientific name	Common name	Survey	NT Class	EPBC	WoNS	Production area
Aeschynomene americana	American jointvetch	May-17				Mt Bonnie
Andropogon gayanus	Gamba grass	May-17, Aug-19	B	Invasive	X	Haul Road, Fountain Head
Calotropis procera	Rubber Bush	May-17, Aug-19	B (zoned)			Haul Road, Fountain Head, Mt Bonnie
Cenchrus pedicellatus	Mission grass	Aug-19				Haul Road
Crotalaria goreensis	Rattlepod	May-17, Aug-19				Haul Road, Mt Bonnie
Cynodon dactylon	Couch Grass	May-17				Haul Road, Fountain Head
Cynodon radiatus	Cynodon	May-17				Mt Bonnie
Cynodon sp.	Cynodon	May-17				Haul Road
Evolvulus nummularius	Evolvulus	May-17				Mt Bonnie
Grewia asiatica	Grewia	Aug-19				Mt Bonnie
Hibiscus sabdariffa	Hibscus	May-17				Iron Blow
Hymenachne amplexicaulis	Olive hymenachne	May-17	B, C	Invasive	X	Mt Bonnie
Ipomoea spp.	Morning glory vine	May-17				Mt Bonnie
Khaya senegalensis	African mahogany	Aug-19				Haul Road, Mt Bonnie
Melinis repens	Red natal grass	May-17				Mt Bonnie
Hyptis suaveolens	Hyptis	May-17, Aug-19	B			Haul Road, Mt Bonnie
Passiflora foetida	Wild Passionfruit	May-17, Aug-19				Haul Road, Fountain Head
Senna alata	Candlebush	May-17, Aug-19	B, C			Haul Road, Mt Bonnie
Senna obtusifolia	Senna	May-17				Mt Bonnie
Sida acuta	Spiny-head sida	May-17	B, C			Mt Bonnie
Sida rhombifolia	Common Sida	Aug-19	B			Haul Road
Stachytarpheta cayennensis	Snakeweed	May-17, Aug-19	B, C			Haul Road, Mt Bonnie
Stylosanthes viscosa	Stylo	May-17, Aug-19				Haul Road, Iron Blow, Mt Bonnie
Themeda quadrivalvis	Grader Grass	May-17, Aug-19	B, C			Fountain Head, Mt Bonnie

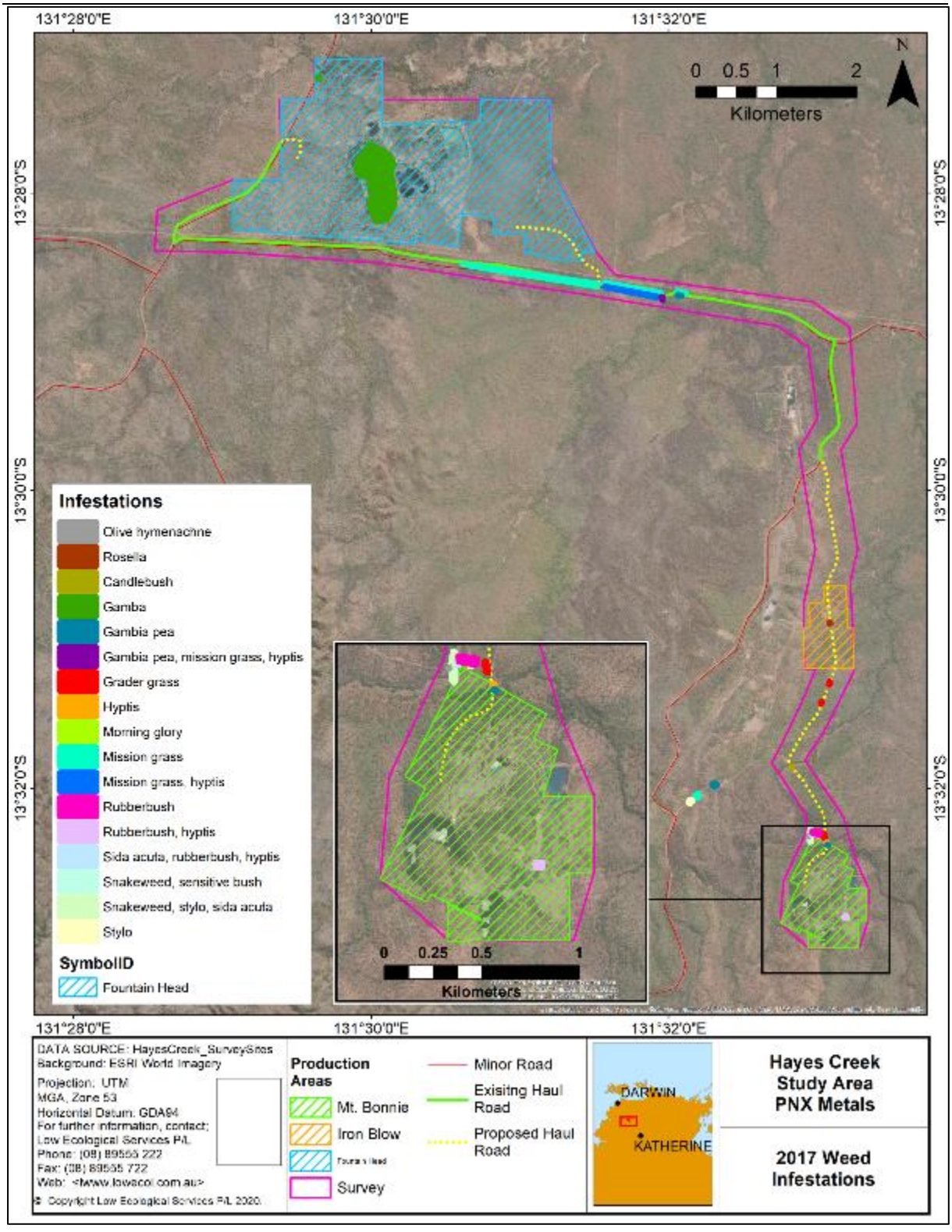

Figure 26. Location of introduced flora species recorded during the May 2017 and August 2019 surveys of the Hayes Creek Project survey area

4.4 Fauna

4.4.1 Native Fauna Species

A total of five native amphibian species, 107 native bird species, 15 native mammal species and eight native reptile species were recorded across the survey area during the May 2017 and August 2019 surveys. An additional seven native bird taxa, seven native mammal taxa and two native reptile taxa could not be identified to species level due to inability to distinguish bat echolocation calls or tracks, or because only brief observation of the animal was possible. Overall, more bird and mammal species were recorded during the August 2019 survey than the May 2017 survey (Table 35). For mammals, this was mostly due to a greater number of bat species being identified from echolocation call recordings. The greater number of bird species identified may have been due to greater survey effort, bird activity being more concentrated around water as a result of the dry conditions, or a combination of both.

Table 35. Number of native amphibians, bird, mammal and reptile species recorded in the Fountain Head, Iron Blow and Mt Bonnie disturbance areas, and along the proposed Haul Road route during the May 2017 and August 2019 surveys. Totals are also presented for each fauna group for each survey period and for each disturbance area. Numbers in parentheses indicate additional taxa that could not be identified to species level. A full list of species for each survey site can be found in Appendices 3-7.

Survey	Fauna group	Disturbance area				Survey total
		Fountain Head	Iron Blow	Mt Bonnie	Haul Road	
May-17	Amphibian	5	0	0	0	5
	Bird	26 (1)	16 (1)	14	38 (1)	66 (4)
	Mammal	4 (2)	3 (3)	5 (3)	4 (3)	7 (3)
	Reptile	2	0	1	5 (1)	7 (1)
Aug-19	Amphibian	0	0	0	0	0
	Bird	50	10	61 (1)	62 (3)	95 (3)
	Mammal	9 (4)	1 (1)	4 (4)	11 (5)	13 (5)
	Reptile	0	0	1	1 (1)	2 (1)
production area total	Amphibian	5	0	0	0	
	Bird	61 (1)	22 (1)	71 (3)	63 (1)	
	Mammal	10 (6)	3 (3)	13 (7)	7 (6)	
	Reptile	2	0	6 (1)	1 (1)	

Amphibians

Native amphibians were only observed in the Fountain Head area during the May 2017 survey (Table 35; Appendix 6). As the August 2019 survey was primarily targeted towards detecting threatened species, of which no amphibians were identified via the desktop survey, no survey methods specifically focused on detecting amphibians.

Birds

Birds were the most commonly recorded native taxa during both the May 2017 and August 2019 surveys, and overall (Table 35). The most common bird species overall (> 20 records) were the blue-winged kookaburra (*Dacleo leachii*), bar-shouldered dove (*Geopelia humeralis*), peaceful dove (*Geopelia placida*), whistling kite (*Haliastur sphenurus*) and brown honeyeater (*Lichmera indistincta*).

The most widespread bird species (recorded at ≥ 10 survey sites) were the red-tailed black cockatoo (*Calyptorhynchus banksii macrorhynchus*), white-bellied cuckoo shrike (*Coracina papuensis*), blue-winged kookaburra, bar-shouldered dove, peaceful dove, whistling kite, brown honeyeater, rainbow bee-eater (*Merops ornatus*) and rufous whistler (*Pachycephala rufiventris*).

Mammals

During the May 2017 and August 2019 surveys, the most commonly recorded native mammal species (> 10 records) were the greater northern free-tailed bat (*Chaerephon jobensis*), Gould's wattled bat (*Chalinolobus gouldii*), orange leaf-nosed bat (*Rhinonicteris aurantia*) and agile wallaby (*Notamacropus agilis*). There were two additional bat taxa that were recorded using handheld and passive bat detectors but could not be identified to species level. These were *Saccolaimus flaviventris/Saccolaimus saccolaimus* and *Scotorepens greyi/Chalinolobus nigrogriseus*. The greater-northern free-tailed bat, Gould's wattled bat and *Scotorepens greyi/Chalinolobus nigrogriseus* were the most widespread mammal species recorded during the surveys (recorded at ≥ 9 survey sites).

Reptiles

The most commonly recorded reptile species were the robust ctenotus (*Ctenotus robustus;* recorded at six survey sites) and Gilbert's dragon (*Lophognathus gilberti*; recorded at 7 survey sites), both were recorded only during the May 2017 survey. The robust ctenotus was also the most widespread reptile species (recorded at 3 survey sites).

4.4.2 Threatened Fauna Species

Of the 17 threatened species that were identified by the desktop study classified as moderately or highly likely to occur within the survey area (Section 3.11.2), two were recorded. The Gouldian finch, listed as endangered under the EPBC Act and vulnerable under the TPWC Act, was recorded during both the May 2017 and August 2019 surveys of the survey area. Merten's water monitor (*Varanus mertensi*), listed as vulnerable under the TPWC Act, was anecdotally recorded in the survey area prior to the May 2017 survey (see Table 36).

Gouldian finch

During the May 2017 survey a flock of Gouldian finches was observed at the southern junction to the Haul Road between Mt Bonnie and Iron Blow production sites and at HR20 (Table 36, Figure 29). Approximately 12 individuals were observed including adult males and females, and juveniles. Birds were initially observed foraging for grass seeds on the proposed Haul Road alignment and over the following two days, were observed moving between the Haul Road and adjacent woodland. Birds were also heard in the vicinity of HR20, a location immediately adjacent to where they were initially sighted.

Table 36. Records of Gouldian finches during the May 2017 and August 2019 surveys of the Hayes Creek Project survey area. Co-ordinates are provided in GDA94.

Date	Co-ordinates	Location	No. of individuals (A/J)	Other comments
16/05/2017	-13.529965, 131.546848	Southern junction of the Haul Road between Mt Bonnie and Iron Blow.	12	Adults and juveniles, and both sexes present. Numbers of each not recorded.

Date	Co-ordinates	Location	No. of individuals (A/J)	Other comments
17/05/2017	-13.53071, 131.547034	HR20		Calls heard but birds not sighted
21/08/2019	-13.544725, 131.548681	MB15 – inundated and well vegetated area at south-eastern tip of dam in Mt Bonnie production area	1 (0/1)	
22/08/2019	-13.544725, 131.548681	MB15 – inundated and well vegetated area at south-eastern tip of dam in Mt Bonnie production area	30	Adults and juveniles present. Numbers of each not recorded.
23/08/2019	-13.544725, 131.548681	MB15 – inundated and well vegetated area at south-eastern tip of dam in Mt Bonnie production area	17 (2/15)	
22/08/2019	-13.546073, 131.54854	MB10 – waterhole in creekline to the east of the Mt Bonnie production area	16 (15/1)	

During the August 2019 survey Gouldian finches were recorded at MB10, a waterhole in the creekline to the west of Mt Bonnie, and MB15, an inundated area on the southern edge of one of the dams at Mt Bonnie (Table 36). Both areas had substantial vegetation cover adjacent to and over the water and were adjacent to rocky hills with woodland vegetation dominated by *E. tintinnans* and a tussock grass understorey. Gouldian finches recorded at MB15 were observed moving between this site and adjacent rocky hills with an overstorey dominated by *E. tintinnans*.

An assessment of hollow abundance was conducted in the vicinity of Iron Blow and Mt Bonnie production areas and the Haul Road route during August 2019. The Fountain Head production area was not included in this assessment as no Gouldian finches were observed within or in the vicinity of Fountain Head and suitable nesting habitat was not identified during vegetation surveys. The assessment revealed that there were a greater number of hollows available at sites where *E. tintinnans* was present than where this species was absent (Figure 27). *E. tintinnans* was most abundant in the open woodland on sandstone hills habitat (Baker landsystem). Except for the northern boundary line, this habitat type surrounds the Mt. Bonnie production area and encroaches into the south-west corner. This habitat also runs up the western side of the proposed Haul Road and Iron Blow area and represents approximately half of the Iron Blow production area. In sites where *E. tintinnans* was present, *E. tintinnans* was the predominant hollow bearing tree species, hollows of all size categories were recorded (1-4 cm – >10 cm) and average hollow height was between 3 m and 8 m above ground level. Hollow bearing trees were numerous and were recorded predominantly in the Baker habitat type (**Error! Reference source not found.**).

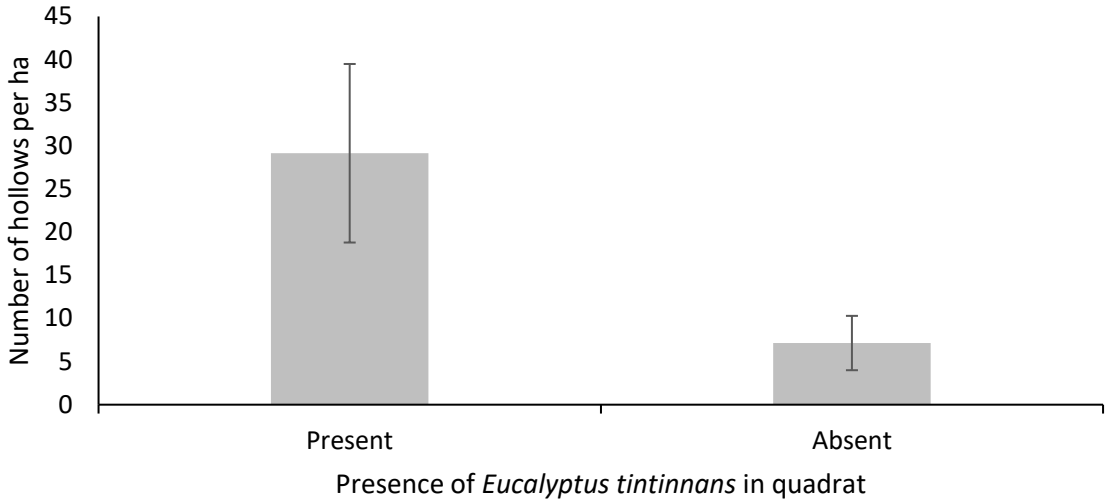

Figure 27. Number of tree hollows per hectare recorded in quadrats where Eucalyptus tintinnans was present or absent. Error bars indicate standard error.

Table 37. Tree species, number of hollows and hollow size classes at Gouldian finch habitat assessment sites.

Site	Habitat type	Tree species (in order of dominance)	No. of hollows per species	Hollow size classes (cm)
HR16	McKinley	*Corymbia disjuncta* *Eucalyptus miniata* *Erythrophleum chlorostachys*	10 2 0	1-4, 4-8, 8-10, >10
HR17	Rumwaggon	*Corymbia sp.* *Eucalyptus tintinnans* *Corymbia disjuncta*	0 0 0	NA
HR18	Baker	*Eucalyptus tintinnans,* *Corymbia sp.*	19 13	1-4, 4-8, 8-10, >10
HR20	Creekline	*Melaleuca viridiflora* *Acacia auriculiformis* *Nauclea orientalis*	0 0 0	NA
IB05	Baker	*Corymbia disjuncta* *Eucalyptus tintinnans*	3 3	1-4, 4-8
MB07	Disturbed	Eucalyptus tectifica Erythrophleum chlorostachys	4 0	1-4
MB08	Creekline	Nauclea orientalis Ficus racemosa	0 2	1-4
MB10	Creekline	*Acacia auriculiformis*	0	NA
MB13	Baker	*Eucalyptus tectifica* *Eucalyptus tintinnans*	10 40	1-4, 4-8, 8-10, >10
MB14	Baker	*Eucalyptus tintinnans* *Eucalyptus tectifica*	35 5	1-4, 4-8, >10
MB15	Dam	*Eucalyptus (dead)*	5	4-8, 8-10

MB16	Baker	*Corymbia disjuncta* *Eucalyptus miniata* *Eucalyptus tectifica*	9 0 9	1-4, 4-8, >10
MB17	Rumwaggon	Eucalyptus tintinnans Eucalyptus tectifica	68 8	1-4, 4-8, 8-10, >10

Gouldian finches were recorded at two small water sources in (MB15) and adjacent (MB10) to the Mt Bonnie survey area during August 2019 (Figure 28). Both water sources were small. MB15 was a swampy area at the southern edge of a tailings dam in the Mt Bonnie production area where water was pooling. There was a dense cover of *Cyperus javanicus* and *Typha* sp. at MB15 and a good availability of perches in the surrounding trees. MB10 was a waterhole in a creekline to the east of the Mt Bonnie production area and had a good cover of vegetation and trees for perching. Large shrub and tree species present at MB10 were *Bambusa arnhemica*, *Ficus racemosa, Grewia asiatica, Nauclea orientalis, Pandanus aquaticus* and *Syzygium nervosum*.

A)  B) 

Figure 28. A) Water sources used by Gouldian finches at MB15 and B) at MB10

Dry season grasses recorded in the survey area during May 2017 and August 2019 were *Sorghum* spp., *Heteropogon contortus* and *H. triticeus* (Table 38). Wet season grasses recorded in the survey area during May 2017 and August 2019 were *Alloteropsis semialata*, *Chrysopogon fallax*, *Triodia bitextura* and *Themeda triandra* (Table 38).

Table 38. Grasses identified in O'Malley (2006) as important dry season and wet season food plants for the Gouldian finch, season of fruiting recorded in NT Flora (Department of Environment and Natural Resources, 2019) and sites at which these grasses were identified during May 2017 and August 2019

Food species	Season	Fruiting recorded	Site
Sorghum spp.	Dry season	January-October	IB1, MB17, FH1, HR11, HR2
Heteropogon spp.	Dry season	January-December	FH1, FH2, HR3, HR5, IB1, FH8, HR17, HR6, MB10, FH11, MB5, HR2, HR17, MB17
Alloteropsis semialata	Wet season	January-December	IB1, FH10
Chrysopogon fallax	Wet season	January-December	HR6 (*Chrysopogon latifolius* at HR16, HR20)
Triodia spp.	Wet season	January-December	HR18
Sehima nervosum	Wet season	January-November	Not recorded
Xerochloa laniflora	Wet season	January-September	Not recorded
Themeda triandra	Wet season		FH2, HR11, HR2, HR3, HR6, MB5, FH11, HR20, MB17

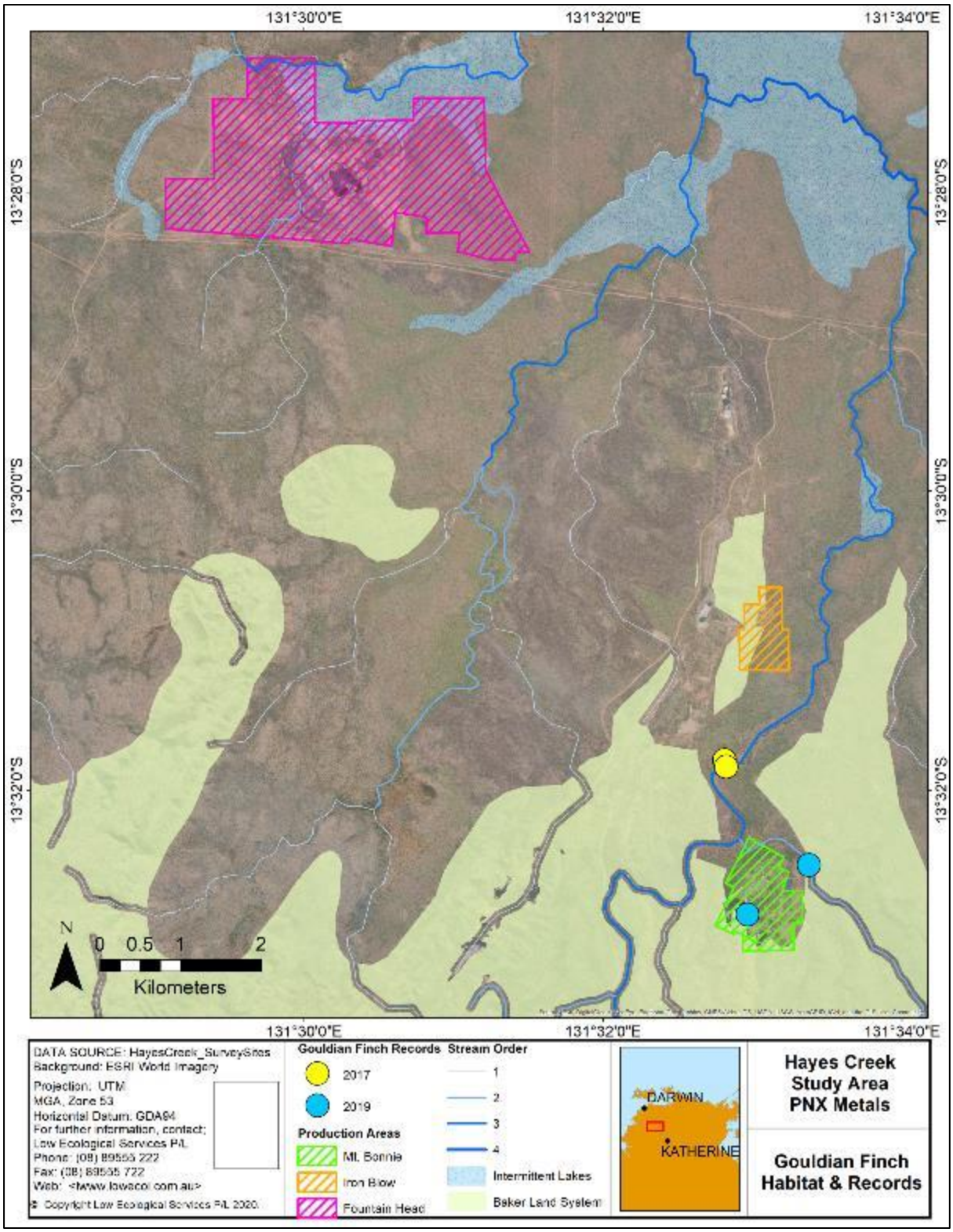

Figure 29. Location of Gouldian finches recorded during the May 2017 and August 2019 surveys of the Hayes Creek Project survey area and extent of suitable Gouldian finch habitat (Baker landsystem) in relation to the survey area.

Merten's water monitor

Merten's water monitor was recorded in the survey area by a Kirkland Lake Gold (KL Gold) in the Iron Blow production area prior to the May 2017 survey (Table 39). The KL Gold employee reported observing a Merten's water monitor in the Iron Blow production area earlier in the year. LES staff confirmed the identification through a photograph taken of the species. This species was not recorded during the August 2019 survey despite targeted survey effort.

Table 39. Records of Merten's water monitor during the May 2017 and August 2019 surveys of the Hayes Creek Project survey area. Co-ordinates are provided in GDA94.

Date	Co-ordinates	Location	No. of individuals (adult/juvenile)	Other comments
Early 2017	-13.54792, 131.551244	Iron Blow pit	1	Recorded prior to the May 2017 survey by KL Gold employee

Threatened species identified in the desktop study that were moderately or highly likely to occur within the survey area but not recorded during the May 2017 or August 2019 surveys despite targeted survey effort included:

- Curlew sandpiper;
- Red goshawk;
- Partridge pigeon;
- Eastern curlew;
- Australian painted snipe;
- Masked owl;
- Fawn antechinus;
- Northern quoll;
- Ghost bat;
- Black-footed tree-rat;
- Northern brush-tailed phascogale;
- Pale field rat;
- Bare-rumped sheath-tailed bat;
- Mitchell's water monitor; and
- Floodplain monitor.

4.4.3 Near Threatened and Data Deficient Fauna Species

Four species listed as near threatened under the TPWC Act were observed during the May 2017 survey and six species listed as near threatened were recorded during the August 2019 survey (Table 40).

Fountain Head

One near-threatened species, the orange leaf-nosed bat, was recorded in the Fountain Head production area (FH2) in May 2017. This species was also widespread across the entire survey area. The Australian bustard, bush stone-curlew and hooded parrot were recorded incidentally in the Fountain Head production area in August 2019.

Mt. Bonnie

The orange leaf-nosed bat was detected at MB5 in 2017 while the buff-sided robin was recorded at MB15 in 2019.

Iron Blow

The northern ridge-tailed monitor was recorded at IB1 in May 2017 and the orange leaf-nosed bat was recorded at IB3 in August 2019.

Haul Road

Five near threatened or data deficient species were recorded along the existing/proposed Haul Road or in the vicinity of the Haul Road. The buff-sided robin was recorded at HR1 while the bush stone-curlew was recorded approximately 750 m west of HR1 along the proposed Haul Road alignment. The orange leaf-nosed bat was detected at three sites along the Haul Road, HR3, HR6 andHR11. The northern ridge-tailed monitor was recorded at HR6 in 2017. The Arnhem sheath-tailed bat was recorded at HR6 in 2019.

Table 40. Fauna species listed as near threatened (NT), data deficient (DD), marine (Ma) or migratory (Mi) under the EPBC Act or TPWC Act recorded during the May 2017 and August 2019 surveys of the Hayes Creek Project survey area. Co-ordinates are provided in GDA94. NA indicates that number of individuals of a bat species cannot be discerned from echolocation call recordings.

Species	Status	Date	Co-ordinates	Location	No. of individuals
Arnhem sheath-tailed bat (*Taphozous kapalgensis*)	NT (TPWC)	21/08/2019	-13.49143, 131.55291	HR6 – woodland adjacent to existing Haul Road	NA
		22/08/2019	-13.49143, 131.55291	HR6 – woodland adjacent to existing Haul Road	NA
		23/08/2019	-13.49143, 131.55291	HR6 – woodland adjacent to existing Haul Road	NA
Australian bustard (*Ardeotis australis*)	NT (TPWC)	21/08/2019	Not recorded	Fountain Head production area	1
		23/08/2019	Not recorded	Fountain Head production area	1
Buff-sided robin (*Poecilodryas cerviniventris*)	NT (TPWC)	17/05/2017	-13.477681, 131.532994	HR1 - Yam Creek	1
		24/08/2019	-13.547182, 131.549429	MB15 – inundated and well vegetated area at south-eastern tip of dam in Mt Bonnie production area	1
Bush stone-curlew (*Burhinus grallarius*)	NT (TPWC)	16/05/2017	-13.476929, 131.526045	Existing Haul Road to the south of Fountain Head	1
		17/05/2017	-13.476929, 131.526045	Existing Haul Road to the south of Fountain Head	1
		18/05/2017	-13.476929, 131.526045	Existing Haul Road to the south of Fountain Head	1
		22/08/2019	-13.47096, 131.50987	Fountain Head production area	1
Hooded parrot (*Psephotus dissimilis*)	NT (TPWC)	23/08/2019		Fountain Head production area	5

Species	Status	Date	Co-ordinates	Location	No. of individuals
Northern ridge-tailed monitor (*Varanus primordius*)	NT (TPWC)	17/05/2017	-13.516030, 131.551667	IB1 – disturbed woodland in Iron Blow production area	
		18/05/2017	-13.491704, 131.553050	HR6 – woodland north of Iron Blow	1
Orange leaf-nosed bat (*Rhinonicteris aurantia*)	NT (TPWC)	17/05/2017 – 19/05/2017	-13.459068, 131.506359	FH2 – disturbed woodland in Fountain Head production area	NA
			-13.479763, 131.532529	HR3 – creekline crossed by existing section of the Haul Road to the south-east of Fountain Head	NA
			-13.491176, 131.553302	HR6 – woodland adjacent to existing Haul Road	NA
			-13.535158, 131.536289	HR11 – woodland north-west of Mt Bonnie production area	NA
			-13.515074, 131.551507	IB1 – disturbed woodland in Iron Blow production area	NA
			-13.544925, 131.54845	MB5 – Disturbed woodland in Mt Bonnie production area	NA
		21/08/2019	-13.512642, 131.551308	IB3 – woodland in Iron Blow production area	NA

4.4.4 Marine and Migratory Fauna Species

Four EPBC listed marine species were observed during the May 2017 survey and four species recorded in the survey area during the August 2019 survey. (Table 40). No fauna species listed as migratory were recorded during the May 2017 on-ground survey.

Fountain Head

Rainbow bee-eaters were recorded in the Fountain Head production area during the May 2017 survey (FH2) and the August 2019 survey (FH9). A great egret was recorded at FH1 in August 2019.

Mount Bonnie

Freshwater crocodiles were recorded at MB1 in May 2017 and at MB6 in August 2019. Rainbow bee-eaters were common and were recorded at MB5 in May 2017 and MB10, MB15 and MB16 in August 2019. A cattle egret was recorded at MB16 during the 2019 survey.

Iron Blow

Rainbow bee-eaters were recorded at IB1 in May 2017.

Haul Road

Rainbow bee-eaters were recorded at HR3, HR6 and HR11 during the May 2017 survey and regularly recorded incidentally along the Haul Road in August 2019. A cattle egret was recorded at HR13 in August 2019.

4.4.5 Introduced Fauna Species

Seven introduced fauna species were recorded in the May 2017 survey and five during the August 2019 survey.

Fountain Head

One introduced amphibian, the cane toad, was ubiquitous throughout the survey area during May 2017 and was recorded in the Fountain Head production area in August 2019. Cattle were recorded in the Fountain Head production area during both the May 2017 and August 2019 surveys. and Pigs were recorded throughout the production area during both the May 2017 and August 2019 surveys.

Mt. Bonnie

Black rats were recorded at MB4 during the May 2017 survey and Buffalo were recorded in the Mt Bonnie production area during the August 2019 survey. Pigs were recorded during both surveys.

Iron Blow

Cane toads and pigs were recorded at Iron Blow during both surveys.

Haul Road

Buffalo were recorded incidentally on the Mt Wells Rd (proposed Haul Road) survey while the presence of cats was confirmed by prints on the track during the May 2017 survey. Cattle were recorded at HR13 and HR14 and Donkeys at HR22 during the August 2019 survey, while pigs were observed throughout the production area.

4.5 Aquatic and Riparian Habitat areas

4.5.1 Classification of Waterways in the survey area

Waterways within the survey area were identified and classified using Straler's stream order classification system (Table 41, Figure 30). Mt Bonnie Creek (MB2) was classified as a 3rd order stream, Yam Creek (HR4) and Downstream Creek (HR5) were classified as 4th order streams. There were also ephemerally inundated swamps present in the survey area.

Table 41. Stream orders of waterways identified within the Hayes Creek Project survey area (Strahler, 1952)

Waterway	Site	Stream Order	Description	Coordinates	
				Latitude	Longitude
Mt Bonnie Creek	MB2	3	Waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event.	-13.538662°	131.548880°
Yam Creek	HR4	4	Permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting area.	-13.478989°	131.532593°
Downstream creek	HR5	4	Permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting area.	-13.482082°	131.566009°
Ephemerally inundated swamp	North of Fountain Head	-	Areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, bracking or salt.	-13.459620°	131.505073°

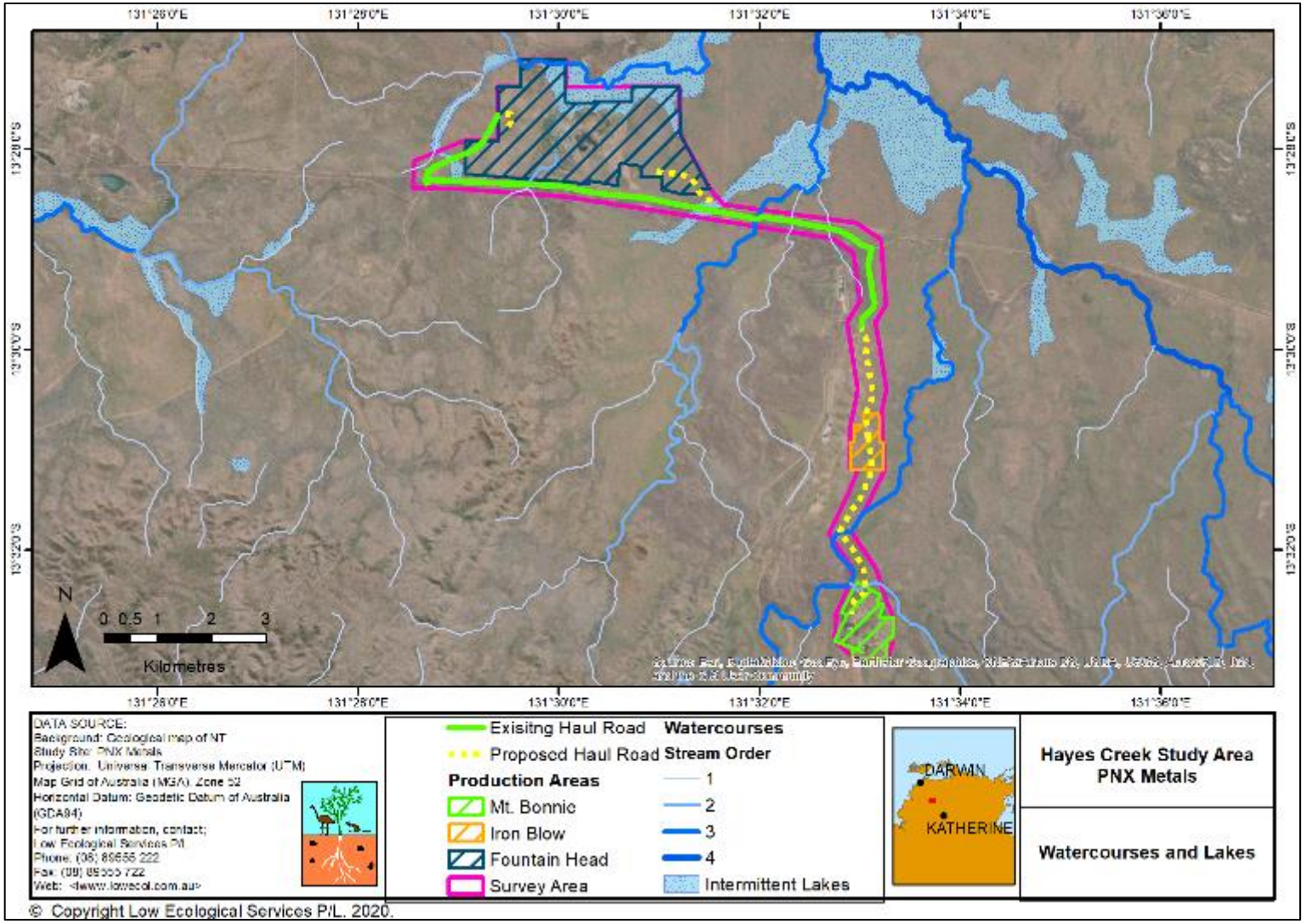

Figure 30. Location of waterways and associated stream order categories within and adjacent to the survey area, with location of aquatic survey sites

4.5.2 Characterisation of Habitat Areas

Creek lines within the survey area were vegetated primarily with forest and woodland communities (see section 4.3). Evidence of disturbance is present along the banks of all creeks adjacent to existing tracks and Haul Roads. Creeks in the south of the survey area, north of Mt Bonnie site have significant weed growth on the banks (see section 4.3.3) and evidence of infrastructure including old culverts and bridges that are no longer structurally sound. Additional waste was observed in creeks adjacent to existing tracks including old fans and air conditioners (Figure 31).

A) B)

Figure 31. Waste observed in and adjacent to A) creeks north of Mt Bonnie and B) in Yam Creek

All three creeks assessed contained flowing water at the time of the post-wet season survey. Freshwater habitat was present in several small scattered pools (Figure 32). Habitat substratum consisted of predominantly sand/silt with some rocky sections. Deep pools were observed at both HR4 and HR5 whilst smaller pools were observed at MB2. Cover was available within all waterways in the form of logs, undercut banks and vegetation roots. Moderate erosion was evident at all creek sites, likely due to large influxes of water during wet season flows.

Bank vegetation cover was moderately dense at all sites, approximately 51-75%. All three creeks were characterised by predominantly native vegetation (85-92%) however large dense patches of weed cover was noted at all sites. Weeds observed included snakeweed (*Stachytarpheta sp.*), gamba grass *(Andropogon gayanus*), *Sida acuta*, candle bush (*Senna alata*), hyptis (*Hyptis suaveolens*), gambia pea (*Crotalaria goreensis*), mission grass (*Cenchrus pedicellatus*) and olive hymenachne (*Hymenachne amplexicaulis*) (see section 4.3.3).

A)

B)

C)

Figure 32. Freshwater habitats at A) MB2, B) HR4 and C) HR5

4.5.3 Aquatic and Terrestrial Fauna Species at Aquatic Assessment Sites

Fauna species were recorded at all three sites based on observation, tracks and scats. No trapping or macroinvertebrate assessments were conducted. Fish and yabbies were observed in shallow and deep pools at all aquatic assessment sites. Fauna species observed are summarised in Table 42. Terrestrial fauna species observed at creek locations within the survey area were incorporated into the fauna species results and recorded as incidental sightings (Appendix 6).

Table 42. Terrestrial and aquatic species observed at aquatic assessment sites during the May 2017 survey in the Hayes Creek Project survey area

Site	Native fauna	Introduced fauna
MB2	Forest kingfisher, rainbow bee-eater, Brown honeyeater, yellow bellied flycatcher, willy wagtail, northern fantail, double barred finch, crimson finch, freshwater crocodile, tata lizard, skink tracks, monitor tracks, rainbow fish (*Melanotaeniidae* sp.), Yabby species (*Cherax* sp.*)*	Cane toad, cat tracks
HR4	Buff-sided robin, sulphur crested cockatoo, striated pardalote, radjah duck, tawny frogmouth, robust ctenotus, tata lizard, rainbow fish	Buffalo, cane toads
HR5	Rainbow fish (*Melanotaeniidae* sp.), yabbie (*Cherax* sp.)	

5 DISCUSSION OF DESKTOP STUDY AND FIELD SURVEY RESULTS

Overall the number of native flora species recorded during on-ground surveys was lower in August 2019 (83 species) than in May 2017 (111 species). This result was to be expected given that the August 2019 survey was undertaken in the late dry season following a wet season with below average rainfall. The August 2019 survey also did not focus on compiling extensive flora lists, rather habitats were described more generally and targeted searches for threatened species were undertaken (in line with the ToR).

Native fauna species richness varied between the two surveys. Five species of native amphibian were recorded during the May 2017 survey, whereas no amphibians were recorded during August 2019. This may have been due to a lack of targeted effort towards detecting amphibians during the August 2019 survey, as no amphibian species of conservation significance were identified as potentially occurring in the survey area in the desktop study. Below average rainfall may also have contributed to no native amphibians being recorded during August 2019. A greater number of birds was recorded during the August 2019 survey (95 species) than in the May 2017 survey (66 species). Surface water sources are more concentrated in the landscape when climatic conditions are dry, and this may have been the reason for the greater number of birds recorded in the survey area in August 2019 compared to May 2017. The greater number of mammal species recorded in August 2019 (13 species) than in May 2017 (seven species) was largely due to a greater number of bat species being recorded using passive and active bat detectors. These were also used in May 2017. However, a greater number of the devices were available for use in August 2019. A greater number of reptile species were recorded in the survey area in May 2017 (seven species) than in August 2019 (two species), and this may have been due to the difference in the season between surveys (early dry season *vs*. late dry season or climatic conditions).

5.1 Threatened Species

5.1.1 Threatened Flora Species

No threatened flora species were recorded in the survey area during May 2017 or August 2019 despite targeted survey effort. A discussion of threatened flora species identified as moderately or highly likely to occur in the survey area (Section 3.10.2) and their residual likelihood of occurrence is provided below (

Table 43).

Table 43. Initial and residual likelihood of occurrence of threatened flora species identified by the Desktop Study (Section 3.10.2) as having a high likelihood of occurrence in the survey area. "Initial" likelihood is the determined likelihood that the species would be found in the survey area based on the desktop assessment. "Res" (residual) likelihood is the likelihood that the species would be found in the survey area based on on-ground surveys. A discussion of the residual likelihood ratings is provided below. '?'indicates specimens collected during the survey that could not be identified to species level.

Family	Scientific Name	Status		PMST	NT Flora Atlas	May 2017	Aug 2019	Likelihood of occurrence	
		TPWC	EPBC					Initial	Res.
Fabaceae	*Acacia praetermissa*	VU	VU	X	X			High	Mod
Stylidiaceae	*Stylidium ensatum*	EN	EN	X	X	?		High	Low

Acacia praetermissa – *Acacia praetermissa* is listed as vulnerable under both the EPBC Act and the TPWC Act. Suitable habitat for *A. praetermissa* was identified in the survey area in the woodland on low sandstone hills habitat. Targeted surveys for *A. praetermissa* were undertaken on stony sandstone slopes in the survey area during May 2017 and August 2019. Despite this, *A. praetermissa* was not recorded. *Acacia praetermissa* is vulnerable to population declines through earthworks and excavation of borrow pits for widening of the Stuart Highway, mineral exploration and the development of new mines (Cowie & Kerrigan, 2012). The species is also susceptible to stochastic events due to its restricted distribution and low populations size (Cowie & Kerrigan, 2012). Fire had burnt 53.61% of the survey area in May 2019 and a further 0.89% in July 2019 (North Australia and Rangelands Fire Information, 2019), prior to the August 2019 survey. Collections indicate that *A. praetermissa* can resprout from a perennial root base, which may occur following fire, but the impact of frequent fire on the longevity of adult and their ability to resprout is unknown (Cowie & Kerrigan, 2012). Therefore, using a precautionary approach, due to the survey area's location close to a known population and presence of suitable habitat, there is still a moderate likelihood that *A. praetermissa* occurs within the survey area but was present as rootstock and was not detected.

Stylidium ensatum – *Stylidium ensatum* is listed as endangered under the EPBC Act and TPWC Act. Suitable habitat for *S. ensatum* was identified in a small section of the open forest on alluvial floodplain habitat on the southern side of the existing Haul Road (south of Fountain Head) and to the north of the Fountain Head production area. There were specimens collected during the May 2017 survey that identified by the NT Herbarium as *Stylidium* sp. These are unlikely to be *S. ensatum* as *S. ensatum* appears to emerge later in the dry season (Cowie & Westaway, 2012). *Stylidium ensatum* has a distinctive growth habit and one distinguishing feature is the broad, sessile leaves scattered along a short basal stem (Northern Territory Herbarium, 2015). *Stylidium ensatum* flowers later than other *Stylidium* sp. The species inhabits areas with ongoing supply of surface, or near surface moisture on moist organic soils that are usually clayey and rarely sandy (Northern Territory Herbarium, 2015). There did not appear to be habitat that provided an ongoing supply of surface or near surface moisture into the late dry season in the survey area. Therefore, there is a low residual likelihood that *S. ensatum* occurs within the survey area.

5.1.2 Threatened Fauna Species

Two threatened fauna species were recorded in the survey area during May 2017 and/or August 2019 (Table 44). Despite targeted survey effort, a further 14 species identified by the Desktop Study as moderately or highly likely to occur in the survey area (Section 3.11.2) were not recorded during the May 2017 or August 2019 surveys.

Table 44. Threatened fauna species that were recorded in the survey area in May 2017 and/or August 2019

Common Name	Scientific Name	Status		May 2017	Aug 2019
		TPWC	EPBC		
Gouldian finch	*Erythrura gouldiae*	VU	EN	Haul Road between Iron Blow and Mt. Bonnie at two locations	Mt Bonnie Production and in close vicinity to north-east corner of Mt\ Bonnie production area boundary
Merten's water monitor	*Varanus mertensi*		VU	Iron Blow (anecdotal account prior to May 2017 survey)	

Threatened fauna species recorded during field surveys

Gouldian finch – The Gouldian finch is listed as endangered under the EPBC Act and vulnerable under the TPWC Act. The Gouldian finch was recorded at four sites during field surveys, two sites during May 2017 and two sites during August 2019. Nesting and roosting habitat was identified for the Gouldian finch in the sandstone hills habitat (Baker landsystem) and foraging habitat was identified in the sandstone plains habitat (Rumwaggon landsystem). Watercourses and the edges of some tailings dams were identified as drinking water sources.

Gouldian finches were observed foraging in the sandstone plain area during May 2017 and moving into adjacent woodland. These areas had dominant trees such as *Eucalyptus tectifica* and *Corymbia foelscheana/latifolia*, and dominant grasses included *Alloteropsis semialata, Heteropogon contortus* and *Themeda triandra.* Gouldian finches are known to preferentially feed on these grass species during the wet season, at which time they forage within a radius of up to 10 km from breeding areas (Dostine, et al., 2001). In northern savannah areas of Australia, Gouldian finch breeding areas are typically characterised by *Eucalyptus tintinnans* and/or *E. brevifolia, E. leucophloia* and *E. dicromophloia* with an understorey of *Sorghum* spp (Tidemann, et al., 1992). *Eucalyptus tintinnans* provides essential cavities for hollow-dependant breeding species and are preferentially selected by Gouldian finch as breeding sites (Brazill-Boast, et al., 2011). Whilst these flora species were not recorded where Gouldian finches were observed, *E. tintinnans* and *Sorghum* sp. grasses were recorded widely across the survey area but predominantly at Iron Blow and Mt Bonnie (see Section 4.2 for a description of habitat types in the survey area).

In August 2019, Gouldian finches were observed at two water sources. One observation was of juveniles over a small waterhole in a creek line just outside the survey area to the east of Mt Bonnie. On three separate occasions juvenile and adult Gouldian finches were observed at the edge of a tailings dam at Mt Bonnie (MB15) at a swampy area where water was pooling. This area also had good cover of dense bush and an abundance of perching sites. Birds at MB15 were also observed flying into

E. tintinnans open woodland adjacent to the tailings dam. This tailings dam and adjacent hills were within the previous disturbance footprint. These sightings conform to previously described habitat associations of the Gouldian finch (Dostine, et al., 2001).

Eucalyptus tintinnans was the predominant hollow-forming tree species in the survey area. While other species of *Eucalyptus* or *Corymbia* were found to form hollows, they either did not appear to form hollows as readily or they were not as common. *Eucalyptus tintinnans* was also widespread throughout the previously disturbed area in Mt Bonnie. Grasses that provide seed for Gouldian finches to forage on during wet season and dry seasons were also identified during the two field surveys.

These data suggest that there is suitable habitat for the Gouldian finch throughout the survey area, but particularly around Mt Bonnie and Iron Blow. That Gouldian finches were recorded in May 2017 and again in August 2019 suggesting that habitat in and adjacent to the survey area may be suitable somewhat continuously through time. The records of juveniles in both May 2017 and August 2019 suggest that breeding occurs either within the survey area or close by.

Merten's water monitor – Merten's water monitor is listed as vulnerable under the TPWC Act. Merten's water monitor is semi-aquatic and has a distribution spanning most of northern Australia (Cogger, 2014; Shine, 1986). It occurs in watercourses, billabongs, springs and soaks, and can also inhabit human-made water bodies including dams and irrigation areas (Mayes, et al., 2005; Shine, 1986). This corresponds with the record of an individual at the Iron Blow pit prior to the May 2017 survey. Merten's water monitor occupies linear activity ranges, rarely travelling far from the water's edge (Smith & Griffiths, 2009). Merten's water monitor don't appear to form specific home ranges or territories, and it is possible that they wander as they forage along the edge of water bodies, natural or human-made (Smith & Griffiths, 2009; Christian, 2004). Given the number of human-made pit lakes and dams, in addition to the natural water sources, Merten's water monitor is highly likely to be a resident species throughout the survey area.

Threatened fauna species not recorded during field surveys

A discussion of threatened fauna species identified as moderately or highly likely to occur in the survey area as a result of the desktop assessment (Section 3.11.2) and their residual likelihood of occurrence after the on-ground surveys is provided below (**Error! Reference source not found.**).

Curlew sandpiper – The curlew sandpiper is listed as critically endangered under the EPBC Act and vulnerable under the TPWC Act. Despite target survey effort, the species was not recorded in the survey area during May 2017 or August 2019. The curlew sandpiper is present in Australia between the August to April non-breeding season where individuals stopover in northern Australia before continuing to south-east Australia (Department of the Environment, 2019). While this species predominantly inhabits coastal areas, it is also quite widespread inland where it occurs at freshwater wetlands (Ward, 2012; Department of the Environment, 2019). The curlew sandpiper was not recorded in the survey area during May 2017 or August 2019. While this species is highly unlikely to occur in the survey area consistently, there remains a moderate likelihood that individuals may stopover in areas with surface water en-route to south-east Australia.

Red goshawk – The red goshawk is listed as vulnerable under both the EPBC Act and the TPWC Act. Despite target survey effort, the species was not recorded in the survey area during May 2017 or August 2019. The red goshawk is widespread but sparse throughout northern Australia. In the Top

End, red goshawks are predominantly found in extensive open forest, open woodlands and riparian vegetation dominated by mature *E. tetrodonta*, *E. miniata* and *Melaleuca leucadendra* and commonly hunt and breed in both lowland sites and rugged terrain (Department of Environment and Resource Management, 2012). Nesting occurs within 1 km of permanent water, usually in the tallest trees and approximately 20 m off the ground (Department of Environment and Resource Management, 2012). Red goshawks also occupy very large territories (recorded up to 200 km^2) where they are year-round residents (Department of Environment and Resource Management, 2012). Potentially suitable nesting habitat occurs along some of the watercourses and foraging habitat in the woodland areas within the survey area. Given that red goshawks occupy large territories in habitats that are present in the survey area, and the closest record is 32 km north-west of the survey area, there remains a moderate likelihood that this species occurs in the survey area.

Partridge pigeon (eastern subspecies) – The eastern sub-species of the partridge pigeon is listed as vulnerable under the EPBC Act and the TPWC Act. Despite target survey effort, the partridge pigeon was not recorded in the survey area during May 2017 or August 2019. However, there are records of the species in the survey area from 2006. The partridge pigeon inhabits lowland eucalypt open forest and woodland with grassy understorey across the Top End (Woinarski, 2006a), which is present within the survey area. Despite not being recorded during field surveys, there remains a high likelihood that the partridge pigeon occurs in the survey area.

Masked owl (northern subspecies) – The masked owl is listed as vulnerable under both the EPBC Act and the TPWC Act. Despite targeted survey effort this species was not recorded during May 2017 or August 2019. Surveys were undertaken over multiple nights and at multiple sites (1 km interval along tracks or roads) to increase the chance of detection (Ward, 2010). The best time for call-playback surveys of masked owls are the build-up (October to December) and the wet season (January to March), and detectability during other times of the year will be lower and the chance of false negative (i.e. not detecting a species when the species is in fact present) is higher (Ward, 2010). The masked owl occurs mainly in eucalypt tall open forest, but roosts mainly in thicker vegetation, such as monsoon rainforests or mangroves, and forages in more open vegetation types including grasslands (Woinarski & Ward, 2012; Ward, 2010). Large hollows in standing trees are preferred for roosting and required for nesting (Ward, 2010). The masked owl forages in more open habitats including open woodland and grasslands (Woinarski & Ward, 2012; Department of the Environment, 2019). Suitable habitat for the species, including trees with large hollows, occurs throughout the survey area. There is no detailed information on movements for the northern subspecies of the masked owl. However, masked owls of other species occupy large, exclusive home ranges (~5-10 km^2) (Kavanagh & Murray, 1996). The closest record of this species to the survey areas is 8 km west of Fountain Head. Given the proximity of this record, the presence of potentially suitable habitat and the low detectability of the species there remains a high likelihood that the masked owl occurs in the survey area.

Fawn antechinus – The fawn antechinus is listed as vulnerable under the EPBC Act and endangered under the TPWC Act. The species was not recorded in the survey area during May 2017 or August 2019 despite targeted survey effort. The fawn antechinus occurs mostly in open forests and woodlands dominated by *E. miniata* and/or *E. tetrodonta*, particularly those with a relatively dense shrubby understorey, where it shelters in tree hollows and fallen logs (Friend, 1985; Friend & Taylor, 1985; Cole & Woinarski, 2002). The species prefers areas with cooler and less frequent fires, but also is not common in long unburnt areas (>20 years without fire) (Woinarski, et al., 2004; Corbett, et al., 2003).

While open forest and woodland habitat is present throughout the survey area, fires have been frequent in the landscape and the understorey is characterised by mainly open vegetation. Dense grassy vegetation is largely confined to areas adjacent to watercourses. As habitats within the survey area do not appear to be suitable for the fawn antechinus, the likelihood that the species is present has been revised to low.

Northern quoll – The northern quoll is listed as endangered under the EPBC Act and critically endangered under the TPWC Act. Despite targeted survey effort, this species was not recorded during May 2017 or August 2019. The northern quoll occurs in a broad range of habitats including rocky areas, Eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert, but in the Top End rocky areas, especially on sandstone escarpment, and tall open coastal eucalypt forests appeared to be preferred (Department of the Environment, 2019). Potential suitable habitat for the northern quoll was identified in the previously disturbed area in the Mt Bonnie production area. Large scale declines and local extinctions have been recorded in Kakadu National Park since the invasion of cane toads (*Rhinella marinusi*) and similar declines are assumed across the rest of the species range (Woinarski, et al., 2010). Despite this, northern quolls still exist in localised areas following cane toad invasion (Woinarski & Hill, 2012b). The closest record to the survey area of the northern quoll is 5 km north-east of the survey area at the North Point mine site from 2006. While there is a small area of potentially suitable habitat for the northern quoll in the Mt Bonnie production area, quolls did not appear to be present during the May 2017 and August 2019 surveys, and there is a higher likelihood that more suitable habitat for the species occurs in the rocky areas surrounding the survey area. Therefore, the likelihood that the northern quoll occurs within the survey area has been revised to low.

Ghost bat – The ghost bat is listed as vulnerable under the EPBC Act and near threatened under the TPWC Act. Despite targeted survey effort, including call-playback surveys during August 2019, this species was not recorded during May 2017 or August 2019. The distribution of the ghost bat is influenced by the availability of suitable caves and mines for roost sites, with one of the largest colonies occurring in gold mine workings at Pine Creek NT (Ward & Milne, 2016). Potentially suitable habitat areas were located in the Mt Bonnie production area, around the old pit and waste rock dump. However, survey of these sites did not reveal any currently being utilised as roosts. Suitable breeding habitat was not observed within the survey area, with breeding habitat generally requiring caves that retain a stable temperature and high humidity such as deep structures or those with a domed entrance. It is therefore likely that any suitable habitat within the survey area would be utilised by ghost bats for foraging. A 2007 survey of the North Point mine site for GBS Gold, north-east of the current survey area recorded at least fifteen individuals within a mine adit (Firth, et al., 2007). There does not appear to be breeding habitat for ghost bats in the survey area. However, there is potentially suitable foraging habitat. Given this, and the proximity of records collected in 2007, there remains a moderate likelihood that ghost bats will occur in the survey area.

Black-footed tree-rat – The black-footed tree-rat is listed as endangered under the EPBC Act and vulnerable under the TPWC Act. Despite targeted survey effort, this species was not recorded during May 2017 or August 2019. The black-footed tree-rat occurs predominantly in open forests and woodlands dominated by *E. miniata* and/or *E. tetrodonta*, particularly with dense, shrubby understorey, which is characteristic of areas with a low frequency or intensity of fires (Friend, 1987; Friend & Taylor, 1985; Woinarski & Burbidge, 2016). Populations appear to be most dense in small

patches of structurally and floristically diverse open-forest where seasonal fluctuations are moderated, probably where there is higher soil moisture, and where resources are relatively stable throughout the year and which are infrequently burnt (Friend, 1987). The distribution of the black-footed tree-rat may be limited somewhat by food resources, which include conspicuous and/or fleshy furits including from *Pandanus* (Friend, 1987). *Eucalyptus* woodlands were widespread throughout the survey area and, fleshy fruited species (e.g. *Gardenia megasperma, Terminalia* spp. and *Pandanus spiralis*) are present adjacent to the survey area near Mt Bonnie. However, much of the survey area has been exposed to frequent fires in recent history. The closest record of the black-footed tree rat to the survey area is 13 km west from 2007. As there have been frequent fires through the survey area and no sign of the black-footed tree-rat was recorded during May 2017 or August 2019, the likelihood that this species occurs in the survey area is low.

Northern brush-tailed phascogale – The northern brush-tailed phascogale is listed as vulnerable under the EPBC Act and endangered under the TPWC Act. This species was not recorded in the survey area in May 2017 or August 2019 despite targeted survey effort. The northern brush-tailed phascogale is restricted to *Eucalyptus* forest (mostly dominated by *E. miniata* and *E. tetrodonta*) in the Top End and shelters in tree hollows during the day. *Eucalyptus* open forest supporting trees with hollows may provide potentially suitable habitat for this species in the survey area. This species appears to have undergone widespread declines, but this is difficult to ascertain because of difficulties with detection during surveys (Woinarski & Ward, 2012b). The closest most recent record of the northern brush-tailed phascogale to the survey area is from 2004 (Department of Environment and Natural Resources, 2019). Given that there is potentially suitable habitat for this species in the survey area, the proximity of previous records and difficulties in surveying for it, there is still a moderate likelihood that the northern brush-tailed phascogale occurs in the survey area.

Pale field rat – The pale field rat is listed as vulnerable under the TPWC Act. Despite targeted survey effort, the species was not recorded during May 2017 and August 2019. The pale field rat is found in higher rainfall areas of northern Australia where it inhabits dense vegetation, including tall grassland, along creeklines and riparian areas and shelters in shallow burrows during the day (Young & Hill, 2012; Braithwaite & Griffiths, 1996). Potentially suitable habitat exists for this species in the survey area along watercourses. However, this suitability is likely to vary temporally as the occurrence of fire will modify habitat suitability by removing dense ground vegetation. In contrast, the occurrence of good rainfall will promote the growth of vegetation, which may provide more suitable habitat for the species. The pale field rat has been recorded approximately 6 km south-west of the survey area. As this species has been recorded close to the survey area in the past, there is suitable habitat present in the survey area, and that this may change depending on the occurrence of fire and rainfall, there remains a high likelihood that the species occurs in the survey area.

Bare-rumped sheath-tailed bat – The bare-rumped sheath-tailed bat is listed as vulnerable under the EPBC Act and data deficient under the TPWC Act. This species is difficult to detect due to a lack of reference calls to reliably identify it from echolocation surveys (bat detectors), difficulty in trapping or taking specimens of such a high-flying species (Department of the Environment, 2019). All confirmed records of the bare-rumped sheath-tailed bat in the NT are from Kakadu National Park (Department of the Environment, 2019). The species occurs mostly in lowland areas in a range of woodland, forest and open environments and all known roosts have been deep tree hollows (Department of the Environment, 2019). In Kakadu, specimens were recovered from open *Pandanus* woodland fringing

the sedgelands of the South Alligator River (Department of the Environment, 2019). *Saccolaimus* sp. echolocation calls were identified from recordings taken in the survey area during the August 2019 survey. However, it could not be determined whether these were calls of the yellow-bellied sheath-tailed bat (*Saccolaimus falviventris*) or the bare-rumped sheath-tailed bat. Given this uncertainty, and the presence of potentially suitable habitat for this species there remains a moderate likelihood that the bare-rumped sheath-tailed bat occurs in the survey area.

Mitchell's water monitor – Mitchell's water monitor is listed as vulnerable under the TPWC Act. Depsite targeted survey effort, this species was not recorded during May 2017 or August 2019. Mitchell's water monitor is widespread across the Top End, inhabiting all the northern river systems except the southern Gulf, but has undergone dramatic population declines since the invasion of cane toads (Doody, et al., 2009; Ward, 2012). It inhabits the margins of watercourses, swamps and lagoons, is semi-aquatic and arboreal and shelters in hollows and under bark on trees next to water (Ward, 2012). Potentially suitable habitat exists along water courses and at dams in the survey area. Mitchell's water monitor was recorded approximately 13 km west of the survey area in 2018. Given that suitable habitat was confirmed to exist in the survey area and the proximity of very recent prior records there remains a high likelihood that Mitchell's water monitor occurs in the survey area.

Floodplain monitor - The floodplain monitor is listed as vulnerable under the TPWC Act. Despite target survey effort, the floodplain monitor was not recorded during May 2017 or August 2019. This species has a broad distribution across the Top End, where it occupies habitats including coastal beaches, floodplains, grasslands and woodlands (Ward, et al., 2012b). However, populations have declined since the invasion of cane toads (Doody, et al., 2009). Floodplains, grasslands and woodlands occur within the survey area and may support the floodplain monitor. The closest record of the floodplain monitor to the survey area is approximately 7.5 km north. However, this record is from 1977. Despite this, there is still a moderate likelihood that the floodplain monitor occurs in the survey area.

Table 45. Initial and residual likelihood of occurrence of threatened fauna species identified by the Desktop Study (Section 3.10.2) as having a moderate or high likelihood of occurrence in the survey area, but that weren't recorded during May 2017 or August 2019. A discussion of the residual likelihood ratings is provided below.

Scientific name	Common name	Status		PMST	NT Flora Atlas	Likelihood of occurrence	
		TPWC	EPBC			Initial	Residual
Calidris ferruginea	Curlew sandpiper	Vu	Cr	X		Moderate	Moderate
Erythrotriorchis radiatus	Red goshawk	Vu	Vu	X	X	High	Moderate
Geophaps smithii smithii	Partridge pigeon (eastern)	Vu	Vu	X	X	High	High
Tyto novaehollandiae kimberli	Masked owl (northern)	Vu	Vu	X		High	High
Antechinus bellus	Fawn antechinus	En	Vu	X		Moderate	Low
Dasyurus hallucatus	Northern quoll	Cr	En	X	X	Moderate	Low
Macroderma gigas	Ghost bat	NT	Vu	X		High	Moderate
Mesembriomys gouldii gouldii	Black-footed tree-rat	Vu	En	X	X	High	Low

Scientific name	Common name	Status		PMST	NT Flora Atlas	Likelihood of occurrence	
		TPWC	EPBC			Initial	Residual
Phascogale pirata	Northern brush-tailed phascogale	En	Vu	X	X	Moderate	Moderate
Rattus tunneyi	Pale field-rat	Vu			X	High	High
Saccolaimus saccolaimus nudicluniatus	Bare-rumped sheath-tailed bat	DD	Vu	X		Moderate	Low
Varanus mitchelli	Mitchell's water monitor	Vu			X	High	High
Varanus panoptes	Floodplain monitor	Vu			X	High	Moderate

5.1.3 Migratory species

Migratory species recorded during field surveys

No Migratory species were observed during either the May 2017 or August 2019 surveys. Despite this, all 14 migratory species identified through desktop studies have either a moderate or high likelihood of occurring on-site.

Migratory species not recorded during field surveys

The residual likelihood of occurrence of migratory species is provided in Table 46. The residual likelihood of other migratory species identified through a desktop search is moderate. Potentially suitable habitat, or habitat that may occasionally be used by these species and occurs within the survey area. Aside from the glossy ibis, a common feature of these migratory species is spending their non-breeding season in Australia.

Table 46. Initial and residual likelihood of occurrence of migratory fauna species identified by the Desktop Study (Section 3.10.3) as having a moderate or high likelihood of occurrence in the survey area, but that weren't recorded during May 2017 or August 2019.

Scientific name	Common name	EPBC	PMST	NT Flora Atlas	Likelihood of occurrence	
					Initial	Residual
Actitis hypoleucos	Common sandpiper	MiMa	X	X	Moderate	Moderate
Apus pacificus	Fork-tailed swift	MiMa	X	X	High	High
Calidris acuminata	Sharp-tailed sandpiper	MiMa		X	High	High
Calidris melanotos	Pectoral sandpiper	MiMa	X		Moderate	Moderate
Cecropis daurica (*Hirundo daurica*)	Red-rumped swallow	MiMa	X		Moderate	Moderate
Charadrius veredus	Oriental plover	MiMa	X		Moderate	Moderate
Cuculus optatus	Oriental cuckoo	MiMa	X		Moderate	Moderate
Glareola maldivarum	Oriental pratincole	MiMa	X		Moderate	Moderate
Hirundo rustica	Barn swallow	MiMa	X		Moderate	Moderate
Motacilla cinerea	Grey wagtail	MiMa	X		Moderate	Moderate
Motacilla flava	Yellow wagtail	MiMa	X		Moderate	Moderate
Numenius minutus	Little curlew	MiMa		X	High	High
Plegadis falcinellus	Glossy ibis	MiMa		X	High	High
Tringa nebularia	Common greenshank	MiMa		X	High	High

5.1.4 Introduced Flora Species

Fifty-six introduced flora species were identified as occurring or potentially occurring within 20 km of the survey area by the EPBC PMST, NT Weeds public database or both (Figure 16, Figure 17, Table 13). Twenty-four of these species were observed in the surveys with 20 observed in the May 2017 survey and 13 in the 2019 survey. The lower number of observed species in the 2019 survey could be as a result of the low rainfall in the preceding months or less-intensive survey effort on flora. In wetter conditions, a greater number and density of weeds than was observed in August 2019 may occur. Operational works and ongoing haulage during the proposal is likely to increase weeds due to environmental disturbance and through spread of weed seeds on vehicles. This increases the risk of the occurrence of weeds that require eradication or control (Class A and Class B weeds). Existing areas of infestation, particularly in the south and north of the survey area (as per Table 34), roads and tracks, production areas and riparian areas are key locations for weeds.

5.1.5 Introduced Fauna Species

Of the 12 introduced fauna species identified through desktop searches, seven of these species were recorded in the May 2017 survey (cane toad, cattle, buffalo, feral cats, black rat, donkey, pig) while five were recorded in August 2019 survey (cane toad, cattle, buffalo, donkey, pig). Introduced species spanned the entire survey area. Pigs were located at water holes and riparian areas (HR13 and HR21). HR13 had the equal greatest variety of bird species (39 species), while HR21 was adjacent to the Gouldian finch sighting in 2017. The impact of feral pigs on bird declines is noted below in Section 6.6.2). Although not recorded during either of the site surveys, house mice, Asian house geckos, feral dogs, flowerpot blind snakes, and rock doves could be present or have the potential to occur on site. The occurrence of predators (and other invasive species) can be influenced by artificial water sources, and potential food sources (e.g. waste bins), and vegetation clearing.

6 ASSESSMENT OF SIGNIFICANT IMPACT

6.1 Scope of Assessments of Impact

The scope of the assessment of the potential impacts of the proposal focuses on the development of the three production areas, Fountain Head, Iron Blow and Mt Bonnie, and the Haul Road connecting these three areas. Development of the three production areas will involve the construction of infrastructure as outlined in

Table 1 of Section 1.1.

Assessments of significant impact from the construction, operation and decommissioning and rehabilitation phases of the proposal were conducted for EPBC listed Matters of National Environmental Significance (MNES) and species or areas of NT significance identified by the desktop study and considered to have a moderate or high likelihood of occurring within the survey area (Sections 3.10 - 3.12). The likelihood of occurrence of threatened species identified by the desktop survey as occurring or potentially occurring in the survey area was re-assessed following the August 2019 survey to provide a residual likelihood of occurrence. Assessment of significant impacts resulting from the proposal was undertaken for those threatened species with a residual likelihood of occurrence of high or moderate.

The only MNES identified by the desktop study were threatened and migratory species. Near threatened and data deficient species were the only matters of NT significance identified by the desktop study. As such, the assessments of significant impact and discussion of potential impacts from the proposal pertain to species listed as threatened under the EPBC Act and TPWC Act, migratory under the EPBC Act, or near threatened or data deficient under the TPWC Act. One vulnerable flora species (*Acacia praetermissa*), one critically endangered fauna species (curlew sandpiper) and one endangered fauna species (Gouldian finch) listed under the EPBC Act were assessed. Six vulnerable fauna species listed under the EPBC Act (red goshawk, partridge pigeon, masked owl, fawn antechinus, ghost bat and northern brush-tailed phascogale) were assessed. Four fauna species listed as vulnerable under the TPWC Act (pale field rat, Merten's water monitor, Mitchell's water monitor and the floodplain monitor) were assessed. Fourteen species listed as migratory under the EPBC Act (common sandpiper, fork-tailed swift, sharp-tailed sandpiper, pectoral sandpiper, red-rumped swallow, oriental plover, oriental cuckoo, oriental pratincole, barn swallow, grey wagtail, yellow wagtail, little curlew, glossy ibis and common greenshank) were assessed.

6.2 Significant Impact Criteria

The *Significant Impact Guidelines 1.1 – Matters of National Environment Significance* (Department of the Environment, 2013) provide 'significant impact' criteria for each MNES to assist in determining whether the impacts of a proposed action (a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things) on any MNES are likely to be significant impacts. The general test for significance is whether an impact is 'important, notable or of consequence, having regard to its context or intensity' (Department of the Environment, 2013). The wordings contained in the *Significant Impact Guidelines* for **critically endangered and**, and **vulnerable** contains minor differences and therefore are both provided verbatim.

The Department of the Environment (2013), states that an action is likely to have a significant impact on a **critically endangered** or **endangered** species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of a population;
- Reduce the area of occupancy of the species;
- Fragment an existing population into two or more populations;
- Adversely affect habitat critical to the survival of a species;
- Disrupt the breeding cycle of a population;

- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- Introduce disease that may cause the species to decline; or
- Interfere with the recovery of the species.

An action that is likely to have a significant impact on a **vulnerable** species is defined by Department of the Environment (2013) as there being a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species;
- Reduce the area of occupancy of an important population;
- Fragment an existing important population into two or more populations;
- Adversely affect habitat critical to the survival of a species;
- Disrupt the breeding cycle of an important population;
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- Introduce disease that may cause the species to decline; or
- Interfere substantially with the recovery of the species.

An action that is likely to have a significant impact on a **migratory** species is defined as (DEE, 2013) as there being a real chance or possibility that it will:

- Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Habitat critical to the survival of a species may be, but is not limited to, that identified in a recovery plan for the species or habitat listed on the Register of Critical Habitat under the EPBC Act (Department of the Environment, 2013). Habitat critical to the survival of a species refers to areas that are:

- For activities such as foraging, breeding, roosting or dispersal;
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators);
- To maintain genetic diversity and long-term evolutionary development; or
- For the reintroduction of populations or recovery of the species or ecological community.

An important population is defined (DEE, 2013) as being one that is necessary for a species' long-term survival and recovery, which may include populations identified as such in recovery plans, and/or populations that are:

- Key source populations either for breeding or dispersal;
- Populations that area necessary for maintaining genetic diversity; and/or
- Populations that are near the limit of the species range.

Where there is a lack of scientific certainty about the impacts of an action, and potential impacts are serious or irreversible, the precautionary principle has been applied. According the precautionary principle, a lack of scientific certainty about the potential impacts of an action do not justify a decision that the action is not likely to have a significant impact on matters of national or NT environmental significance.

6.3 Assessment of the Risk of Significant Impact

Prior to assessing the risk of significant impacts, it was assessed whether each MNES or matter of NT significance met the criteria outlined in Section 6.2; for example, whether a population of a vulnerable species in the survey area could be considered an "important population" following the definition of Department of the Environment (2013), or whether a source of impact from the proposal could occur a broad enough scale to impact the species as a whole.

A risk assessment was then undertaken to identify and evaluate the risk (defined as "real chance or possibility", DEE 2013) of significant impact from the potential sources of impact (Section 6.4 to MNES and sites or species of NT significance. Levels of risk were determined using standard qualitative risk assessment procedures based on principles outlined in AS 31000:2018 (Table 47), and risk assessment categories outlined in previous EISs (Tellus – Chandler Facility (2018), Vista Gold Australia - Mt Todd Gold Mine (2014), Jemena - Northern Gas Pipeline (2016)). Definitions for the levels of likelihood of consequence and severity of consequence from a potential source of impact are provided in Table 48 and Table 49. Levels of risk were calculated by assessing the severity of the impact, then assessing the likelihood of the impact occurring as a result of the proposal. Impacts are defined by the criteria outlined in Section 6.2 and the potential sources of impact are discussed in Section 6.4.

Levels of risk are summarised in Sections 6.5 and 6.6. The summarised level of risk provided for each impact criteria given in these sections is the maximum level of risk from any source of impact leading to the impact criteria being met. Mitigation measures for impacts with a risk level of medium to extreme are addressed in Section 7, and a residual risk level (i.e. the risk of an impact occurring after the mitigation measure is put into place) is provided.

Table 47. Matrix for the analysis of the risk of significant impact resulting from the Hayes Creek Project proposal

		Severity of consequence				
		Severe (5)	Major (4)	Moderate (3)	Minor (2)	Very Minor (1)
Likelihood of consequence	Almost certain (5)	Extreme	Extreme	High	High	Medium
	Likely (4)	Extreme	High	High	Medium	Medium
	Possible (3)	Extreme	High	Medium	Medium	Low
	Unlikely (2)	High	Medium	Medium	Low	Very low
	Rare (1)	Medium	Medium	Low	Low	Very low

Table 48. Definitions of levels of the severity of an impact should it occur

Level of severity	Definition
Severe	Extensive long-term harm and/or harm that is extremely widespread. Impacts permanent or irreversible within 10 years.
Major	Major or widespread, unplanned impact on or off the site. Impacts long-term (2-10 years)
Moderate	Significant, unplanned impact contained within the site or minor impact that is off the site. Impacts medium-term (<2 years)
Minor	Unplanned localised impact contained on-site or with negligible off-site impact. Impacts short-term.
Very Minor	Any impacts are contained on-site and are short-term in nature with no lasting damage or effect

Table 49. Definitions of levels of the likelihood that an impact will occur

Level of likelihood	Definition
Almost certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event might occur at some time
Unlikely	The event could occur at some time
Rare	The event may occur only in exceptional circumstances

Table 50. Definitions of risk significance as determined by the product of likelihood and severity of an impact

Level of risk	Definition
Very low	Impacts are negligible.
Low	Impacts are recognisable but acceptable. These impacts tend to be short-term and at the local scale.
Medium	Impacts range from long- to short-term, at medium to local scale. The impact receptor is moderately sensitive, and/or the impacts are of regional/species or local/population significance.
High	Impacts are permanent or long- to medium-term and occur over large or medium scale areas. The impact receptor is highly to moderately sensitive, and/or the impacts are of regional/species significance.
Extreme	Impacts are permanent or irreversible, or long-term, and occur over large-scale areas. The impacts are generally, but not exclusively, associated with MNES and/or sites and/or species of NT significance.

6.4 Potential Sources of Impact from the Proposal

The main potential sources of impact to native flora and fauna species and their habitats from the proposal is:

- Vegetation clearing and habitat disturbance;
- Changes to surface water quality and quantity;
- Changes to groundwater quality and quantity;
- Erosion and sedimentation;
- Invasion or increases in populations or activity of weeds and pest animals;
- Altered fire regimes;

- Vehicle collision;
- Increased artificial light;
- Increased vibration;
- Increased noise; and
- Increased dust emissions.

6.4.1 Vegetation Clearing and Habitat Disturbance

The proposal has the potential to impact habitat important for MNES through the clearing and disturbance of existing vegetation, introduction of weeds and facilitating movement of pest fauna. Vegetation clearing and disturbance has the potential to impact MNES *via* direct mortality of threatened flora and fauna, or removal of habitat required by these species. Habitat disturbance encompasses habitat modification, destruction, removal or isolation, or a decrease in habitat availability or quality and is particularly detrimental if the habitat is important for breeding behaviours as it may disrupt the breeding cycle of a population. Vegetation clearing and habitat disturbance may also cause fragmentation of existing populations into two or more populations, if fragmentation inhibits dispersal between areas of suitable habitat (Fahrig, 2003). Clearing or disturbance to native vegetation may increase the potential for weed species to become established in threatened species habitat. Weed invasion can be associated with further disturbances such as changes in habitat structure (Young & Schlesinger, 2015), decreased access to resources (Ferdinands, et al., 2005) and changes in fire regime (Setterfield, et al., 2010), which may decrease habitat suitability for a threatened species. Clearing of vegetation may also increase pathways through the landscape for introduced and pest animals that may negatively impact threatened species (e.g. increased predator activity) (Claridge, 1990).

The disturbance area across the three production areas and the new section of the Haul Road is proposed to be 318 ha (Table 51). Of this area, 147.82 ha has been previously disturbed by mining development. The existing section of the Haul Road requires no further vegetation clearing. However, the new section of Haul Road requires existing one-way vehicle tracks to be upgraded to a 12 m corridor (Figure 33). Habitat disturbance will also occur as a result of the creation of waste rock dumps in the three production areas. This activity will substantially change the topography of these areas. Proposed clearing of areas not previously disturbed falls predominantly within the open woodland on sandstone plain habitat, but will also impact the woodland on low sandstone hills and creekline and riparian zone habitats (Table 51).

Table 51. Amount (ha) and percentage of each habitat type present in survey area, amount (ha) of each habitat type to be cleared in each production area and along the new section of Haul Road and percentage of each habitat type in the survey area that is to be cleared during the proposal. Also presented is the total area of each habitat present in the survey area within a 20 km radius, and the percentage of that area to be cleared during the proposal. For habitat descriptions see Section 4.2.

Habitat type	survey area		Fountain Head	Iron Blow	Mt Bonnie	Haul Road (new section)	Total (ha)	% of footprint	20 km radius of survey area	
	Total (ha)	% of habitat in survey area							Total (ha)	% to be cleared
			Area (ha) not require further clearing or only requires minimal clearing of heavily disturbed landscape							
Pit lakes and tailings dams	34.9	2.32	12.47	0	1.86	0	14.33	41.06	330.86	NA
Pre-cleared/heavily disturbed	393.22	26.18	102.75	0.04	35.26	1.01	139.06	35.36	2,616.32	NA
			Area (ha) to be cleared							
Woodland on low sandstone hills	95.23	6.34	0	8.95	2.22	0.49	11.66	12.24	52,134.93	0.022
Open forest on alluvial floodplain	66.62	4.44	0.5	0	0	0	0.5	0.70	15,977.82	0.003
Open woodland on sandstone plain	850.55	56.63	74.37	44.27	5.32	5.12	129.08	15.17	54,276.82	0.238
Creekline and riparian zone	61.33	4.08	1.42	0	0.33	0.26	2.01	3.28	13,559.65	0.014
Total area	**1501.85**		**76.29**	**53.22**	**7.87**	**5.87**	**284.98**		**192,502.40**	**0.27**

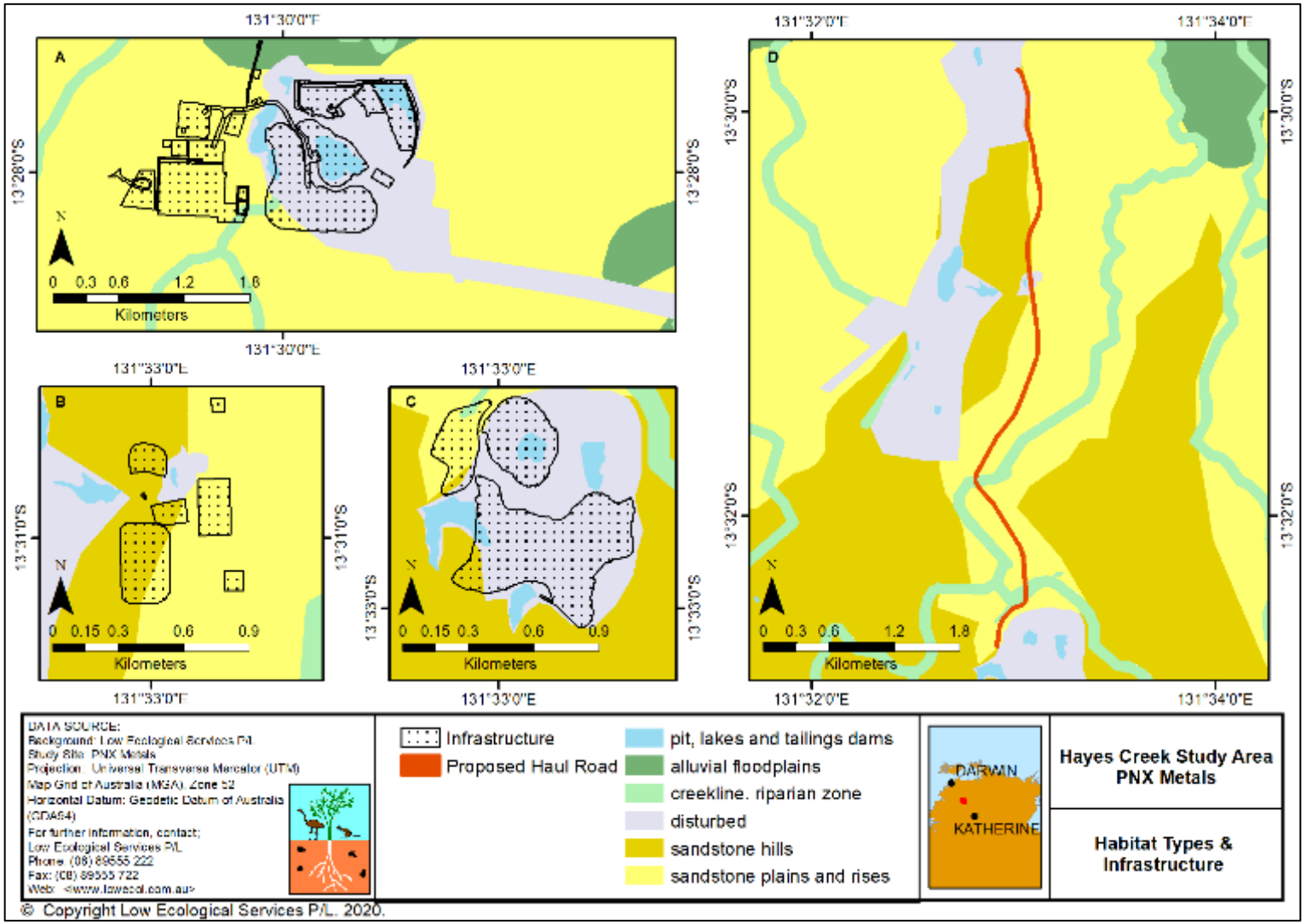

Figure 33. Habitats identified during on-ground surveys in the A) Fountain Head, B) Iron Blow and C) Mt Bonnie production areas, and D) along the new sections of the Haul Road. See Figure 19 for habitats in the survey area and Figure 34 for habitats within a 20 km radius of the survey area.

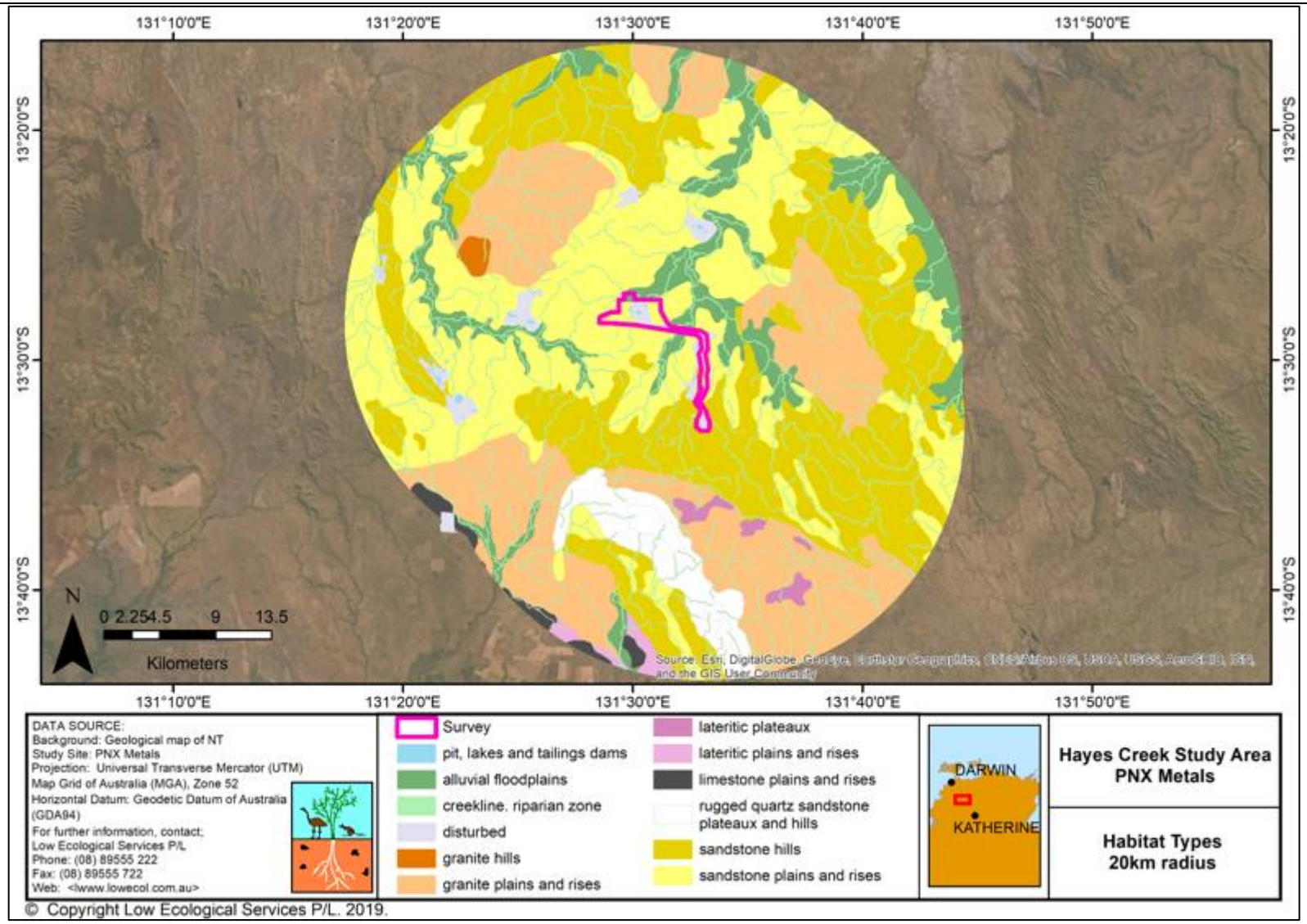

Figure 34. Habitat types in the area within a 20 km radius of the survey area. See Table 51 for calculations of the area (ha) of each habitat type.

6.4.2 Surface Water Quality and Quantity

The proposal has the potential to impact surface water quality and quantity due to changes in surface water flows and contamination of surface water from operational activities. Potential sources of surface water contamination from the proposal are water from the pit lakes, tailings storage facilities, waste rock stockpiles (especially stockpiles containing potentially-acid forming rock) and heap leach facilities, run-off from operational areas, contaminated water being used for dust suppression, passive discharge or seepage of non-benign contaminants from historical or proposal-related mine waste storage, unintended release/discharge through loss of control or containment or unintended release of hazardous substances (including hydrocarbons). Of note is that elevated levels of dissolved arsenic occur in the Fountain Head pit water as a result of the surrounding geology, although the water is of reasonable quality and is to be used for non-potable and process water during operations (ERIAS, 2017). A small number of production wells may be required to provide additional water supply for mining and dust suppression (ERIAS, 2017). Potable water will be sourced from Batchelor, NT and trucked to site (ERIAS, 2017). Potential causes of the reduction of surface water quantity may occur as a result of dewatering of current pit lakes and dams, altered surface water flow pathways, volumes and timing (seasonality) and groundwater drawdown. If not managed well, the proposal has the potential to impact watercourses including the Margaret River.

6.4.3 Groundwater Quality and Quantity

The proposal has the potential to impact groundwater quality and quantity through contamination or drawdown from operational activities. Contaminated water has the potential to interact with groundwater. The source of contaminated water that may interact with groundwater include passive discharge or seepage from waste rock stockpiles, the heap leach pad and process water dam. The exposure of potentially acid forming (PAF) rock in the walls of the pit has the potential to facilitate the seepage of acid mine drainage into the underlying groundwater. In addition, the storage and use of chemicals and hydrocarbons have the potential to contaminate groundwater through unintentional spills or leaks. A second way in which groundwater quality and quantity can potentially be affected is by groundwater drawdown as a result of de-watering of pit lakes or progressive water drawdown for operations. Impacts of groundwater contamination and drawdown may occur within the proposal area or in the region surrounding, depending on the connectivity of the receiving waters with groundwater in the surrounding region.

6.4.4 Erosion and Sedimentation

Erosion is most likely in areas with low or no vegetation cover, such as dam walls, roads and vehicle tracks, hardstand areas and waste rock dumps. Vegetation clearing and modification of topography can alter surface water flows and cause erosion outside of core disturbance areas. A loss of topsoil resulting from erosion can reduce the available seed bank and decrease rehabilitation success. Increased erosion can lead the movement of sediment into lower lying areas and local waterways following high rainfall or strong winds. Sedimentation may result in the direct mortality of flora, changes in habitat suitability or infilling of waterways that are important for riparian vegetation and as a water source for fauna. Sedimentation and erosion may also result in increased sediment load, which can impact ecosystems downstream), changes to watercourse channel form and a change in

hydrology. Increases in sediment loads in waterways may have physical effects on fauna (e.g. blocking of gills or direct toxicity). Changes to channel form and hydrology may impact habitat suitability for riparian flora and aquatic fauna.

Erosion potential from the proposal is highest in areas where vegetation clearing is proposed, such as the waste rock stockpiles, ore stockpile, Haul Roads and other disturbed areas. Sedimentation may occur downslope of these areas, including the release of sediment laden water into waterways including the Margaret River.

6.4.5 Invasion or Increases in Populations of Weeds or Pest Animals

Introduced grasses are of particular concern in northern Australia, as indicated by the listing of invasion of northern Australia by gamba grass and other introduced grass as a key threatening process under the EPBC Act. Introduced grass, and other weeds, can cause changes in habitat structure, food and shelter availability and changes to fire regimes. Introduced grasses often outcompete native understorey species and can lead to the thickening of the midstorey vegetation. Predation by introduced cats is also listed as a key threatening process. Predation by feral cats is regarded as one of the greatest threats to native fauna and is thought to have contributed to the decline and extinction of many species (Commonwealth of Australia, 2015). Feral and domestic herbivores have a detrimental impact on native species through grazing of native flora species and changes in habitat structure from grazing and browsing pressure. Feral pigs trample habitat and may cause direct mortality to flora by consuming them. Pigs also pose a disease risk to native species.

Potential sources of weed incursion from the proposal include clearing and disturbance of vegetation. Vegetation clearing may also increase pathways for predators through the landscape and allow them to reach broader areas than previously. If water and anthropogenic waste (particularly food waste) are unmanaged and unfenced, pest animals (including predators and herbivores) may be attracted to them. An increase in resources in the proposal area may result in an increase in the activity of feral animals in the survey area or lead to greater reproductive success through a more consistent supply of resources.

6.4.6 Altered Fire Regimes

Wildfire is a natural disturbance in northern Australia, helping to maintain vegetation community structure and heterogeneity and promoting flowering, germination and seed release of some plant species (Miller & Murphy, 2017). Changes to fire regimes (i.e. the frequency, timing and severity of fires) can cause changes in habitat structure (e.g. vegetation structure, loss of fallen timber), food availability (e.g. removing seeds, plants, insects or other foods used by fauna) and roosting or breeding site availability (e.g. loss of nesting trees) (Williams, et al., 2003; Woinarski & Westaway, 2008). Wildfire can also cause direct mortality of plants (e.g. reduce density or extent of fire-sensitive flora) and animals (particularly slow-moving species) and the mortality and displacement of animals. If changes to the prevailing fire regime are detrimental to a species life-cycle population declines may occur from which the population cannot recover. Wildfire can also lead to the destruction of habitat, which can itself result in habitat fragmentation. The reduction in vegetation cover resulting from a wildfire can the lead to erosion and sedimentation, as outlined in Section 6.4.4. Some flora species

require fire to promote phases of their life cycle such as germination and seed set (Miller & Murphy, 2017). Therefore, suppression of fire can be detrimental to some species.

The proposal has the potential to alter fire regimes as a result of additional ignition sources, or as a result of fire suppression. Additional ignition sources include vehicles, machinery, hot works, switchgear, transformers, high voltage power sources and personnel (e.g. cigarette butts). Suppression of fire may occur for HSE reasons and asset protection. The Haul Road may alter fire regimes by acting as a fire break.

6.4.7 Vehicle Collision

Increased traffic associated with mining operations increases the risk of vehicle collision with fauna. Slow-moving, easily startled or nocturnal species are most at risk from vehicle collision. Species that interact in large groups are most likely to be at risk of population level impacts, due to the potential for mortality of multiple individuals in a single incident. The risk of vehicle collision is especially high at night when visibility is lower. Vehicle collision can lead to injury and mortality of fauna. Additionally, the creation of carcasses may increase predator activity in the local area temporarily.

Potential impacts from the proposal is more likely along the Haul Road route, where vehicles will be travelling at greater speeds than in the production areas.

6.4.8 Increased Artificial Light

Artificial light can have an array of impacts on fauna populations, including by interfering with natural sleep patterns and daily activity patterns, predation success, navigation of nocturnal species and migrating birds, timing of daily activities, causing attraction of or long-term declines in insect populations, changes to bird calling behaviour and exposing nocturnal prey to elevated levels of predation (Perry, et al., 2008; Longcore & Rich, 2004). Through these impacts there may be local displacement of fauna and population declines through impacts to reproduction and predation success. Artificial light may also interfere with phenology, growth form and resource allocation in plants (Bennie, et al., 2016).

Artificial light will be used during the operational phase of the mine 24 hours a day. Artificial light and its impacts will likely be concentrated to the area within and immediately surrounding the three productions sites. Night driving will increase artificial light along the Haul Road temporarily at times, although this is expected to be minimal as there will be no haulage of ore at night.

6.4.9 Increased Vibration

No reports of the ecological impacts of vibration on wildlife could be found in the literature. Seismic waves from rock-blasting may be felt at long distances from the sources. Potential sources of increased vibration from the proposal will be from fixed and mobile sources including vehicles, machinery such as drills, loaders, haul trucks and excavators, blasting and the process plant that includes crushers, vibrating screens, mills and compressors.

6.4.10 Increased Noise

The ecological effects of increased noise vary by species, and its effects depend on the regularity, duration and volume of the noise (Shannon, et al., 2016). The effects of noise on wildlife include altered vocal behaviour, reduced abundance in noisy habitats, changes in predator avoidance and foraging behaviour and impacts on individual fitness and the structure of ecological communities (Shannon, et al., 2016). Wildlife responses to noise start at about 40dBA (Shannon, et al., 2016). Noise can cause sensory degradation or the inability to detect cues from conspecifics, predators, prey and the environment, which can lead to altered reproductive success, changes in predator-prey interactions and change settlement dynamics (Shannon, et al., 2016). It can also distract animals from more important environmental stimuli, be a direct stressor (e.g. cause pain or elevated stress levels) or may even provide shelter from more noise-sensitive predators (Shannon, et al., 2016). Repeated exposure to additional noise sources can result in tolerance or habituation to the noise source for some species but not others, which may respond through local displacement away from the noise source (Shannon, et al., 2016).

Potential sources of increased noise from the proposal include increased traffic noise, mine blasting, construction of infrastructure and processing and production activities.

6.4.11 Increased Dust Emissions

Increased dust emissions can impact flora as dust settling on leaves or other photosynthetic areas can reduce the amount of light reaching photosynthetic pigments, affect respiration and transpiration, allow the penetration of phytotoxic gaseous pollutants and increase leaf temperature, which can lead to decreased productivity and changes to plant community structure (Sharifi, et al., 1997; Farmer, 1993). Dust deposition levels as low as 0.2g/m^2 can impact on vegetation, such as reduced growth and reduced seed set (Farmer, 1993). Dust can also exacerbate secondary stressors, such as drought or insects and pathogens due to reduced photosynthesis and increased leaf temperature (Farmer, 1993). Increased dust emissions may detrimentally impact the health of fauna species *via* inhalation of excessive amounts of dust or inhalation of contaminated dust. Dust can contain elevated levels of metal contaminants, which as well as being directly inhaled by fauna, may settle in waterways and accumulate in the tissues of fauna (Indo-Pacific Environmental, 2017). (Department of the Environment, 2016) set a particulate criterion limit of 50 µ/m^3 for PM_{10} particulates (averaged over the period of a day) and 25 µ/m^3 for $PM_{2.5}$ particulates (averaged over the period of a day) for human exposure. There is no applicable criterion for fauna and no information on the impact of dust specific to Australian wildlife, but it is likely that levels much lower than the human exposure limit are required to prevent adverse health impacts in fauna and they have a higher rate of inhalation per unit body mass than humans (Newman & Schreiber, 1988). Increased dust emissions may also carry additional contaminants that could adversely impact the health of fauna (Collins & Algers, 1986; Spellerberg, 1998).

Increased dust emissions from the proposal may be caused by vegetation clearing and construction activities, increased vehicle movements, drilling and blasting or waste rock and ore, excavation, wind erosion from exposed surfaces, loading and moving of waste rock, loading and moving ore.

6.5 Impacts on Flora Species of National Environmental Significance

An assessment of significant impact was conducted for all flora species listed under the EPBC or TPWC Act deemed to have a moderate or high residual likelihood of occurrence within the survey area. Details of the assessment of each threatened flora species considered are provided below.

6.5.1 Vulnerable Flora

Acacia praetermissa

Acacia praetermissa was not recorded during field surveys. *A. praetermissa* can resprout from perennial root base and therefore may not have been detectable during the two on-ground surveys (see Section 5.1.1). Therefore, there remains a possibility that a sub-population of *A. praetermissa* exists within the proposal footprint. Due to this, it is recommended that a process be put in place for Environment staff to be able to identify and report the presence of *A. praetermissa* if encountered. As only two sub-populations of *A. praetermissa* are known, any plants subsequently identified within the footprint would substantially increase the risk levels identified below. The below risk assessment is based on the survey effort conducted in the survey area and the lack of *A. praetermissa* recorded but throughout takes into consideration the possiblility that individuals may have been missed due to recent fire activity and ability to repsrout. In addition to being listed as vulnerable under the EPBC Act, *A. praetermissa* is also listed as vulnerable under the TPWC Act. See Appendix 11a for a detailed risk assessment for *A. praetermissa*.

Lead to a long-term decrease in the size of an important population – Habitat suitable for *A. praetermissa* was identified in the sandstone hills habitat in the survey area (Figure 33), which occurs particularly around Iron Blow and Mt Bonnie. Earthworks and excavation for roadworks, mineral exploration and the development of new mines is a threat to populations of *A. praetermissa* (Cowie & Kerrigan, 2012). The species is also susceptible to stochastic events due to its restricted distribution, area of occupancy (~2.5 ha) and low population size (Cowie & Kerrigan, 2012). As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will lead to a long-term decrease in the size of an important population. Processes for identification and reporting *of A. praetermissa* by mine Environment staff will ensure that the risk does not increase as a result of individuals missed during targeted on-ground surveys. The risk rating of the proposal leading to a long-term decrease in the size of the population is low. The invasion of weeds into the species habitat, particularly invasive grasses, may lead to competition and changes in fire regime, but the risk that these could lead to a long-term decrease of a population if one should occur in the survey area is low. Levels of risk associated with surface water quality and quantity, erosion and sedimentation, increased artificial light, increased vibration and increased dust emissions were low. Levels of risk associated with groundwater quality and quantity, vehicle collision and increased noise were very low.

Reduce the area of occupancy of an important population – As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will reduce the area of occupancy of an important population. Processes for identification and reporting *of A. praetermissa* by mine Environment staff will ensure that the risk does not increase as a result of individuals missed

during targeted on-ground surveys. The risk rating of the proposal leading to a long-term decrease in the size of the population is low. There is a low risk that invasion or increases in the density of weeds, particularly invasive grasses will reduce area of occupancy for this species. *A. praetermissa* relies on cool fires for resprouting but hot fires can result in mortality therefore altered fire regimes could reduce the area of occupancy of an important population of *A. praetermissa*. There is a low risk that changes in surface water quality and quantity, increased erosion and sedimentation, increased artificial light, increased vibration and increased dust emissions could reduce the area of occupancy of a population of *A. praetermissa* in the survey area, should it occur. There is a very low risk that changes in groundwater quality and quantity could reduce the area of occupancy of a population of *A. praetermissa* in the survey area should it occur.

Fragment an existing important population into two or more populations – As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will fragment an existing important population into two or more populations with the risk identified as low. There is also a low risk that invasion or increased density of weeds and altered fire regimes could fragment an existing important population into two or more populations in a similar manner to which it could reduce the area of occupancy of an important population or lead to a long-term decrease in the size of an important population.

Adversely affect habitat critical to the survival of a species – As *A. praetermissa* was not identified within the survey area during the two surveys, there is a low risk that the proposal will adversely affect habitat critical to the survival of the species. There is a low risk that erosion may adversely affect habitat critical to the survival of the species through degradation and loss of soil. There is also a low risk that invasive weeds and altered fire regimes would adversely affect habitat critical to the survival of *A. praetermissa*, in similar ways to that discussed above, should it occur in the survey area. There is a low risk that changes in surface water quality and quantity and increased artificial light or vibration would adversely affect *A. praetermissa* should it occur in the survey area.

Disrupt the breeding cycle of an important population – As *A. praetermissa* was not identified within the survey area during the two surveys, there is a low risk that the proposal will disrupt the breeding cycle of an important population. There is a low risk that erosion and sedimentation could disrupt the breeding cycle of *A. praetermissa* in the survey area through habitat degradation and loss of topsoil containing seeds. Invasion or increased density of weeds in the habitat of *A. praetermissa* has the potential outcompete native seeds or seedlings, and therefore to a reduction in reproductive success. There is a low risk that invasive weeds could disrupt the breeding cycle of an important population of *A. praetermissa*, should one occur in the survey area. There is a low risk that changes to surface water quality or quantity and increased vibration and dust emissions could disrupt the breeding cycle of a population. There is a very low risk that changes to groundwater quality or quantity, vehicle collision, increased artificial light or increased dust emissions could disrupt the breeding cycle of a population of *A. praetermissa*, should one occur in the survey area.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline – As *A. praetermissa* was not identified within the survey area during the two surveys, and therefore there is a low risk that the proposal will modify, destroy, isolate or decrease the availability or quality of habitat to the extent that numbers of *A. praetermissa* will decline. The risk rating of the proposal impacting habitat causing the species to decline is low. In similar ways to that discussed above, there is a low risk that erosion, invasive weeds and altered fire

regimes will impact habitat to the extent that the species is likely to decline, should there be a population of *A. praetermissa* in the survey area.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat – As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will result in an increase in invasive species that are harmful to *A. praetermissa*. In addition, there were no invasive plant species recorded on sandstone hills habitat during the surveys. Processes for identification and reported *of A. praetermissa* by mine Environment staff will ensure that the risk does not increase as a result of individuals missed during targeted on-ground surveys. Vegetation clearing and habitat disturbance has the potential to open up areas allowing weeds to spread. The risk of the proposal resulting in invasive species becoming established in *A. praetermissa* is still deemed to be low. Altered fire regimes have a medium risk of resulting in invasive species becoming established in the habitat of *A. praetermissa* in a similar pathway to that of vegetation clearing and disturbance. There is a low risk that changes to surface water quality or quantity or increased dust emissions will result in invasive species becoming established in the habitat of *A. praetermissa*, should the species occur in the survey area. There is a very low risk that changes in groundwater quality or quantity, erosion and sedimentation, vehicle collision, or increased artificial light, vibration, noise or dust emissions may result in invasive species becoming established in the habitat of *A. praetermissa*.

Introduce disease that may cause the species to decline – As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will introduce disease that may case *A. praetermissa* to decline. No diseases are documented to affect *A. praetermissa. Ganoderma* spp. are species belonging to the club group and mushroom group of fungi (Basidiomycete), and can cause plant death in some *Acacia* species (Hennessy & Daly, 2007). This disease is known to occur in the Top End (Hennessy & Daly, 2007), however there are no reports of *Ganoderma* spp. affecting *A. praetermissa*. *Ganoderma* spp. are soil borne fungi and dispersal is through airborne spores (Hennessy & Daly, 2007). Movement of diseased material may also promote dispersal (Hennessy & Daly, 2007). Movement of soil around site and introduction of new soils to the site during construction (incorporated into vegetation clearing and habitat disturbance), and increased dust emissions have a low risk of introducing disease that may cause the species to decline. There is a very low risk the changes in surface and groundwater quality and quantity, erosion and sedimentation, invasion or increases in the populations of weeds, altered fire regimes, vehicle collision and increased artificial light, vibration, noise and dust emissions will result in the introduction of disease that may cause the species to decline.

Interfere substantially with the recovery of the species – As *A. praetermissa* was not identified within the survey area during the two surveys, it is unlikely that the proposal will interfere substantially with the recovery of *A. praetermissa.* Processes for identification and reported *of A. praetermissa* by mine Environment staff will ensure that the risk does not increase as a result of individuals missed during targeted on-ground surveys. The risk to the species therefore has been deemed to be low. There is a low risk that habitat degradation and topsoil loss resulting from erosion, invasion of weed species and altered fire regimes could interfere substantially with the recovery of *A. praetermissa*, should the species occur in the survey area. There is a low risk that dust emissions could interfere substantially with the recovery of the species. There is a very low risk that changes to surface water and

groundwater quality and quantity, vehicle collision, or increases in artificial light, vibration or noise could interfere substantially with the recovery of the species.

Table 52. Summary of the assessment of significant impacts on *Acacia praetermissa* from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Max level of risk
Lead to a long-term decrease in the size of a population of a species	Unlikely	Minor	Low
Reduce the area of occupancy of a species	Unlikely	Minor	Low
Fragment an existing population into two or more populations	Unlikely	Minor	Low
Adversely affect habitat critical to the survival of a species	Unlikely	Minor	Low
Disrupt the breeding cycle of a population	Unlikely	Minor	Low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Minor	Low
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat	Unlikely	Minor	Low
Introduce disease that may cause the species to decline	Rare	Minor	Low
Interfere substantially with the recovery of the species	Unlikely	Minor	Low

6.6 Impacts on Fauna of National Environmental Significance

A significant impact assessment (method outlined in Sections 6.1-6.3) was conducted for all fauna species listed under the EPBC or TPWC Act deemed to have a moderate likelihood of occurrence or greater within the proposal footprint. The proposal footprint was determined prior to the on-ground field survey by PNX Metals and is synonymous with the "survey area". Of the species assessed, no species were determined likely to be significantly impacted by development of the Hayes Creek Project Project. Details of the assessment of each threatened fauna species considered are provided below in Sections 6.5 - 6.7.

A significant impact assessment was also conducted for migratory species identified as having a moderate likelihood of occurrence or greater within the survey area. No species were determined as likely to be significantly impacted by proposal developments.

6.6.1 Critically Endangered Fauna

The only fauna species listed as critically endangered under the EPBC Act assessed for significant impacts was the curlew sandpiper.

Curlew sandpiper

As the curlew sandpiper is listed as critically endangered under the EPBC Act, assessments to determine the risk of significant impact from the proposal were undertaken using the assessment criteria for critically endangered and endangered species (see Section 6.2). The curlew sandpiper is also listed as a marine and a migratory species under the EPBC Act and vulnerable under the TPWC Act.

Lead to a long-term decrease in the size of a population – The curlew sandpiper is present in Australia from August to April, during its non-breeding season (Department of the Environment, 2019). This species predominantly inhabits coastal areas, but also occurs more broadly at inland freshwater wetlands when migrating (Ward, 2012; Department of the Environment, 2019). Freshwater wetlands are present in the survey area. Therefore, there is a moderate likelihood that individuals may occur in the survey area during migration between August and April. However, it is not likely that the number of individuals present at any one time in the survey area will constitute a population, or that the proposal will have cumulative impacts on enough individuals over time to have any impact on a population. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of a population of the curlew sandpiper.

Reduce the area of occupancy of the species – The curlew sandpiper is a migratory wader with breeding grounds in Siberia, that migrates through Siberia, China and south Asia to Australia during the non-breeding season (Department of the Environment, 2019). Given this broad distribution and that the species is only likely to occur in the survey area very occasionally and in small numbers, there is a very low risk that the proposal will reduce the area of occupancy of the species.

Fragment an existing population into two or more populations – As discussed above, it is not likely that the number of individuals present at any one time in the survey area will constitute a population of the curlew sandpiper, or that the proposal will have cumulative impacts on enough individuals over time to have any impact on a population. Additionally, as the global population of the curlew

sandpiper is widespread, and any individuals that occur in the survey area will be transitory and migrating between northern Australia and south-east Australia (Department of the Environment, 2019) and the proposal will occur at relatively very local scale, there is a very low risk that the proposal will fragment an existing population of the curlew sandpiper into two or more populations.

Adversely affect habitat critical to the survival of a species – Although there are freshwater wetlands in the survey area that the curlew sandpiper may occur at during migration, the Project will not directly disturb this habitat. In addition, the identified wetlands in the survey area are not considered optimal habitat for the curlew sandpiper, and individuals are likely to use these in a transient manner on migration from northern Australia to south-east Australia. Alternative habitat is present in the landscape surrounding the proposal area including number of human-made pit lakes and tailings dams, and natural water bodies. For these reasons, there is a very low risk that the proposal will adversely affect habitat critical to the survival of the curlew sandpiper as a species.

Disrupt the breeding cycle of a population – The curlew sandpiper is only present in Australia during the non-breeding season (Department of the Environment, 2019). Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of a population of the curlew sandpiper.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline – As discussed above, habitat in the survey area is not preferred habitat, is likely to be occupied only irregularly and transiently and by a small number of individuals that would not constitute a population, and there is similar habitat available to the species in the broader region (Figure 34). The species is also a wide-ranging species and impacts from the proposal will be very localised in comparison. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat – Invasive species are not listed as a threat to the curlew sandpiper (Department of the Environment, 2019). However, feral cats may prey on curlew sandpipers when they occur in the survey area, and the introduction of weeds may alter habitat suitability. However, feral cats and habitat altering weeds are already present in the survey area, and freshwater habitats are likely to only be used transiently during migration. Therefore, there is a very low risk that the proposal will result in invasive species that are harmful to the curlew sandpiper becoming established in the species habitat.

Introduce disease that may cause the species to decline – it is not likely that operations associated with the proposal will lead to the introduction of diseases impact on migratory shorebirds. As discussed above, it is highly likely that there will not be a high number of individuals occurring in the survey area. Therefore, there is a very low risk that the proposal will introduce disease that may cause the curlew sandpiper, as a species, to decline.

Interfere substantially with the recovery of the species – Much of the population decline of the curlew sandpiper is probably due to threats in breeding areas outside of Australia (Department of the Environment, 2019). However, because of this it is necessary to maintain good habitat used by the species during migration (Department of the Environment, 2019). As discussed above, the curlew sandpiper is likely to only occur in the survey area is small number on a transient basis, and similar

habitat is widely available in the surrounding region (Figure 19). Therefore, there is a very low risk that the proposal will interfere with the recovery of the species.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact on the curlew sandpiper (Table 53).

Table 53. Summary of the assessment of significant impacts on the curlew sandpiper from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of a population of a species	Rare	Very minor	Very low
Reduce the area of occupancy of a species	Rare	Very minor	Very low
Fragment an existing population into two or more populations	Rare	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Rare	Very minor	Very low
Disrupt the breeding cycle of a population	Rare	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Rare	Very minor	Very low
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat	Rare	Very minor	Very low
Introduce disease that may cause the species to decline	Rare	Very minor	Very low
Interfere substantially with the recovery of the species	Rare	Very minor	Very low

6.6.2 Endangered Fauna

Assessments to determine the risk of significant impact from the proposal on fauna species listed under the EPBC Act were undertaken using the assessment criteria for critically endangered and endangered species (see Section 6.2).

Fauna listed as endangered under the EPBC Act and either recorded during on-ground surveys or having a moderate to high residual likelihood of occurring in the survey area (**Error! Reference source not found.**) were the Gouldian finch and the black-footed tree-rat.

Gouldian finch

The Gouldian finch (*Erythrura gouldiae*) is listed Nationally as endangered under the EPBC Act, and in the Northern Territory as vulnerable under the Territory Parks and Wildlife Conservation Act 2000. The species is endemic (native and restricted to a certain place) to northern Australia and over the past century has suffered significant declines in population size and distribution (Tidemann, et al., 1992).

The likelihood of any or all (cumulatively) impact factors leading to a long-term decrease in the size of the Gouldian finch population in the survey area is high. The following factors are recognised as areas of conservation concern for the Gouldian finch.

Lead to a long-term decrease in the size of a population

Data recorded during on-ground surveys were inadequate for assessing the population size of the Gouldian finch and further targeted survey effort would be required to determine this. The presence of flocks of Gouldian finches recorded in the survey area in both May 2017 and August 2019 suggest that there may be a resident population in the area, although its exact location from season to season will depend on food resource availability. Therefore, it is difficult to assess the impacts of the proposal on the size of the population occurring in the survey area and the precautionary principle was applied when undertaking this assessment. Subject to further targeted studies, the risk may be ree-evaluated based on more data on the extent of seasonal habitat use of the survey area.

Eucalyptus tintinnans provides essential cavities for hollow-dependant breeding species and are preferentially selected by Gouldian finch as breeding sites (Brazill-Boast, et al., 2011). *Eucalyptus tintinnans* was the predominant hollow-bearing tree in the survey area and was recorded over much of the sandstone hills habitat (Baker landsystem) in the survey area, with most records located around Mt Bonnie and the proposed Haul Road areas. The retention of critical breeding habitat is recognised as an integral component of conservation strategies for this species (Brazil-Boast, et al., 2010; O'Malley, 2006; Manning, et al., 2012) and retaining breeding habitat will help reduce the risk of any negative implications that the proposal development might have on the species survival in the area. Although juveniles were recorded during May 2017 and August 2019, breeding in the survey area has not been confirmed and further survey effort is required to determine this. The Gouldian finch has been recorded using foraging sites within a radius of up to 10 km from breeding areas. Foraging areas contain perennial grasses and are typically located in lowland grassy woodland. The birds tend to favour small foraging patches for brief periods until widespread seed fall provides broader availability (Dostine, et al., 2001). Critical dry and wet season food resources for the Gouldian finch were widespread within the survey area including annual *Sorghum* spp. (dry season) and *Themeda triandra, Alloteropsis semialata, Chrysopogon fallax* and *Heteropogon* sp. (wet season). Gouldian finches use water bodies that are (relatively) small with shallow water edges and gently sloping banks as drinking sites. Other characteristics of suitable water bodies include nearby overhanging vegetative cover from aerial predators and availability of safe perching areas.

Vegetation clearing and disturbance will be concentrated in the three production areas and along the new section of the Haul Road. Habitat for the Gouldian finch was identified in the sandstone hill habitat, where there were hollow-bearing *Eucalyptus tintinnans* (shelter) and food plants, the sandplain habitat, where there were food plants, and standing water sources along the creek lines and at the edge of dams from previous mining operations (Section 5.1.2). These habitats occurred over approximately 945.78 ha within the survey area (~65% of the survey area). 11.66 ha of sandstone hills habitat occurs within the footprint of the proposal. This equates to 12.24% of the sandstone hills habitat available in the survey area, and 0.02% of that available within a 20 km radius of the survey area (including the survey area). 129.08 ha of sandstone plain habitat occurs within the footprint of the proposal. This equates to 15.17% of sandstone plain habitat available in the survey area and 0.24% of that within a 20 km radium of the survey area. 2.01 ha of watercourse habitat occurs within the footprint of the proposal. This equates to 3.28% of the watercourse habitat available in the survey area and 0.01 % of that within 20 km of the survey area. Pit lakes and tailings dams cover 14.33 ha of the survey area, equating to 41.06% of the pit lakes and tailings dam habitat in the survey area. 139.06 ha of already heavily disturbed habitat occurs within the proposal footprint. While this habitat has

been disturbed previously, some areas still provide habitat for the Gouldian finch, as suggested by the records of the species at MB16 in August 2019. Despite this, we only consider the survey area in the vicinity of Mt Bonnie and Iron Blow to be suitable for Gouldian finches due to the close vicinity to suitable breeding habitat and the confirmed sigthtings of Gouldian finches in this area. While the area of habitat to be cleared is small in size and in proportion to that in the surrounding region, the occurrence of suitable breeding/roosting, feeding and drinking habitats within close proximity is key. Gouldian finches were recorded using sandstone plain, watercourse, sandstone hill and tailings dam habitat in the survey area. It is not clear how far this population moves, how intensively it uses the survey area or whether there is suitable habitat in the surrounding area that is not already occupied. Furthermore, the restricted diet of the Gouldian finch (grass seeds), combined with a strongly annual life-cycle, makes them vulnerable to the availability of patchy food resources and seed shortages that can occur at the onset of the wet season (O'Malley, 2006). The late dry/early wet season is a period during which the Gouldian finch are reliant on the availability of declining dry season food resources prior to wet season food resources becoming available. Reduced availability of food resources in the landscape at this critical time may be detrimental to a population of the Gouldian finch. Therefore, in line with the precautionary principle, there is a high risk that vegetation clearing and habitat disturbance during the proposal could lead to a long-term decline in the size of a Gouldian finch population. See Section 6.4.1 for more information on the impacts of vegetation clearing and habitat disturbance from the proposal.

Gouldian finches require surface water for drinking, and prefer areas with gently sloping banks, shelter from overhanging vegetation and availability of perches. A decline in surface water as a result of the proposal could occur due to construction of infrastructure or groundwater drawdown and could decrease the number of available drinking sites for Gouldian finches. Additionally, contamination of drinking water with toxicants from contaminated run-off into waterways or high concentrations of contaminants in tailings dams could result in mortality and/or a loss of suitable habitat. Furthermore, as Gouldian finches drink in flocks (the largest recorded during field surveys was 30), there is the potential for many deaths to occur simultaneously from contaminated drinking water. There is a medium risk that changes in surface water quality and quantity may lead to a long-term decline in the size of a Gouldian finch population. See Section 6.4.2 for more information on the potential impacts to surface water quality and quantity from the proposal.

Changes to groundwater quality and quantity could impact Gouldian finches in a similar way to that discussed above for surface water quality and quantity. Drawdown of groundwater for the proposal could result in a decline in the availability or period of inundation of surface water pools fed by groundwater in the survey area, thereby reducing the availability of drinking water for Gouldian finches. Additionally, leaching of contaminants into groundwater (e.g. acid mine drainage) resulting from inadequate barriers between the contaminants and the water table may lead to the contamination of surface water pools where they are fed by groundwater flows. There is a medium risk that changes in groundwater quality and quantity could lead to a decline in the size of a Gouldian finch population. See Section 6.4.36.4.2 for more information on the potential impacts to groundwater quality and quantity from the proposal.

Erosion risk will be highest in the survey area following high rainfall where vegetation clearing, and habitat disturbance is proposed. Erosion can lead to plant mortality and a loss of topsoil. The most likely impacts from erosion to Gouldian finch habitat are the loss of the grass seed soil bank in

association with the loss of topsoil, and the loss of food plants as a direct result of erosion. Erosion can also lead to sedimentation of lower lying areas and watercourses. Sediment laden run-off may wash off areas cleared for the proposal and into waterways leading to infilling of surface water sources and potentially resulting in a decline in the quality and availability of drinking water for the Gouldian finch. Using a precautionary approach, there is a medium risk that erosion and sedimentation could lead to a long-term decline in the size of a Gouldian finch population. See section 6.4.4 for more information on the potential impacts of erosion and sedimentation resulting from the proposal.

The proposal could facilitate the spread of introduced weeds that are present in the survey area. Existing weed species in the survey area were predominantly situated around creek lines in the south of the survey area. Vegetation clearing increases the vulnerability to new invasive species to establish themselves in the area. Invasive weed species of major concern to the persistence of the Gouldian finch are gamba grass, perennial mission grass, annual mission grass and grader grass and already occur in high densities in the survey area. Soil or canopy disturbance increases the ability of gamba grass ability to colonise undisturbed sites (Setterfield, et al., 2005) and the species is easily spread along roads and disturbance corridors (Kean & Price, 2002) resulting in even more of the survey area covered by weeds. Invasive grasses can attain a higher biomass than native grasses, and have the propensity to out-compete native species, decrease soil nitrogen availability and contribute to increased fuel loads, resulting in more intense and frequent fires (Threatened Species Scientific Committee, 2009). Inappropriate fire regimes are a major threat to the Gouldian finch, as fire can affect both seed productivity and hollow availability. Pastoral grazing may be detrimental to the Gouldian finch (Department of Environment and Natural Resources, 2017), and as such an increase in the abundance or activity of herbivores, feral or stock, resulting from the proposal may have a detrimental impact on the Gouldian finch through overgrazing of food plants or disturbance of water sources. Wet season grasses used by the Gouldian finch, including cockatoo grass and golden beard grass, are selectively grazed by cattle and horses, which can reduce the extent of these species as well as reduce seed production (O'Malley, 2006). Pigs have also been recorded damaging patches of cockatoo grass (O'Malley, 2006). Cattle and buffalo can both potentially degrade, reduce or damage waterholes used by Gouldian finches. For these reasons, there is a medium risk that an increase in the activity or populations of weeds or pest animals may lead to a decline in the size of a Gouldian finch population. See Section 6.4.5 for more information on invasive weeds and peat animals.

Changes to natural fire regimes, particularly an increase in fire frequency, extent and burn temperatures, have been implicated in population declines of the Gouldian finch owing to altered availability of food resources (O'Malley, 2006; Weier, et al., 2016). Fire as a threatening process to the Gouldian finch operates at the landscape scale and can affect food and shelter availability, as well as causing direct mortality. More frequent and extensive fires have been implicated in population declines of Gouldian finches due to the impacts of fire on grass seed availability (Weier, et al., 2016). Some evidence suggests that heterogeneous fire patterns favour the Gouldian finch (O'Malley, 2006). Finches appear to breed at sites burnt in the last 12-24 months, thought to be a result of the positive influence of fire on *Sorghum* grass seed availability and highest seed production of wet season grass resources tends to occur with cool burns, occurring approximately every 2-3 years (Lewis, 2007; Weier, et al., 2016). Therefore, some fire is likely beneficial to the Gouldian finch. Much of the survey area has burnt annually since 2010 (>50% of the survey area in all years except 2015, see Section 3.9), and fire frequency is high in the southern two thirds (Figure 14). Gouldian finches appear to be persisting

in the survey area, but any increases to the frequency and intensity of fires may be detrimental to the population. Increases in the frequency and intensity of fires resulting from the proposal could be caused by increases in the biomass of invasive grasses or an increase in the number and types of ignition sources (e.g. machinery, vehicles, hot works etc. see Section 6.4.6). Given the level of threat that inappropriate fire regimes pose to Gouldian finches, there is a high risk that altered fire regimes could lead to a long-term decline in the size of a Gouldian finch population. See Section 6.4.6 for more information on altered fire regimes.

Vehicle collision could impact on the Gouldian finch through direct mortality. Gouldian finches may occur on roads or vehicle tracks in large flocks, either flying through areas or feeding or drinking from pools on or next to the road. As Gouldian finches may occur in large flocks there exists the possibility that many individuals could be killed simultaneously. Gouldian finches were recorded adjacent to the new section of the Haul Road and in the Mt Bonnie production area during surveys, where vehicle use will be regular. Therefore, there is a medium risk that vehicle collision could lead to a decline in the size of a Gouldian finch population. For more information on vehicle collision see Section 6.4.7.

Increased artificial light can impact on the daily activity and sleep patterns of animals, and may change the calling behaviour of birds, among other impacts (Section 6.4.8). During operations there will likely be 24/7 artificial lighting in the production areas, and night-time driving using headlights. Artificial light used for the proposal is likely to only have localised impacts and be concentrated in the production areas. However, some local displacement or behavioural disturbance could affect Gouldian finches. The level of the impact will depend on whether individuals can adapt to tolerate elevated levels of artificial light, or if there is suitable, unoccupied habitat in the surrounding area to disperse into. Therefore, there is a medium risk that increased artificial light could lead to a decline in the size of a Gouldian finch population.

It is unknown how increased vibration affects fauna (see Section 6.4.9). However, while it is hard to predict, vibration from sources such as blasting may be felt far from the source. Sources of vibration from the proposal range from higher intensity but shorter duration sources, such as blasting, to lower intensity but more regular sources, such as haul trucks and other vehicles. Recognising the lack of knowledge about the effects of vibration on fauna, the most foreseeable impact to the Gouldian finch is local disturbance and displacement. As discussed for the impact of artificial light above, the level of the impact will depend on whether individuals can adapt to tolerate elevated levels of vibration, or if there is suitable, unoccupied habitat in the surrounding area to disperse into. Therefore, using a precautionary approach, there is a medium risk that increased vibration may lead to a decline in the size of a Gouldian finch population.

The impacts of noise on fauna varies greatly by species. Ongoing increased noise disturbance can affect fauna activities such as breeding and foraging, and populations may decline in the vicinity of the noise as a result of animals avoiding the area (see Section 6.4.10). Increased noise production from the proposal will result from vehicles, mine blasting, construction of infrastructure and processing and production activities. As with the impacts of artificial light and vibration, the impacts of increased noise production on Gouldian finches is hard to predict. It will likely affect Gouldian finches at a local scale and be concentrated in the production areas. However, this increased noise production may affect feeding or breeding behaviours and cause local displacement or disturbance and the magnitude of these effects will depend upon the ability of Gouldian finches to tolerate increased noise production or the availability of suitable, unoccupied habitat to disperse into. Using a precautionary approach,

there is a medium risk that in increased noise production from the proposal could lead to a long-term decline in the size of a Gouldian finch population.

Increased vehicle use of roads through Gouldian finch habitat, increased vegetation clearing leading to increased bare ground and mine blasting are some potential sources of increased dust emissions from the proposal. Inhalation of increased dust concentrations could directly affect the health and fitness of individual Gouldian finches, which in turn may lead to mortality or reduced reproductive success. The Gouldian finch is also susceptible to the nasal cavity dust mite *Sternostoma tracheacolum* (Murray, 1966). Limited research suggests that the mite is transferred in wild populations from already infected individuals (Tidemann, et al., 1992). As well as inhalation of increased dust concentrations, increased dust emissions may exacerbate the susceptibility of individuals to *S. tracheacolum* and likewise decrease health and fitness. Using a precautionary approach, there is a medium risk that increased dust emissions from the proposal could lead to a decline in the size of a Gouldian finch population.

Reduce the area of occupancy of the species

The proposal will impact directly on areas surrounding Fountain Head, Iron Blow, Mt Bonnie and the proposed Haul Road. This proposed development will reduce the amount of available habitat (sandstone hills with *E. tintinnans*) suitable for Gouldian finch within the survey area by approximately 260 ha and by approximately 0.3% of suitable habitat in the 20 km radius surrounding the survey area. While a habitat loss of 0.3% is seemingly not a significant reduction in the overall extent of Gouldian finch habitat available across the species range, ongoing habitat loss, fragmentation and degradation across the species range can have a cumulative effect and compound the impacts of smaller, incremental habitat modifications for an endangered species (Fahrig, 2001). Therefore, there is a high risk that the proposal will reduce the area of occupancy of the Gouldian finch as a species.

As discussed above, the Gouldian finch requires small, well vegetated pools of surface water for drinking. Declines in the quality (increased in the concentration of toxicants) and quantity of surface water may lead to a reduction in the area of suitable habitat for a population. Declines in surface water quantity are likely to be localised but impacts from contamination may be apparent further downstream. As there are potential sources for impacts to surface water quality and quantity from the proposal, but taking into account the localised scale of operations and the distribution of the Gouldian finch across the Top End, there is a medium risk that it will reduce the area of occupancy of the species.

For reasons similar to those discussed for surface water and for the previous criteria, changes to the quality and quantity of groundwater from the proposal may cause a reduction in surface water availability if surface water is fed by groundwater flows, and if contaminants leach into groundwater that feeds into surface water. A reduction in surface water availability is likely to be localised, but the effects of contamination may be apparent downstream. As there are potential sources for impacts to groundwater quality and quantity from the proposal, but taking into account the localised scale of operations and the distribution of the Gouldian finch across the Top End, there is a medium risk that it will reduce the area of occupancy of the species.

Erosion and sedimentation may impact the availability of food plants or surface water, as discussed for the previous criteria. The impacts of erosion are likely to be localised. The impacts of sedimentation may be apparent downstream, depending on sediment loads. The risk of erosion, and subsequent run-

off of sediment laden water into waterways, is highest in areas where vegetation has been cleared or disturbed. This will occur in the production areas and along the Haul Road for the proposal. There is a medium risk that the proposal will reduce the area of occupancy of the species.

The risk of invasion or increased densities of weeds will be highest in areas being cleared or disturbed for the proposal, and in lower lying areas where water collects. This could decrease the amount of suitable habitat for the Gouldian finch in the survey area, as discussed in the previous criteria. Feral animals, particularly herbivores, can damage water sources that are important for the Gouldian finch, and reduce the availability of grass seeds for foraging (see previous criteria). Invasive weeds and feral herbivores have the potential to impact Gouldian finch habitat on a scale that goes beyond the footprint of the proposal. However, as discussed above the Gouldian finch has a wide distribution across the Top End and the proposal and its impacts will occur at a relatively local scale. Currently the survey area already contains a high density of weeds and the risk is not that proposal will introduce weeds into a pristine landscape but that clearing and disturbance may facilitate the further spread of weeds already present. Acknowledging the potential for off-site impacts, but also the broader distribution of the Gouldian finch, there is a medium risk that the proposal will reduce the area of occupancy of the species.

As discussed above, inappropriate fire regimes are a major threat the Gouldian finch. Intense and large or frequent fires are detrimental to the species, primarily through the reduction in food resources. Impacts of altered fire regimes from the proposal could be potentially widespread and damaging. However, as discussed, the Gouldian finch occurs widely across the Top End. Therefore, there is a medium risk that the proposal could reduce the area of occupancy of the species.

Vehicle collision during the proposal could lead to local mortality of individuals or flocks of Gouldian finches. However, there is a low risk that the localised impact of vehicle strike will reduce the area of occupancy of the species.

As discussed in the previous criteria, increased artificial light, vibration, noise and dust emissions are likely to cause localised impacts to the Gouldian finch population in the survey area, but these will be concentrated around the three production areas and Haul Road. Therefore, there is a low risk that increased artificial light, vibration, noise and dust emissions will reduce the area of occupancy of the species.

<u>Fragment an existing population into two or more populations</u>

The proposal is not likely to cause the existing Hayes Creek Project population to split into two or more disconnected subpopulations. However, the current distribution and population size of the Gouldian finch in the survey area remains unconfirmed. Therefore, it is difficult to establish a realistic estimation for the potential risk for population fragmentation, until further census of Gouldian finch population is undertaken in the survey area incorporating the species breeding and non-breeding seasons. Small populations are more vulnerable to threatening processes (Jamieson & Allendorf, 2012).While risk of population fragmentation is estimated as low, the potential for fragmentation of a small population is greater than it would be for a large population.

As discussed in the first criteria, the status and size of the population in the survey area could not be ascertained from the data available. This increases the uncertainty of the assessment of whether a population in the survey area is likely to be fragmented into multiple populations.

Vegetation clearing and habitat disturbance, as discussed above, will occur on a localised scale compared to the availability of habitat in the surrounding area (Table 51). Despite this, the size of the population and its distribution across the survey area is still relatively unknown and requires further investigation. Therefore, there is a high risk that the vegetation clearing and habitat disturbance for the proposal may fragment an existing population of the Gouldian finch into two or more populations.

The potential impacts of the proposal on groundwater quality and quantity, in relation to the Gouldian finch, involve impacts to surface water quality and quantity. Impacts to water quantity will likely be localised but impacts to water quality may be apparent further downstream. Reducing the availability of drinking water over an area could impact on the suitability of habitat over that area. Therefore, there is a medium risk that changes to surface and groundwater quality and quantity could fragment an existing population of the Gouldian finch into two or more populations.

As discussed above, the impacts of erosion are likely to be localised and on-site. Whereas, the impacts of sedimentation may be apparent downstream. However, there is a low risk that erosion and sedimentation will fragment an existing population into two populations.

The invasion and increased densities of weeds and feral herbivores has the potential to impact the Gouldian finch off-site as well as on-site. Though the scale at which this is likely to occur is still localised relative to the movements of the Gouldian finch (Dostine, et al., 2001). Therefore, there is a low risk that invasion or increases in populations or activity of weeds and pest animals could fragment an existing population into two or more populations.

As discussed above, inappropriate fire regimes are a major threat to the Gouldian finch and can have impacts at a broad scale and have impacts on foraging as well as breeding/roosting habitat. Therefore, there is a high risk that altered fire regimes could fragment an existing population into two or more populations.

As discussed above, the impacts of vehicle collision, and increased artificial light, vibration, noise and dust emissions will be local-scale and concentrated in the production areas and along the Haul Road. Therefore, there is a very low likelihood that these sources of impact will fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

The National Recovery Plan for the Gouldian finch (O'Malley, 2006) identifies four key sites for the Gouldian finch in the NT, including Yinberrie Hills and surrounds, Limmen National Park, Kakadu National Park and surrounds, the Bradshaw Field Training Area and Newry Station and Keep River National Park. These are key areas with significant populations of Gouldian finches, including records of adult and juvenile birds, where it is assumed that the species is likely to persist if threatening processes can be minimised. Given the disturbance experienced over the survey area, including frequent fires and previous mining operations, the distance from key areas identified in the Recovery Plan (>100 km), the local scale of the proposed disturbance footprint and the availability of potentially suitable habitat in the surrounding area it is unlikely that habitat in the survey area is habitat critical to the survival of the species. Therefore, there is a very low risk that any of the identified potential sources of impact will adversely affect habitat critical to the survival of the species.

Disrupt the breeding cycle of a population

Juvenile Gouldian finches were recorded in both May 2017 and August 2019, which is suggestive that breeding occurs within or close to the survey area. Therefore, there is the potential for the proposal to disrupt the breeding cycle of a population.

Loss of breeding habitat from vegetation clearing and habitat disturbance during the proposal may reduce the number of hollow-bearing trees for use as nesting habitat. Additionally, a loss of food resources, especially at key times of the year, may lead to a reduction in breeding success. 11.66 ha of potential breeding habitat and 129.08 ha of potential foraging habitat occurs within the proposal footprint. And at least a part of this area is known to be used by Gouldian finches. The level of impact is dependent on whether Gouldian finches can readily find unoccupied breeding habitat in the surrounding area. Using a precautionary approach, there is a medium risk that vegetation clearing, and habitat disturbance will disrupt the breeding cycle of a population.

A reduction in the availability or quality of surface water, which could be driven by declines in the quality and quantity of groundwater, may impact drinking water sources for Gouldian finches. This may impact fitness and breeding success of Gouldian finches in the survey area. Therefore, there is a medium risk that a reduction in either surface water or groundwater could disrupt the breeding cycle of a population.

As discussed above, erosion and sedimentation may reduce the food resources or drinking water availability for Gouldian finches. Though, this is likely to be at a local scale. Therefore, there is a medium risk that erosion and sedimentation could disrupt the breeding cycle of a population.

Invasion or increases in density or activity of weeds and feral herbivores can reduce food and surface water availability or alter fire regimes, and both have the potential for off-site impacts. Altered fire regimes in turn may reduce food availability or the abundance of trees with nesting hollows. Therefore, there is a high risk that both invasion or increases in populations or activity of weeds and pest animals could disrupt the breeding cycle of a population.

Vehicle collison is likely to have acute and very localised impacts on the Gouldian finch in the survey area. However, as Gouldian finches congregate in flocks that often contain large numbers of juveniles, there is the potential for a significant number of mortalities to occur simultaneously. Therefore, there is a medium risk that vehicle collision will disrupt the breeding cycle of a population.

Increased artificial light can impact on the daily patterns and behaviour of fauna (see Section 6.4.8). Increased vibration and noise may also disrupt behaviour on a local scale. Increased dust emissions can impact the health of individuals (as discussed under the first criteria), which can also adversely impact the fitness of individuals These impacts are all likely to be concentrated around the three production areas and the Haul Road. Therefore, there is a low risk that these four sources of impact could disrupt the breeding cycle of a population.

<u>Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline</u>

Approximately 160 ha of known and potential Gouldian finch habitat occurs within the proposal footprint. This is approximately <0.3% of the potentially suitable habitat in the surrounding area. The Gouldian finch also occurs more widely across the NT and northern WA. Therefore, the proposal is not likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline. Therefore, there is a very low risk that any of the identified

potential sources of impact will modify, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat

Invasive species that are harmful to the Gouldian finch include feral herbivores and invasive weeds, as discussed above. Feral herbivores, including pigs, are already established in the survey area, including Gouldian finch habitat. However, weeds had not established in all Gouldian finch habitat in the survey area. Therefore, there is a potential for the proposal to result in the establishment of invasive weeds detrimental to the Gouldian finch in the species habitat.

Vegetation clearing and habitat disturbance provide pathways for weeds to become established in areas where they did not previously occur. Approximately 160 ha of known and potentially suitable Gouldian finch habitat occurs within the proposal footprint. Therefore, there is a high risk that vegetation clearing and habitat disturbance will result in invasive species that are harmful to the Gouldian finch becoming established in the species habitat.

Changes to groundwater or surface water quality or quantity may promote the establishment of weeds due to high concentrations of nutrients or greater water flows into areas where this previously did not occur. Though, this is likely to occur only at a local scale. Therefore, there is a low risk that changes to surface water or groundwater quality and quantity will result in invasive species that are harmful to the Gouldian finch becoming established in the species habitat.

Erosion and sedimentation may lead to the establishment of weeds in areas where they didn't previously occur through the movement of sediment containing seeds of weed species. Movement of sediment may occur on a local scale. However, if sediment reaches water ways there is the potential for seeds to be carried downstream and for impacts to occur in potential Gouldian finch habitat outside the survey area. Therefore, there is a medium risk that erosion and sedimentation will result in invasive that are harmful to the Gouldian finch becoming established in the species habitat.The invasion or increases in the populations of weed species in the survey area outside of Gouldian finch habitat may increase the chances of establishment inside the species habitat. There is the potential for these impacts to occur outside the survey area, as well as inside. Therefore, there is a medium risk that invasion or increases in the populations of weeds species in the survey area will result in invasive that are harmful to the Gouldian finch becoming established in the species habitat.

In addition to reducing foraging habitat and nesting sites, altered fire regimes may also promote the spread of invasive grasses. Fire opens up bare areas that invasive species can rapidly colonise, which then leads to greater biomass and higher fuel loads of invasive grasses. These impacts have the potential to be widespread. Therefore, there is a high risk that altered fire regimes could result in invasive species that are harmful to the Gouldian finch becoming established in the species habitat.

There is no foreseeable way that vehicle collision, increased artificial light, increased vibration and increased noise could result in the establishment of invasive weeds. Therefore, there is a very low risk that these potential sources of impact could result in invasive species that are harmful to the Gouldian finch becoming established in the species habitat.

Increased dust emissions could spread seeds of invasive weeds by wind dispersal. Weeds could then become established if they are transported to a suitable environment. There is the possibility that

dispersal of seed in dust emissions to areas both on- and off-site could occur during the proposal. Therefore, there is a medium risk that increased dust emissions could result in invasive species that are harmful to the Gouldian finch becoming established in the species habitat.

Introduce disease that may cause the species to decline

As discussed above, the Gouldian finch is also susceptible to the nasal cavity dust mite *Sternostoma tracheacolum* (Murray, 1966). Limited research suggests that the mite is transferred in wild populations from already infected individuals (Tidemann, et al., 1992). It is unlikely that any of the potential sources of impact from the proposal will result in the introduction of this dust mite into the population. Therefore, there is a very low risk that any of the potential sources of impact could introduce disease that may cause the species to decline.

Interfere substantially with the recovery of the species

As the potential sources of impact discussed in Section 6.4 will likely only have localised impacts, that any off-site impacts will be contained in the area adjacent to the survey area and that the species occurs across the Top End and northern WA, it is unlikely that the potential sources of impact identified will have an effect on the recovery of the species in its entirety. Therefore, there is a very low risk that any of the sources of impact from the proposal will interfere substantially with the recovery of the species.

Table 54. Summary of the assessment of significant impacts on the Gouldian finch from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of a population of a species	Possible	Major	High
Reduce the area of occupancy of a species	Likely	Moderate	High
Fragment an existing population into two or more populations	Possible	Major	High
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of a population	Possible	Moderate	Medium
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat	Likely	Moderate	High
Introduce disease that may cause the species to decline	Unlikely	Very Minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very Minor	Very low

6.6.3 Vulnerable Fauna

Assessments to determine the risk of significant impact from the proposal on fauna species listed as vulnerable under the EPBC Act were undertaken using the assessment criteria for vulnerable species (see Section 6.2). The following fauna listed as vulnerable under the EPBC Act were recorded or have a moderate or high likelihood of occurring within the survey area:

- Red goshawk;
- Partridge pigeon;

- Masked owl;
- Fawn antechinus;
- Ghost bat; and
- Northern brush-tailed phascogale.

Red goshawk

The red goshawk is also listed as vulnerable under the TPWC Act.

Lead to a long-term decrease in the size of an important population – Potentially suitable habitat for the red goshawk occurs in the survey area in riparian areas. There are few areas where trees are large enough to provide nesting habitat (>20 m tall), but as these are likely to occur in the surrounding region and the red goshawk has a large home range (reported up to 200 km^2), there is a high likelihood that the species may forage in the survey area. Despite this, it was assessed that any red goshawks occurring the survey area would not meet the criteria of an important population as defined in Section 6.2. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of the red goshawk.

Reduce the area of occupancy of an important population – As above, the red goshawk was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of the red goshawk.

Fragment an existing important population into two or more populations - As above, the red goshawk was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will fragment an existing important population of the red goshawk into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat exists for the red goshawk in the survey area (riparian habitats) for activities such as foraging, breeding, roosting and dispersal. However, this habitat is not considered to be habitat critical to the survival of the red goshawk as a species and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. The red goshawk occurs more broadly, albeit sparsely, across the Top End of the NT, into northern WA, north and eastern Queensland and north-eastern NSW, and is occasionally recorded further south in arid NT (Atlas of Living Australia, 2019), and the planned and unplanned impacts from the proposal will be restricted to the local area. As such, the proposal is unlikely to impact the red goshawk as a species. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of the red goshawk.

Disrupt the breeding cycle of an important population - As above, the red goshawk was not assessed as having an important population within the survey area following the definition provided in Section 6.2. Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of the pale field rat.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, the red goshawk occurs more broadly, albeit sparsely, across the Top End of the NT, into WA, Queensland and NSW, and is occasionally recorded further south in arid NT (Atlas of Living Australia, 2019), and the planned and unplanned impacts from

the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the red goshawk as a species. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the red goshawk as a species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat – Invasive species are not listed as a threat to the red goshawk, with the main threat to the species thought to be habitat loss (Threatened Species Scientific Committee, 2015; Woinarski, 2006b). Invasive grass species may present a threat to riparian habitat in the survey area, as these species are known to increase fire frequency and cause subsequent declines in woody vegetation (Threatened Species Scientific Committee, 2009). However, invasive grasses known to alter fire regimes are already established in the survey area (see Section 4.3.3). Therefore, there is a very low risk that the proposal will result in invasive species that are harmful to the red goshawk becoming established in the species' habitat.

Introduce disease that may cause the species to decline – No reports of disease in the red goshawk could be found in the scientific literature. Operations associated with the proposal are also not likely to be of a nature to introduce any disease or disease vector likely to impact the red goshawk. Therefore, there is a very low risk that the proposal will introduce disease that may cause the species to decline.

Interfere substantially with the recovery of the species - As discussed above, the red goshawk occurs broadly, albeit sparsely, across the Top End of the NT, into WA, Queensland and NSW, and is occasionally recorded further south in arid NT (Atlas of Living Australia, 2019), and the planned and unplanned impacts from the proposal will be restricted to a localised area. As such, it is highly unlikely that the proposal will impact the red goshawk as a species. Therefore, there is a very low risk that impacts for the proposal will interfere substantially with the recovery of the red goshawk as a species.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact the red goshawk (Table 55).

Table 55. Summary of the assessment of significant impacts on the red goshawk from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very Minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very Minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very Minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very Minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very Minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very Minor	Very low

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very Minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very Minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very Minor	Very low

Partridge pigeon (eastern subspecies)

The partridge pigeon (eastern subspecies) is also listed as vulnerable under the TPWC Act.

Lead to a long-term decrease in the size of an important population –Suitable habitat for the partridge pigeon occurs in the survey area in lowland eucalypt forest and woodlands with grassy understorey, and this species has been recorded in the survey area in the past according to the NT Fauna Atlas. Conservation advice provided by the Threatened Species Scientific Committee (2015) appears to suggest that partridge pigeons recorded between the Yinberrie Hills in the south, Litchfield National Park in the west and western Arnhem Land in the east are one subpopulation. It was assessed that a population of the partridge pigeon occurring the survey area would not meet the criteria of an important population as defined in Section 6.2. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of the partridge pigeon.

Reduce the area of occupancy of an important population – As above, the partridge pigeon was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of the partridge pigeon.

Fragment an existing important population into two or more populations - As above, the partridge pigeon was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will fragment an existing important population of the partridge pigeon into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat exists for the partridge pigeon in the survey area for activities such as foraging, breeding, roosting and dispersal. As assessed in Section 3.9, fire has occurred in much of the survey area each year. Frequent, patchy and localised fire is probably advantageous for the partridge pigeon, but more extensive fires are probably disadvantageous (Woinarski, 2006a). Fire frequency is high over much of the survey area (Figure 14), particularly around Mt Bonnie, Iron Blow and the southern two thirds of the Haul Road. Where fire frequency is lower, around Fountain Head, is highly disturbed. This species was recorded in the survey area in 2006, indicating suitable habitat is present for the species, and this is probably related to fire mediated habitat availability. However, given the disturbance regimes in the survey area, habitat is not considered to be habitat critical to the survival of the partridge pigeon as a species and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. As such, the proposal is unlikely to impact the partridge pigeon as a species. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of the partridge pigeon as a species.

Disrupt the breeding cycle of an important population - As above, the partridge pigeon was not assessed as having an important population within the survey area following the definition provided in Section 6.2. Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of the partridge pigeon.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, the partridge pigeon appears to occur from the Yinberrie Hills in the south to Litchfield National Park in the west and western Arnhem Land in the east. Planned and unplanned impacts from the proposal will be restricted to a very localised area relative (154.16 ha, 0.28% of that available in the surrounding area, Table 51, Figure 34) to the species distribution throughout the Top End. Therefore, it is highly unlikely that the proposal will impact the partridge pigeon as a species. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the partridge pigeon as a species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat – Invasive grasses such as mission grass and gamba grass have spread across the Top End in recent decades. These species have led to reduced diversity of native grasses and may change the diversity timing and abundance or seeds available to the partridge pigeon (Woinarski, 2006a). These invasive grasses also alter fire regimes, resulting in higher fuel loads, more intense and frequent fires, and a subsequent change in vegetation structure (Threatened Species Scientific Committee, 2009). Partridge pigeons may also be susceptible to predation by feral cats (Woinarski, 2006a). However, these invasive species are already established in the survey area (see Section 4), and, as such, there is a very low risk that the proposal will result in invasive species that are harmful to the partridge pigeon becoming established in the species' habitat.

Introduce disease that may cause the species to decline – No reports of disease in the partridge pigeon could be found in the scientific literature. Operations associated with the proposal are also not likely to be of a nature to introduce any disease or disease vector likely to impact the partridge pigeon as a species. Therefore, there is a very low risk that the proposal will introduce disease that may cause the species to decline.

Interfere substantially with the recovery of the species - As discussed above, the partridge pigeon appears to occur from the Yinberrie Hills in the south to Litchfield National Park in the west and western Arnhem Land in the east, and the planned and unplanned impacts from the proposal will be restricted to a relatively very localised area. As such, it is highly unlikely that the proposal will impact the partridge pigeon as a species. Therefore, there is a very low risk that impacts for the proposal will interfere substantially with the recovery of the partridge pigeon as a species.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact on the partridge pigeon (Table 56).

Table 56. Summary of the assessment of significant impacts on the partridge pigeon from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very Minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very Minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very Minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very Minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very Minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very Minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very Minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very Minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very Minor	Very low

Masked owl (northern subspecies)

Masked owl (*Tyto novaehollandiae kimberli*) – The masked owl occurs mainly in eucalypt tall open forest, but also roosts in monsoon rainforests and forages in more open vegetation types including grasslands (Woinarski & Ward, 2012). The closest record of this species to the survey areas is 8 km west of Fountain Head. No sign of the species was recorded during the May 2017 survey. Suitable habitat for the species occurs across over 55% of the survey area. The species is thought to primarily roost in tree hollows. Given the history of disturbance across a large amount of the survey area, the presence of trees old enough to host large tree hollows is limited, however they may occur sparsely throughout the survey area. Clearing of the proposed Haul Road may therefore reduce availability of suitable nesting and foraging habitat for the masked owl. However, the vegetation community within the survey area preferred by the masked owl, is abundant both within the locality (Over 55% of survey area) and regionally. With the home range of the species presumed large, estimated at 5-10km^2, it is unlikely that the proposed clearing will significantly impact the species should it occur within the survey area.

The masked owl (northern subspecies) is also listed as vulnerable under the TPWC Act.

Lead to a long-term decrease in the size of an important population – Suitable habitat for the masked owl occurs in the survey area in riparian areas and open forest where tree hollows are present, and in woodland areas where the species may forage (Woinarski & Ward, 2012; Department of the Environment, 2019). The masked owl has been recorded 8 km west of the survey area previously. There is no detailed information on movements for the northern subspecies of the masked owl. However, masked owls of other species occupy large, exclusive home ranges (~5-10 km^2) (Kavanagh

& Murray, 1996). The masked owl occurs across the northern Kimberley region, the Top End extending south to Katherine, and in north-eastern Queensland (Woinarski & Ward, 2012). It was assessed that masked owls occurring in the survey area would not meet the criteria of an important population as defined in Section 6.2. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of the masked owl.

Reduce the area of occupancy of an important population – As above, the masked owl was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of the masked owl.

Fragment an existing important population into two or more populations - As above, the masked owl was not assessed as having an important population within the survey area following the definition provided in Section 6.2. As such, there is a very low risk that the proposal will fragment an existing important population of the masked owl into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat for the masked owl occurs in the survey area in riparian areas and open forest where tree hollows are present, and in woodland areas where the species may forage (Woinarski & Ward, 2012; Department of the Environment, 2019). However, habitat in the survey area is not considered to be habitat critical to the survival of the masked owl as a species and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. As such, the proposal is unlikely to impact the masked owl as a species. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of the masked owl as a species.

Disrupt the breeding cycle of an important population - As above, the masked owl was not assessed as having an important population within the survey area following the definition provided in Section 6.2. Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of the masked owl.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, The masked owl occurs across the northern Kimberley region, the Top End extending south to Katherine, and in north-eastern Queensland (Woinarski & Ward, 2012). Planned and unplanned impacts from the proposal will be restricted to a very localised area relative to the species distribution through the Top End and more broadly. Therefore, it is highly unlikely that the proposal will impact the masked owl as a species. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the masked owl as a species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat – Increased cover and height of vegetation caused by invasion of exotic grasses may reduce foraging efficiency for the masked owl (Woinarski & Ward, 2012). The invasion of exotic grasses may also lead to more intense, frequent and extensive fire that may reduce tree cover and therefore the availability of hollows for roosting and nesting (Threatened Species Scientific Committee, 2009). However, invasive grasses are already established in the survey area. Therefore, there is a very low risk that the proposal will result in invasive species that are harmful to the masked owl becoming established in the species' habitat.

Introduce disease that may cause the species to decline – No reports of disease-causing population declines of masked owls (of any subspecies) could be found in the scientific literature. Operations associated with the proposal are not likely to be of a nature to introduce any disease or disease vector likely to impact the masked owl as a species. Therefore, there is a very low risk that the proposal will introduce disease that may cause the species to decline.

Interfere substantially with the recovery of the species - As discussed above, The masked owl occurs across the northern Kimberley region, the Top End extending south to Katherine, and in north-eastern Queensland, and the planned and unplanned impacts from the proposal will be restricted to a relatively very localised area. As such, it is highly unlikely that the proposal will impact the masked owl as a species. Therefore, there is a very low risk that impacts for the proposal will interfere substantially with the recovery of the masked owl as a species.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact the masked owl (Table 57).

Table 57. Summary of the assessment of significant impacts on the masked owl from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very Minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very Minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very Minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very Minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very Minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very Minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very Minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very Minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very Minor	Very low

Fawn antechinus

Fawn antechinus (*Antechinus bellus*) – Fawn antechinus are typically found in the savannah woodland and tall open forests of the Top End NT (Young, 2012). The nearest record to the survey area is 30 km away, however potentially suitable habitat for the species covers over 50% of the survey area. No sign of the species was recorded during the May 2017 survey. With proposed clearing primarily occurring along the central Haul Road, approximately 32ha of Eucalyptus woodland habitat which is suitable habitat for the species, would be removed as a result of the proposal. Habitat areas extend outside

the survey area within the Hayes Creek Project and Grove Hill locality as well as more broadly in the region. Therefore the proposed clearing of habitat within the survey area should not be such that the species would be at risk of extinction.

Should species occur within the survey area, there may be a risk of local loss of individuals within the proposal footprint, however the species is unlikely to be placed at risk of extinction as a result of the proposal.

Lead to a long-term decrease in the size of an important population – No individuals were captured during the on-ground surveys and therefore an important population of fawn antechinus was not deemed to be occupying the survey area despite targeted surveys. The fawn antechinus is restricted to savannah woodland and tall open forest in the Top End of the Northern Territory (Young, 2012), of which approximately 32 ha will be removed as part of the proposal. Threats to the species includes hot and frequent dry season fires and removal of shelter such as tree hollows and fallen logs (Young, 2012), therefore fire management is important for this species. The closest record to the survey area is 30 km away and the fact that no sign of this species was identified during the on-ground surveys means there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population – The proposal will clear approximately 32 ha of suitable habitat for the fawn antechinus. Despite targeted surveys, no fawn antechinus were trapped during the on-ground surveys therefore there is a very low risk that the proposal will reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations – No information is known about the home range of fawn antechinus but studies on other species of antechinus estimate the home range of females to be between 0.28 ha and 0.38 ha (Marchesan, 2002; Cockburn & Lazenby-Cohen, 1992) and movement by individuals (mostly males) in the mating season has been estimated at between 80 m and 720 m in the breeding season (Marchesan, 2002). Due to their likely small home ranges, limited movement and lack of records in the vicinity of the survey area, there is a very low risk that the proposal will fragment an existing population of fawn antechinus.

Adversely affect habitat critical to the survival of a species - The proposal will clear approximately 32 ha of suitable habitat for the fawn antechinus. This habitat (savannah woodland and tall open forest) is widespread throughout the Top End. Despite targeted surveys, no fawn antechinus were trapped during the on-ground surveys therefore the habitat identified within the survey area is likely to be used by a very small group of individuals, if any, and therefore is a very low risk that the proposal will reduce the area of occupancy of an important population.

Disrupt the breeding cycle of an important population - No individuals were captured during the on-ground surveys and therefore an important population of fawn antechinus was not deemed to be occupying the survey area despite targeted surveys. As such, there is a very low risk that the proposal will

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - The proposal will clear approximately 32 ha of suitable habitat for the fawn antechinus. This habitat (savannah woodland and tall open forest) is widespread throughout the Top End. Despite targeted surveys, no fawn antechinus were trapped during the on-ground surveys

therefore the habitat identified within the survey area is likely to be used by a very small group of individuals, if any, and therefore is a very low risk that the proposal will modify, destroy, remove, isolate or decrease habitat causing the species to decline.

Introduce disease that may cause the species to decline – A potential threat to fawn antechinus is the spread of disease from black rats although no confirmed transmission of any disease from black rats to fawn antechinus has been recorded (Threatened Species Scientific Committee, 2015). As no fawn antechinus were recorded in the survey area it is unlikely that the proposal will have any influence of the introduction of disease to the fawn antechinus and the risk has been assessed as very low.

Interfere substantially with the recovery of the species – No fawn antechinus were identified as occupying the survey area and therefore the proposal has a very low risk of interfering substantially with the recovery of the species.

Table 58. Summary of the assessment of significant impacts on the fawn antechinus from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

Ghost bat

Ghost bat (*Macroderma gigas*) – The distribution of the ghost bat is influenced by the availability of suitable natural caves and mines for roost sites, with one of the largest colonies occurring in gold mine workings at Pine Creek NT (Ward & Milne, 2016). Ghost bats were recorded within the survey area in 1988. A 2007 survey of the North Point mine site for GBS Gold, north-east of the current survey area recorded at least fifteen individuals within a mine adit (Firth, et al., 2007). No sign of the species was recorded in the May 2017 survey. Potentially suitable habitat areas were located in the Mt Bonnie production area around the old pit and waste rock dump however exploration of these sites did not reveal any currently being utilised as roosts. These areas are likely to be affected by development of

the proposal. Any suitable habitat within the survey area would be utilised transiently by ghost bats between breeding times with breeding unlikely to be affected by development activities. Ghost bats are known to move between a number of cave sites seasonally or as dictated by weather conditions (Ward & Milne, 2016). Given the mobility of this species and the proximity to appropriate habitat in adjacent rocky-hill areas and other disturbed mine sites in the locality and the broader region, it is unlikely the development activities within the survey area will significantly impact the species.

Lead to a long-term decrease in the size of an important population – No evidence of current or recent ghost bat roost occupancy was recorded within the survey area during on-ground surveys. No ghost bats were detected using passive or acoustic monitoring or as a result of call playback. Therefore, ghost bats are likely to only use the survey area for occasional foraging, if at all.

Reduce the area of occupancy of an important population – Ghost bats were not recorded as occupying the survey area and therefore there is a very low risk that the proposal will reduce the area of occupancy of an important population of ghost bats.

Fragment an existing important population into two or more populations Ghost bats were not recorded within the survey area and there was no evidence of recent occupancy in roosting habitat in the Mt Bonnie area. The closest known significant colonies are located at Spring Hill (Northern Resource Consultants, 2018), within 20 km of Mt Bonnie, and Dorat Road, under 40 km from Mt Bonnie (N. Hanrahan, unpublished data). Ghost bats, mostly males and non-reproductive females, are known to disperse over 100 km in the dry season (Toop, 1985). The presence of sandstone outcrop and abandoned subterranean mines in the surrounding region makes it unlikely that the removal of the roost habitat identified in the survey area would restrict movement of ghost bats between nearby stronghold colonies. Therefore, there is a very low risk that the proposal will fragment an existing population of ghost bats.

Adversely affect habitat critical to the survival of a species – Ghost bats were not recorded occupying or using the survey area during the May 2017 or August 2019 surveys. A small number of ghost bats were recorded at the North Point mine in 2007 (Firth, et al., 2007), north-east of Iron Blow and Mt Bonnie production areas. Although recent occupation is unknown it is feasible that a small number of ghost bats may forage within the survey area or in the surrounding hills. As the proposal will not affect roosting habitat used by ghost bats the risk of affecting habitat critical to the survival of the species is very low.

Disrupt the breeding cycle of an important population – Ghost bats congregate in maternity roosts from March to May in order to mate (Churchill, 2008). These roosts require optimal temperature and humidity conditions in which to give birth and raise pups (Churchill, 2008). No evidence of recent occupancy was detected in the May 2017 or August 2019 surveys indicating that the roost habitat identified in the Mt Bonnie area is not used as an important breeding roost. Thus, there is a very low risk that the breeding cycle of an important ghost bat population will be disrupted.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline – The roosting habitat found on site is sub-optimal and not recorded to be used by ghost bats. While the open woodland habitat in the survey area and surrounding areas may be used occasionally by foraging ghost bats, there is a very low risk that the proposal will modify, destroy, remove or decrease habitat causing the species to decline.

Introduce disease that may cause the species to decline – A herpes-like disease was suspected be effecting the Mt Etna colony of ghost bats (Threatened Species Scientific Committee, 2016) but no further investigation into the cause of the skin issue was conducted (pers. comm J. Augusteyn). There is a very low risk that the proposal would cause the introduction of disease to ghost bat in the region.

Interfere substantially with the recovery of the species – Ghost bats were not recorded as occupying the survey area and therefore there is a very low risk that the proposal will interfere substantially with the recovery of the ghost bat.

Table 59. Summary of the assessment of significant impacts on the ghost bat from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

Northern brush-tailed phascogale

Northern brush-tailed phascogale (*Phascogale pirata*) – Little is known about the ecology of northern brush-tailed phascogale, but most records are from tall open forest dominated by *E. miniata* and *E. tertodonta* (Woinarski & Ward, 2012b). The closest record of this species to the survey areas is 5 km east of survey area at Yam Creek however this record is dated back to pre 1971. No sign of the species was recorded during the May 2017 survey. Whilst there are no recent records of the species near the survey area, suitable habitat occurs across over more than 50% of the survey area and we therefore assume that clearing of this habitat area along the Haul Road has potential to reduce the area of occupancy of the species. However, as development is primarily limited to areas already disturbed by historical mining activity, proposed habitat that will be affected by clearing is only 5.58% of the total intact habitat available within the locality. Clearing of habitat areas is unlikely to result in a decrease in habitat to the extent that the species is likely to decline and should not lead to a long-term decrease in the size of the population. Given the abundance of available habitat adjacent to proposed clearing and in the broader locality, proposed clearing is unlikely to significantly impact the species should it occur within the survey area.

Lead to a long-term decrease in the size of an important population – No evidence of occupancy of the survey area by northern brush-tailed phascogales was recorded during the on-ground surveys and therefore is not considered to support an important population. Northern brush-tailed phascogales are restricted to the Top End and require tall open forests of *Eucalyptus miniata* and *Eucalyptus tintinnans*. This habitat is found across approximately 50% of the survey area. Despite this, the lack of records since 1971 and recent records restricted to Kakadu and Litchfield National Park areas suggest that the species is not present in the area. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of northern brush-tailed phascogales.

Reduce the area of occupancy of an important population – No evidence of occupancy of the survey area by northern brush-tailed phascogales was recorded during the on-ground surveys and therefore is not considered to support an important population. The habitat that this species utilises is widespread throughout the Top End and therefore there is a very low risk that the proposal will reduce the occupancy of an important population.

Fragment an existing important population into two or more populations - No evidence of occupancy of the survey area by northern brush-tailed phascogales was recorded during the on-ground surveys and therefore is not considered to support an important population. Therefore, there is a very low risk that the proposal will fragment an existing population.

Adversely affect habitat critical to the survival of a species – The proposal will clear approximately 32 ha of suitable habitat for the northern Brush-tail phascogale. Recent records of this species are restricted to clusters in the vicinity of Litchfield National Park and Kakadu National Park and therefore the species is unlikely to be residing in the region surrounding the survey area. In addition, this habitat is widespread throughout the Top End and therefore the proposal has a very low risk of adversely affecting habitat critical to the northern brush-tailed phascogale.

Disrupt the breeding cycle of an important population - No evidence of occupancy of the survey area by northern brush-tailed phascogales was recorded during the on-ground surveys and therefore is not considered to support an important population. Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of northern brush-tailed phascogales.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - The proposal will clear approximately 32 ha of suitable habitat for the northern Brush-tail phascogale. Recent records of this species are restricted to clusters in the vicinity of Litchfield National Park and Kakadu National Park and therefore the species is unlikely to be residing in the region surrounding the survey area. In addition, suitable habitat is widespread throughout the Top End and therefore the proposal has a very low risk of modifying, destroying, removing, isolating or decreasing the availability or quality of habitat to the extent that the species is likely to decline.

Introduce disease that may cause the species to decline – Woinarski and Ward (2012b) suggest that the decline of northern brush-tailed phascogales prior to the arrival of cane toads indicates another reason such as predation by cats or a disease. No further information is provided as to what this disease may be. The lack of records in and surrounding the survey area indicate that the proposal would have a very low risk or introducing any disease to northern brush-tailed phascogales that would result in a decline in the species.

Interfere substantially with the recovery of the species - No evidence of occupancy of the survey area by northern brush-tailed phascogales was recorded during the on-ground surveys and therefore is not considered to support an important population. Therefore, there is a very low risk that the proposal will interfere substantially with the recovery of the species.

Table 60. Summary of the assessment of significant impacts on the northern brush-tailed phascogale from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

6.7 Impacts on Fauna Species of NT Significance

6.7.1 Vulnerable Fauna

The following fauna are listed as vulnerable under the TPWC Act and were either recorded or have a moderate or high likelihood of occurring within the proposal area:

- Pale field rat (*Rattus tunneyi*);
- Mertens water monitor (*Varanus mertensi*);
- Mitchell's water monitor (*Varanus mitchelli*); and
- Floodplain monitor (*Varanus panoptes*)

Pale field rat

As the pale field rat is listed as vulnerable under the TPWC Act, assessments to determine the risk of significant impact from the proposal were undertaken using the assessment criteria for vulnerable species (see Section 6.2).

Lead to a long-term decrease in the size of an important population – The pale field rat was not assessed as having an important population within the survey area following the definition provided

in the *Matters of National Environmental Significance: Significant impact guidelines 1.1* ((Department of the Environment, 2013)). Based on the known records of the pale field rat in the region surrounding the survey area and more broadly (Department of Environment and Natural Resources, 2019; Atlas of Living Australia, 2019), and known aspects of their ecology and decline (Young & Hill, 2012; Woinarski, 2000), it is unlikely that a population in the survey area is a key source population for breeding or dispersal, a population that is necessary for maintaining genetic diversity, or a population near the limit of the species range. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of the pale field rat.

Reduce the area of occupancy of an important population – As above, the pale field rat was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of the pale field rat.

Fragment an existing important population into two or more populations - As above, the pale field rat was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will fragment an existing important population of the pale field rat into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat exists for the pale field rat in the survey area (dense vegetation along watercourses) for activities such as foraging, breeding, roosting and dispersal. However, this habitat is not considered to be habitat critical to the survival of the species in its entirety and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. The pale field rat occurs more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland (Atlas of Living Australia, 2019), and the planned and unplanned impacts from the proposal will be restricted to the local area. As such, the proposal is unlikely to impact the species in its entirety. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of the pale field rat.

Disrupt the breeding cycle of an important population - As above, the pale field rat was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of the pale field rat.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, the pale field rat occurs more broadly across the Top End of the NT and into northern WA and Queensland (Atlas of Living Australia, 2019), and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in its entirety. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the pale field rat is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat – There has been no clear cause found for the decline of the pale field rat in the NT. However, predation by feral cats has probably played a role (Young & Hill, 2012; Woinarski, 2000). While the proposal may lead to an increase in feral cat activity through increased provision of resources such as water and food waste (Algar, et al., 2011), the feral cat is already well established

in the survey area and across Australia in general. There are no other invasive species reported in the literature to threaten the pale field rat. Therefore, there is a very low risk that the proposal will result in species that are harmful to these varanid species becoming established the habitat of the pale field rat.

Introduce disease that may cause the species to decline – A study of the mammal declines in Kakadu National Park, Woinarski, et al. (2010) notes the spread of the black rat (*Rattus rattus*) across the monsoonal tropics of the NT (which includes the survey area) and the potential for transmission of disease and parasites to native rodents. While diseases transmitted by black rats can cause population declines in other rodents, this has not been confirmed and does not appear to be the case in northern Australia (Barbosa, et al., 2017; Wyatt, et al., 2008; Ziembicki, et al., 2015). Given that the black rat, a known vector of diseases that can be transmitted to native rodents, has already spread across the Top End, the likelihood that the proposal will lead to the introduction a disease, or the vector of a disease that is detrimental to the pale field rat as a species is highly unlikely. Therefore, there is a very low risk that the proposal will introduce a disease that may cause the pale field rat to decline.

Interfere substantially with the recovery of the species - As discussed above, the pale field rat occurs more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in its entirety. Therefore, there is a very low risk that impacts for the proposal will interfere substantially with the recovery of the pale field rat.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact the pale field rat (Table 61).

Table 61. Summary of the assessment of significant impacts on the pale field rat from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low

Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

Merten's water monitor and Mitchell's water monitor

Merten's water monitor and Mitchell's water monitor were included in the same assessment of significant impact as the two species are often sympatric and have similar habitat requirements (Shine, 1986). As Merten's water monitor and Mitchell's water monitor are both listed as vulnerable under the TPWC Act, assessments to determine the risk of significant impact from the proposal were undertaken using the assessment criteria for vulnerable species (see Section 6.2).

Lead to a long-term decrease in the size of an important population - Neither Merten's water monitor nor Mitchell's water monitor were assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). Based on the known records of Merten's water monitor and Mitchell's water monitor in the region surrounding the survey area and more broadly, and known aspects of their ecology, it is unlikely that a population in the survey area is a key source population for breeding or dispersal, a population that is necessary for maintaining genetic diversity, or a population near the limit of the species range. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of Merten's water monitor or Mitchell's water monitor.

Reduce the area of occupancy of an important population – As above, neither Merten's water monitor nor Mitchell's water monitor were assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of Merten's water monitor or Mitchell's water monitor.

Fragment an existing important population into two or more populations - As above, neither Merten's water monitor nor Mitchell's water monitor were assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will fragment an existing important population of Merten's water monitor or Mitchell's water monitor into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat exists for Merten's water monitor and Mitchell's water monitor in the survey area (pit lakes and tailings dams, and watercourses) for activities such as foraging, breeding, roosting and dispersal. However, this habitat is not considered to be habitat critical to the survival of either species in their entirety and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. Merten's water monitor and Mitchell's water monitor occur more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to the local area. As such, the proposal is unlikely to impact either species in their entirety. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of Merten's water monitor and Mitchell's water monitor.

Disrupt the breeding cycle of an important population - As above, neither Merten's water monitor nor Mitchell's water monitor were assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). Therefore, there is a very

low risk that the proposal will disrupt the breeding cycle of an important population of Merten's water monitor or Mitchell's water monitor.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, Merten's water monitor and Mitchell's water monitor occur more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in their entirety. Therefore, there is a very low risk that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that either species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat - Cane toads are the most acute threat facing Merten's water monitor and Mitchell's water monitor (Griffiths & McKay, 2007; Doody, et al., 2009) (Ward et al. 2006 and other NT factsheets). While any increases in available surface water into the dry season resulting from the proposal may provide additional breeding areas for cane toads, and they may be attracted to artificial lighting around the production areas (Meshaka, et al., 2006; Yeagar, et al., 2014), this invasive species is already established and ubiquitous throughout the survey area. There are no other invasive species reported in the literature to threaten Merten's water monitor and Mitchell's water monitor. Therefore, there is a very low risk that the proposal will result in invasive species that are harmful to a vulnerable species becoming established in Merten's water monitor or Mitchell's water monitor habitat.

Introduce disease that may cause the species to decline - No reported incidences attributing disease to population declines in varanids resulted from a search of the scientific literature, and as such there is a very low risk that the proposal will lead to the introduction of disease that may cause Merten's water monitor or Mitchell's water monitor to decline.

Interfere substantially with the recovery of the species - As discussed above, Merten's water monitor and Mitchell's water monitor occur more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in their entirety. Therefore, there is a very low risk that impacts for the proposal will interfere substantially with the recovery of Merten's water monitor or Mitchell's water monitor.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact on Merten's water monitor and Mitchell's water monitor (Table 62).

Table 62. Summary of the assessment of significant impacts on Merten's water monitor and Mitchell's water monitor from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

Floodplain monitor

As the floodplain monitor is listed as vulnerable under the TPWC Act, assessments to determine the risk of significant impact from the proposal were undertaken using the assessment criteria for vulnerable species (see Section 6.2).

Lead to a long-term decrease in the size of an important population – The floodplain monitor was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). Based on the known records of the floodplain monitor in the region surrounding the survey area and more broadly, and known aspects of the species ecology, it is unlikely that a population in the survey area is a key source population for breeding or dispersal, a population that is necessary for maintaining genetic diversity, or a population near the limit of the species range. Therefore, there is a very low risk that the proposal will lead to a long-term decrease in the size of an important population of the floodplain monitor.

Reduce the area of occupancy of an important population – As above, the floodplain monitor was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will reduce the area of occupancy of an important population of the floodplain monitor.

Fragment an existing important population into two or more populations - As above, the floodplain monitor was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). As such, there is a very low risk that the proposal will fragment an existing important population of the floodplain monitor into two or more populations.

Adversely affect habitat critical to the survival of a species - Suitable habitat exists for the floodplain monitor in the survey area (floodplains, grasslands and woodlands) for activities such as foraging, breeding, roosting and dispersal. However, this habitat is not considered to be habitat critical to the survival of the species in its entirety and is not considered to be important for the long-term maintenance of the species, to maintain genetic diversity or for the reintroduction of populations or recovery of the species. The floodplain monitor occurs more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to the local area. As such, the proposal is unlikely to impact the species in its entirety. Therefore, there is a very low likelihood that the proposal will adversely affect habitat critical to the survival of the floodplain monitor.

Disrupt the breeding cycle of an important population - As above, the floodplain monitor was not assessed as having an important population within the survey area following the definition provided in Department of the Environment (2013). Therefore, there is a very low risk that the proposal will disrupt the breeding cycle of an important population of the floodplain monitor.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline - As discussed above, the floodplain monitor occurs more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in its entirety. Therefore, there is a very low risk that the proposal will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the floodplain monitor is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat - Cane toads are the most acute threat facing the floodplain monitor (Doody, et al., 2009). While any increases in available surface water into the dry season resulting from the proposal may provide additional breeding areas for cane toads, and they may be attracted to artificial lighting around the production areas (Meshaka, et al., 2006; Yeagar, et al., 2014) , this invasive species is already established and ubiquitous throughout the survey area. There are no other invasive species reported in the literature to threaten the floodplain monitor. Therefore, there is a very low risk that the proposal will result in species that are harmful to these varanid species becoming established the habitat of the floodplain monitor.

Introduce disease that may cause the species to decline - No reported incidences attributing disease to population declines in varanids resulted from a search of the scientific literature, and as such there is a very low risk that the proposal will lead to the introduction of disease that may cause the floodplain monitor to decline.

Interfere substantially with the recovery of the species - As discussed above, Merten's water monitor and Mitchell's water monitor occur more broadly across the Top End of the NT and into northern Western Australia (WA) and Queensland, and the planned and unplanned impacts from the proposal will be restricted to a more localised area, it is highly unlikely that the proposal will impact the species in their entirety. Therefore, there is a very low risk that any impacts from the proposal will interfere substantially with the recovery of the floodplain monitor.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact on the floodplain monitor (Table 63).

Table 63. Summary of the assessment of significant impacts on the floodplain monitor from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Very minor	Very low
Reduce the area of occupancy of an important population	Unlikely	Very minor	Very low
Fragment an existing important population into two or more populations	Unlikely	Very minor	Very low
Adversely affect habitat critical to the survival of a species	Unlikely	Very minor	Very low
Disrupt the breeding cycle of an important population	Unlikely	Very minor	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Very minor	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Very minor	Very low
Introduce disease that may cause the species to decline	Unlikely	Very minor	Very low
Interfere substantially with the recovery of the species	Unlikely	Very minor	Very low

6.8 Impacts on Migratory Fauna

The assessment of significant impacts on species listed as Migratory and Marine under the EPBC Act recorded or with a moderate to high likelihood of occurring in the proposal area is presented as one assessment below. This is due to the commonalities between assessments of the species. Species assessed include:

- Common sandpiper
- Fork-tailed swift;
- Sharp-tailed sandpiper;
- Pectoral sandpiper;
- Red-rumped swallow;
- Oriental plover;
- Oriental cuckoo;
- Oriental pratincole;
- Barn swallow;
- Grey wagtail;
- Yellow wagtail;
- Little curlew;
- Glossy ibis; and
- Common greenshank.

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species –

The common sandpiper inhabits coastal wetlands and some inland wetlands when in Australia and is mostly found around muddy margins or rocky shores (Department of the Environment, 2019). In the Northern Territory, Kakadu National Park and the Darwin area are areas of national importance (Department of the Environment, 2019). These areas are >100 km from the survey area. These habitats are present within the survey area, but also common in the broader landscape. While there may be habitat in the survey area that the common sandpiper may use transiently, there is unlikely to be important habitat for the species.

The fork-tailed swift is widespread and occurs in a wide variety of habitats (Department of the Environment, 2019). While there may be habitat in the survey area that the fork-tailed swift may use transiently, there is unlikely to be important habitat for the species.

In Australia, the sharp-tailed sandpiper prefers edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation (Department of the Environment, 2019).There are three important sites for the sharp-tailed sandpiper in the NT; Kakadu National Park, Chambers Bay and Port McArthur (Department of the Environment, 2019). None of these sites encompasses or is in the vicinity of the survey area. While there may be habitat in the survey area that the sharp-tailed sandpiper may use transiently, there is unlikely to be important habitat for the species.

The pectoral sandpiper is predominantly found in shallow fresh to saline wetlands in Australia (Department of the Environment, 2019). It is usually found in coastal or subcoastal habitats but is occasionally recorded inland (Department of the Environment, 2019). Kakadu National Park is the only site in the NT that is listed as a key site for migratory shorebirds (Department of the Environment, 2019). While there may be habitat in the survey area that the pectoral sandpiper may use transiently, there is unlikely to be important habitat for the species.

The red-rumped swallow occurs mostly in the air above wetlands or above open areas, and often perch on overhead wires or occasionally on shrubs (Higgins, et al., 2006). While it is a regular visitor to Australia, the red-rumped swallow appears to visit only in small numbers around coastal areas (Higgins, et al., 2006). While there may be habitat in the survey area that the red-rumped swallow may use transiently, there is unlikely to be important habitat for the species.

In Australia, oriental plovers spend a few weeks in coastal habitats before dispersing inland (Department of the Environment, 2019). When inland they usually inhabit flat, open, semi-arid or arid grasslands (Department of the Environment, 2019). One internationally important site has been identified in the NT; Lake Sylvester on the Barkly Tablelands, which is approximately 725 km from the survey area (Department of the Environment, 2019). While there may be habitat in the survey area that the oriental plover may use transiently, there is unlikely to be important habitat for the species.

The oriental cuckoo uses a wide range of dense to open woodland and forest, especially the edges of riparian forest (Menkhorst, et al., 2017). These habitats are widespread throughout northern Australia. While there may be habitat in the survey area that the oriental cuckoo may use, there is unlikely to be important habitat for the species.

In Australia, the oriental pratincole usually inhabits open plains, floodplains or short grasslands, often near terrestrial wetlands or along the coast (Department of the Environment, 2019). Three sites have been identified as internationally and nationally important sites in the NT; Lake De Burg, Lake Woods and Lake Sylvester in the Barkly region. These lakes are between approximately 500 km and 725 km from the survey area. There is limited open plain habitat in the survey area. While there may be habitat in the survey area that the oriental pratincole may use transiently, there is unlikely to be important habitat for the species.

In Australia, the barn swallow inhabits open country in coastal lowlands, often near water, towns and cities (Department of the Environment, 2019). The barn swallow is a regular visitor in small numbers to northern Australia, where it is predominantly recorded around Darwin (Higgins, et al., 2006). While there may be habitat in the survey area that the barn swallow may use transiently, there is unlikely to be important habitat for the species.

In Australia, the grey wagtail has a strong association with water, especially creeks, rivers and waterfalls (Higgins, et al., 2006). The grey wagtail is a scarce but regular visitor to Australia (Higgins, et al., 2006). Preferred habitats are present within the Survey Area but are also common in the broader landscape. While there may be habitat in the survey area that the grey wagtail may use transiently, there is unlikely to be important habitat for the species.

In Australia, the yellow wagtail inhabits a variety of moist, muddy or grassy habitats (Higgins, et al., 2006). The yellow wagtail is a regular summer visitor to the western Top End, with most records from around Darwin, and vagrant elsewhere (Higgins, et al., 2006). These habitats are present within the

survey area, but also common in the broader landscape. While there may be habitat in the survey area that the yellow wagtail may use transiently, there is unlikely to be important habitat for the species.

In the NT, two sites, Kakadu National Park and Lake Finniss are sites of international importance for the little curlew (Department of the Environment, 2019). Both are >100 km from the survey area. Little curlews feed in short, dry grassland and sedgeland that have scattered, shallow freshwater pools or seasonally inundated areas (Department of the Environment, 2019). The species prefers pools with bare, dry mud and don't use pools if they are totally dry, flooded or heavily vegetated (Department of the Environment, 2019). These habitats are present within the survey area, but also common in the broader landscape. While there may be habitat in the survey area that the little curlew will use transiently, it is unlikely that there is important habitat for the species.

The glossy ibis inhabits freshwater marshes and is occasionally found in coastal locations (Department of the Environment, 2019). Areas of prime habitat are the inland and northern floodplains, particularly in drying Top End grass/sedge swamps and Channel Country grass/forb meadows (Department of the Environment, 2019). Breeding in the NT has been mostly recorded in the lower Keep River (Department of the Environment, 2019). These habitats are present within the survey area, but also common in the broader landscape. While there may be suitable habitat for the glossy ibis in the survey area during some times of the year, it is unlikely that there is important habitat for the species.

The common greenshank has been recorded sparsely through most of the NT (Department of the Environment, 2019). No sites of internationally or national importance have been identified in the NT; however, Kakadu National Park is listed as a key site for migratory shorebirds in general (Department of the Environment, 2019). The common greenshank is found in a variety of inland wetlands and sheltered coastal habitats, using both ephemeral and permanent water sources (Department of the Environment, 2019). These habitats are present within the survey area, but also common in the broader landscape. While there may be suitable habitat for the common greenshank in the survey area, there is unlikely to be important habitat for the species.

As it is unlikely that there is important habitat for any of the above migratory species in the survey area there is a very low risk that the proposal could substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species – As it is unlikely that there is important habitat for any of the above migratory species in the survey area there is a very low risk that the proposal could result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for these migratory species.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species – As habitats potentially used by the migratory species in the survey area are not identified as important habitats, and are widespread in the region surround the survey area, there is a very low risk that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of these migratory species. Additionally, many of these species are non-breeding migrants in Australia.

Given the information provided above and the more detailed risk assessment table provided in Appendix 11, there is a very low risk that the proposal will have a significant impact on the common danpiper, fork-tailed swift, sharp-tailed sandpiper, pectoral sandpiper, red-rumped swallow, oriental plover, oriental cuckoo, oriental pratincole, barn swallow, grey wagtail, yellow wagtail, little curlew, glossy ibis or common greenshank (Table 65).

Table 64. Summary of the assessment of significant impacts on the curlew sandpiper from sources of impact identified from the proposal. A detailed assessment of the risk of significant impacts is provided in Appendix 11.

Consequence	Likelihood	Severity	Maximum level of risk
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	Unlikely	Very minor	Very low
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species	Unlikely	Very minor	Very low
Seriously disrupt the lifecycle (breeding, feeding, migrating or resting behaviour) of an ecologically significant proportion of the population	Unlikely	Very minor	Very low

7 MANAGEMENT AND MITIGATION

Of the 13 threatened and 14 migratory species identified having a moderate or high residual likelihood of occurrence in the proposal area, the Gouldian finch was assessed as having a real chance or possibility or being significantly impacted by the proposal and *A. praetermissa* was assessed as having a real chance or possibility of being impacted by the proposal should it be found to occur in the survey area. The Gouldian finch is the only species for which mitigation and monitoring measures are recommended separately (see Section 7.1). Mitigation and monitoring measures will be developed for *A. praetermissa* should it be found to occur in the survey area by mine staff. Mitigation and monitoring measures for other species of national or NT significance are covered under the general mitigation measures to limit impacts to flora and fauna (see Section 7.2).

The mitigation hierarchy was observed when developing mitigation measures for each identified risk from each potential source of impact. In line with *A cross-sector guide for implementing the Mitigation Hierarchy* (The Biodiversity Consultancy, 2015). The Biodiversity Consultancy (2015) define the sequence of four key actions in the mitigation hierarchy as:

1) Avoidance - measures taken to anticipate and prevent adverse impacts on biodiversity before actions or decisions are taken that could lead to such impacts
2) Minimisation – measures taken to reduce the duration, intensity, significance and/or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible
3) Restoration – measures taken to repair degradation or damage to specific biodiversity feature and ecosystem services of concern (which might be species, ecosystems/habitats or ecosystem services) following project impacts that cannot be completely avoided and/or minimised
4) Offset – measurable conservation outcomes, resulting from actions applied to areas not impacted by the project, that compensate for significant, adverse impacts of a project that cannot be avoided, minimised and/or restored.

7.1 Mitigation and Monitoring Measures for the Gouldian finch

Recommended mitigation and monitoring measures are provided in Table 65 to mitigate the impacts from the proposal to the Gouldian finch with risk levels of medium to extreme (Section 6.6.2). The mitigation and monitoring measures outlined in Table 65 are only relevant to the Mt Bonnie and Iron Blow production areas and the haul road between and in the vicinity of these production areas i.e. the Hayes Creek Project only. This table is not relevant for the Fountain Head project area. Following the collection of more detailed data on the Gouldian finch population, it is recommended that a Gouldian finch monitoring program is developed.

Table 65. Recommended measures to mitigate impacts to the Gouldian finch (*Erythrura gouldiae*) from the potential sources of impact identified in Section 6.4, recommendations for monitoring, threshold criteria and a residual level of the risk of impact

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
Vegetation clearing and habitat disturbance	Lead to a long-term decrease in the size of a population	High	- Location of proposal in previously disturbed areas as far as practicable - Implement and adhere to a system of approval for vegetation clearing - Avoid clearing of mature hollow bearing trees (15 cm DBH), of which *Eucalyptus tintinnans* is the most predominant, where practically feasible - Site walkover prior to clearing by experienced personnel to prevent direct mortality of Gouldian finches from vegetation clearing - Vegetation clearing to be undertaken outside of breeding season where practically feasible (February to October)	- Biennial monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal - Maintain a fauna sighting register during all phases of the proposal - Record the area and type of vegetation being cleared	Medium
	Reduce the area of occupancy of the species	High			Medium
	Fragment an existing population into two or more populations	High			Medium
	Disrupt the breeding cycle of a population	Medium			Low
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	High			Medium

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
Surface water quality and quantity	Lead to a long-term decrease in the size of a population	Medium	- Storage of fuels and chemicals in bunded areas in accordance with Australian Standards - Process plant designed with concrete bunds and sumps to collect and return any spills internally - Oil separator washdown bays to remove oil from wastewater - Placement and long-term storage of tailings under a permanent water cover following mining at the Mt Bonnie pit - Treatment of water above tailings if required at the completion of processing - Maintenance of barriers to discharge of contaminated water into the environment - Cover contaminated surface water with bird balls or netting where practically feasible - Limit exposed cyanide or other toxicant bearing solutions in collection trenches with the use of pipes, netting, gravel or other material (Donato et al. 2017)	- Monitoring surface water levels, particularly of natural small pools of water preferred by Gouldian finches - Maintenance of chemical spills register - Monitoring of barriers to prevent discharge of contaminated water into the environment - Monitoring of water quality in dams and small pools of water preferred by Gouldian finches - Biennial monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
	Reduce the area of occupancy of the species	Medium			Low
	Fragment an existing population into two or more populations	Medium			Low
	Disrupt the breeding cycle of a population	Medium			Low
Groundwater quality and quantity	Lead to a long-term decrease in the size of a population	Medium	- Identify and adhere to acceptable extraction rates through modelling of dewatering rates - Placement of PAF waste and tailings under permanent water cover	- Monitor response of surface water availability to groundwater extraction, particularly pools that are likely to be fed by groundwater	Low
	Reduce the area of occupancy of the species	Medium			Low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
	Fragment an existing population into two or more populations	Medium	following cessation of mining at Mt Bonnie - Construction of lined run-off ponds	- Monitoring of water quality in small pools of water that are likely to be fed by groundwater - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Very low
	Disrupt the breeding cycle of a population	Medium			Low
Erosion and sedimentation	Lead to a long-term decrease in the size of a population	Medium	- Avoid clearing of areas with a native grass understorey where practically feasible - Vegetation clearing and disturbance kept to the minimum require for operations to occur - Erosion control measures, such as diversion banks implemented - "Blade-up" clearing implemented where possible to maintain a layer of vegetation 10 cm above ground to lower loss of soil integrity - Progressively rehabilitate areas as activities cease - Separation of clean from mine impacted water - Construction of sediment ponds, as a control and collection measure to manage run-off - Develop and implement surface water management plan - Monitor levels of sediment in sediment traps, ponds and areas	- Regular inspection of erosion control measures to ensure integrity - Monitoring of areas where erosion risk has been identified - Monitoring of sedimentation in surface water pools preferred by Gouldian finches - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
	Reduce the area of occupancy of the species	Medium			Low
	Disrupt the breeding cycle of a population	Medium			Low
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Medium			Low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
			holding surface water. Excavation may be required		
Invasion or increases in populations of weeds or pest animals	Lead to a long-term decrease in the size of a population	Medium	- Develop and implement Weed Management Plan, including weed identification guides with photos for common weeds on-site and register for reporting any sightings of weeds or potential weeds - Inspection and wash-down of all vehicles, machinery and equipment that enters the proposal area - Inspection and wash-down of all vehicles, machinery and equipment that travel from an area within the proposal area where a weed infestation occurs into an area where it does not - Keep vegetation clearing and disturbance to the minimum required for construction - Minimise the time between vegetation being cleared and the area being used for proposal requirements - Implementation of accepted weed control measures where weeds	- Monitor new and existing infestations of invasive grasses - Personnel to report any new or increasing weed infestations - Undertake annual weed monitoring and mapping in the proposal area. - Undertake monitoring in the vicinity of the proposal area as a pro-active measure to predict and prevent potential new weed infestations - Monitoring and reporting in line with the Weed Management Plan - Record predator and pest animal populations in the proposal area, particularly around potential water and food sources - Record-keeping of control measures used to control predators and pest animals	Low
	Reduce the area of occupancy of the species	Medium			Low
	Disrupt the breeding cycle of a population	High			Low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Medium	have established in areas previously identified as being weed free. Obtain expert advice from the NT Government Weeds Branch or a qualified ecologist - Regular monitoring and weed control where the density of weeds is increasing - Control of weed populations on any topsoil stockpiles - Remove weeds prior to seeding where practically feasible - Rehabilitation of disturbed areas as soon as possible, and prior to the subsequent wet season, to minimise the likelihood of weeds becoming established - Develop a no tolerance policy to the introduction of weeds and pest animals by contractors, suppliers and personnel - Fencing to prevent pest species access to the production areas - Fencing to prevent pest species access to potential water sources - Control of new and existing feral pest populations	- Record-keeping of numbers of predators and pest animals controlled - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
Altered fire regimes	Lead to a long-term decrease in the size of a population	High	- Develop and implement a Bushfire Management Plan - PNX should consult with Ban Ban Springs where possible to ensure burn regimes are suitable for maintaining Gouldian finch habitat	- Recording of unplanned wildfire occurring in the proposal area - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, including	Medium
	Reduce the area of occupancy of the species	Medium			Low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
	Fragment an existing population into two or more populations	High	i.e. maximise the occurrence of food plants for Gouldian finches, while minimising loss of hollow-bearing trees and preventing the occurrence of widespread and intense wildfire - Daily checking of bushfire alerts and weather conditions - No flames outside of designated areas unless hot works permit is approved - Firefighting equipment present on-site, readily accessible and appropriate to potential sources of ignition present on-site - Smoking only permitted in designated smoking areas - Minimise additional sources of ignition (e.g. turn off vehicles when not driving, don't park vehicles over dry grass)	recording the response of the population to fire regimes experience in the survey area	Medium
	Disrupt the breeding cycle of a population	High			Medium
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	High			Medium
Vehicle collision	Lead to a long-term decrease in the size of a population	Medium	- Develop and implement a traffic/vehicle management plan and induct all staff in accordance with the plan - Implement speed restrictions in areas of known Gouldian Finch activity where identified during the monitoring program - Prohibit off-road driving from non designated routes	- Monitor adherence to vehicle speed limits - Records of fauna injured or killed by vehicle strike to be maintained in a fauna sighting register	Low
	Disrupt the breeding cycle of a population	Medium			Very low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
Increased artificial light	Lead to a long-term decrease in the size of a population	Medium	- Implement minimum lighting requirements required for safe operation - Angle lighting towards the ground where possible to minimise light pollution outside of the proposal area	- Record any sightings of Gouldian finches near artificial light sources and their behaviour - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
Increased vibration	Lead to a long-term decrease in the size of a population	Medium	- Vehicles and equipment creating vibrations to be turned off when not in use - Operations producing vibrations to be kept to the minimum required for operations to occur	- Record timing of blasting where practically feasible - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
Increased noise	Lead to a long-term decrease in the size of a population	Medium	- Vehicles and equipment creating noise to be turned off when not in use - Noise reduction measures implemented on machinery where available and practically feasible - Operations producing loud noises to be kept to the minimum required for operations to occur - Conduct noise assessment	- Record any observed behavioural response of Gouldian finches to elevated noise levels - Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low

Potential source of impact	Risk	Initial level of risk	Mitigation measure	Monitoring	Residual level of risk
Increased dust emissions	Increased dust emissions	Medium	- Sustainable use of water to control dust emissions along the Haul Road an in-production areas - Implement speed limits to minimise dust creation - Enclosing or use of water spray on conveyors and conveyor transfer points - Conduct air quality assessment - Implement automatic water spray at the dump hopper - Use of covered/containerised transport to move product if dust generated from loads - Progressive rehabilitation of the WRS - Progressive rehabilitation of production areas as mining and operations cease - Minimise area of vegetation to be cleared - Minimise areas exposed to wind erosion	- Annual monitoring program for Gouldian finches in line with recommended guidelines for the survey of this species, with a focus on monitoring of potential impacts from the proposal	Low
	Result in invasive species that are harmful to the endangered species becoming established in the endangered species' habitat	Medium			Very low

7.2 General Mitigation Measures to Limit Impacts to Flora and Fauna

More general recommended measures to mitigate and monitor impacts to flora and fauna are provided in Table 66. These measures can be applied to reduce the impacts on threatened flora and fauna, or migratory fauna assessed as not meeting the significant impact criteria as discussed in Section 6. These measures are relevant to the Hayes Creek project and the Fountain Head project and can also be applied to the flora, fauna and natural environment of the survey area in general.

Table 66. Recommended mitigation measures for risks of impact from the potential sources of impact identified in Section 6.4, recommendations for monitoring, threshold criteria and a residual level of the risk of impact

Potential source of impact	Risk	Mitigation measure	Monitoring
Vegetation clearing and habitat disturbance	Reduced species abundance through direct mortality of flora and fauna	- Location of proposal in previously disturbed areas where practicable - Implement and adhere to a system of approval for vegetation clearing - Minimise the area of direct land clearing, especially in areas sensitive to disturbance such as along the Margaret River - Training of environmental staff to recognise *A. praetermissa* and S. ensatum. - Site walkover prior to clearing by experienced personnel to prevent direct mortality of fauna and ensure *A. praetermissa* and *S. ensatum* are not present.	- Establish record of the amount of each habitat type cleared for the proposal - Ensure clearing does not exceed the minimum identified as required for proposed operations to occur - Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal
	Reduction in, or fragmentation of suitable habitat for native flora and fauna	- Location of proposal in previously disturbed areas where practicable - Implement and adhere to a system of approval for vegetation clearing - Minimise the area of direct land clearing, especially in areas sensitive to disturbance such as along the Margaret River, or those known to support species of National or NT significance - Avoid clearing of mature trees >15 cm DBH where practically feasible	

Potential source of impact	Risk	Mitigation measure	Monitoring
Changes to surface water quality and quantity	Reduction in water quality resulting from sedimentation increasing suspended solids resulting in potential adverse effects on aquatic flora and fauna and riparian/creekline habitats	- Separation of clean water from mine impacted water - Construction of sediment ponds to manage runoff and mitigate downstream sedimentation effects - Development and implementation of surface water management plan	- Monitor to ensure sedimentation mitigation measures are effective and identify necessary remediation actions - Implement biennial flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal - Reporting of spills or discharge of potential toxicants - Reporting of any fauna mortalities suspected to have resulted from contaminated surface water - Monitoring of surface water levels - Monitoring of water quality in exposed surface water used for operations - Monitoring of pit water contaminant levels following submersion of PAF waste rock -
	Reduced water volume in local creeks and drainage areas resulting in reduced surface water flow and availability and impacts to riparian vegetation and aquatic or surface water depending fauna	- Divert water to remain in the same catchment - Minimise areas impacted by mining activities	
	Spills or uncontrolled release of fuels or other hazardous chemicals resulting in acute or chronic impacts on riparian vegetation and aquatic or surface water dependent fauna. This can have impacts both on-site and off-site (e.g. downstream)	- Storage of fuels and chemicals in bunded areas in accordance with Australian Standards - Process plant designed with concrete bunds and sumps to collect and return any spills internally - Oil separator washdown bays to remove oil from wastewater	
	Discharge of contaminated water from pits and tailings storage facilities resulting in acute or chronic adverse effects on riparian vegetation and aquatic or surface water dependent fauna, or flora and fauna at the site of discharge.	- Placement and long-term storage of tailings under a permanent water cover at Fountain Head - Treatment of water above tailings if required at the completion of processing - Maintenance of barriers to discharge of contaminated water into the environment	
	Leaching of metals and salts from waste rock and ore into surface water resulting in impacts to riparian vegetation and aquatic or surface water dependent fauna	- Temporary stockpiling of PAF waste rock at Mt Bonnie and then relocation of PAF waste rock under permanent water cover at Mt Bonnie pit - Treatment of water above waste rock if required at the completion of backfilling at Mt Bonnie pit	
	Changes to surface water flow	- Run-off diversion and water flow/erosion control measures constructed to prevent changes to surface water flow off-site - Culverts installed at creek crossings	

Potential source of impact	Risk	Mitigation measure	Monitoring
	Heavy metals from road construction materials contaminating surface water pools along the roadside or adjacent to the roads. Potential adverse impacts to flora in receiving areas and fauna drinking for surface water pools	- Careful consideration of road construction materials prior to road construction to avoid introducing sources of heavy metals or hydrocarbons	
	Concentrations of toxicants in exposed water in pits and TSFs exceeding accepted limits resulting in the poisoning of fauna drinking from these sites	- Ensure exposed water sources meet acceptable levels of toxicants as provided in national and international guidelines - Cover contaminated surface water with bird balls or netting where practically feasible - Limit exposed cyanide or other toxicant bearing solutions in collection trenches with the use of pipes, netting, gravel or other material (Donato, et al., 2017)	
Groundwater quality and quantity	Reduction in groundwater levels and availability as a result of dewatering activities at production areas. Potential adverse acute and chronic impact on groundwater dependent vegetation and ecosystems, riparian vegetation and aquatic fauna	- Identify and adhere to acceptable extraction rates through modelling of dewatering rates	- Undertake site water balance to ensure adherence to acceptable extraction rates - Monitoring of contaminant levels in groundwater in the vicinity of the proposal area - Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal
	Leaching of metals and salts from waste rock and ore into groundwater resulting in potential adverse acute and chronic impacts to groundwater dependent vegetation and ecosystems, riparian vegetation and aquatic fauna	- Placement of PAF waste and tailings under permanent water cover following cessation of mining at Mt Bonnie - Construction of lined run-off ponds	
Erosion and sedimentation	Wind or water caused soil erosion of cleared or disturbed areas resulting in a loss of topsoil	- Vegetation clearing and disturbance kept to the minimum require for operations to occur - Erosion control measures, such as whoa boys and diversion banks implemented	- Regular inspection of erosion control structures to ensure maintained integrity - Monitoring of contaminants in sediment accumulating in sediment traps

Potential source of impact	Risk	Mitigation measure	Monitoring
		- "Blade-up" clearing implemented where possible to maintain a layer of vegetation 10 cm above ground to lower loss of soil integrity	- Monitor to ensure sedimentation mitigation measures are effective and identify necessary remediation actions
	Sedimentation resulting from erosion of material from cleared, disturbed or bare areas leading to increased sediment loads, infilling of waterways and changes in habitat suitability for flora and fauna	- Separation of clean from mine impacted water - Construction of sediment ponds to manage run-off - Develop and implement surface water management plan	
Invasion or increased in populations of weeds or pest animals	Spread and increased density of established weeds resulting from transport on vehicles, machinery and equipment. Potential adverse impacts include decreased populations of flora through competition, reduction in habitat suitability for flora and fauna and altered fire regimes	- Develop and implement Weed Management Plan, including weed identification guides with photos for common weeds on-site and register for reporting any sightings of weeds or potential weeds - Inspection and wash-down of all vehicles, machinery and equipment that enters the proposal area - Inspection and wash-down of all vehicles, machinery and equipment that travel from an area within the proposal area where a weed infestation occurs into an area where it does not - Keep vegetation clearing and disturbance to the minimum require for operations - Minimise the time between vegetation being cleared and the area being used for proposal requirements - Implementation of accepted weed control measures where weeds have established in areas previously identified as being weed free. Obtain expert advice from the NT Government Weeds Branch or a qualified ecologist - Regular monitoring and weed control where the density of weeds is increasing - Control of weed populations on any topsoil stockpiles - Remove weeds prior to seeding where practically feasible	- Personnel to report any new or increasing infestations of weeds in the proposal area - Monitoring and reporting in line with the Weed Management Plan - Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal

Potential source of impact	Risk	Mitigation measure	Monitoring
		- Rehabilitation of disturbed areas as soon as possible, and prior to the subsequent wet season, to minimise the likelihood of weeds becoming established - Develop a no tolerance policy to the introduction of weeds by contractors, suppliers and personnel	
	Introduction of weeds in the proposal area that were not previously recorded in the proposal area	- Regular monitoring of the proposal area to identify any new weed species present on-site -	
	Increased water or food sources resulting in increased predator activity. Potential increased predation pressure on native species	- Control of existing and new feral predator populations by licensed personnel - Fencing to prevent access to potential food and water sources - Implement no tolerance policy for the introduction and feeding of pest species by contractors, suppliers or personnel - Reduce the occurrence of standing water where possible - Removal of food waste from site where practically feasible	- Record predator and pest animal populations in the proposal area, particularly around potential water and food sources - Record-keeping of control measures used to control predators and pest animals - Record-keeping of numbers of predators and pest animals controlled - Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal
	Increased water sources resulting in an increase in other pest animal species (e.g. cattle, buffalo, donkey, pig) activity. Potential adverse impacts to native vegetation and soil integrity (e.g. over-grazing and trampling), and introduction or spread of disease (e.g. by pigs)	- Control of new and existing feral pest populations by licensed personnel - Fencing to prevent pest species access to the production areas - Fencing to prevent pest species access to potential water sources - Implement no tolerance policy for the introduction and feeding of pest species by contractors, suppliers or personnel - Reduce the occurrence of standing water where possible	
Altered fire regimes	Changes to fire regime resulting in a decline in flora and fauna populations or a loss of vegetation cover	- Develop and implement a Bushfire Management Plan and consult with surrounding pastoral properties on their burning regimes.	- Monitoring in accordance with a Bushfire Management Plan

Potential source of impact	Risk	Mitigation measure	Monitoring
		- Daily checking of bushfire alerts and weather conditions - Construct and maintain fire breaks around infrastructure and significant habitats - No flames outside of designated areas unless hot works permit is approved - Firefighting equipment present on-site and readily accessible - Firefighting equipment to be appropriate to potential sources of ignition present on-site - Minimise additional sources of ignition (e.g. turn off vehicles when not driving, don't park vehicles over dry grass)	- Recording of unplanned wildfire occurring in the proposal area - Keep records of fire equipment maintenance
Vehicle collision	Vehicle collision causing injury or mortality to fauna	- Develop and implement a traffic/vehicle management plan and induct all staff in accordance with the plan - Implement speed restrictions in areas identified as high-risk locations including riparian zones and areas inhabited by significant fauna - Minimise vehicle use by car-pooling - Prohibit off-road driving from non designated routes - Develop and maintain a fauna register to be kept on-site that includes reporting of vehicle strike	- Records of fauna injured or killed by vehicle strike to be maintained in a fauna sighting register
Increased artificial light	Artificial light extending beyond daytime hours having adverse impacts on flora growth and fauna activity times, behaviour and occurrence leading to potential population declines in the vicinity of operations	- Implement minimum lighting requirements require for safe operation - Angle lighting towards the ground where possible to minimise light pollution outside of the proposal area	- Record animals attracted to artificial light sources in fauna sightings register - Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal
Increased vibration	Increased vibration from fixed and mobile sources having adverse impacts on habitat suitability of flora and fauna, and behaviour and occurrence of fauna. May	- Vehicles and equipment creating vibrations to be turned off when not in use - Operations producing vibrations to be kept to the minimum required for operations to occur	- Record timing of blasting where practically feasible - Implement biennial vegetation, flora and fauna monitoring program with the aim of

Potential source of impact	Risk	Mitigation measure	Monitoring
	impact on population levels in the vicinity of operations		monitoring flora and fauna community and population responses to impacts from the proposal
Increased noise	Increased volume and frequency of noise disturbance disrupting fauna behaviour and occurrence. May impact on population levels in the vicinity of operations	- Vehicles and equipment creating noise to be turned off when not in use - Noise reduction measures implemented on machinery where available and practically feasible - Operations producing loud noises to be kept to the minimum required for operations to occur - Conduct noise assessment	- Implement biennial vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal
Increased dust emissions	Increased dust emissions may result in reduced health of flora and fauna or a reduction in habitat suitability	- Conduct AQ assessment - Sustainable use of water to control dust emissions along the Haul Road and in production areas - Implement speed limits to minimise dust creation - Enclosing or use of water spray on conveyors and conveyor transfer points - Implement automatic water spray at the dump hopper - Use of covered/containerised transport to move product if required - Progressive rehabilitation of the WRS - Progressive rehabilitation of production areas as mining and operations cease - Minimise area of vegetation to be cleared - Minimise areas exposed to wind erosion	- Implement annual vegetation, flora and fauna monitoring program with the aim of monitoring flora and fauna community and population responses to impacts from the proposal

7.3 Riparian Zones and Aquatic Habitats

The Haul Road connecting Mt Bonnie and Iron Blow production sites is proposed to cross two watercourses in the south of the survey area, adjacent to Mt Bonnie site. Development in these areas may result in disturbance of sensitive riparian zone and aquatic habitat.

Riparian zones are recognised as areas of importance, providing restricted habitat areas for a range of native fauna, supporting distinct and diverse vegetation and providing important services to the adjacent aquatic ecosystem (Department of Land Resource Management, 2016). Riparian vegetation communities support a distinct and diverse suite of plant and animal species when compared with adjacent habitats. It plays several significant roles in the maintenance of a healthy aquatic ecosystem including:

- Providing shade and moderating temperature fluctuations in streams;
- Creating suitable conditions for breeding in aquatic species;
- Maintaining dissolved oxygen levels;
- Restricting the occurrence of algal blooms; and
- Protecting stream banks from erosion and reducing sedimentation of aquatic habitats.

Riparian zones are particularly vulnerable to disturbance including weed invasion, feral animal, fire, over-grazing and erosion; many of which are indirect impacts associated with development of mining activities.

Aquatic habitats were observed to have a several small fish and yabbie species, freshwater crocodiles and aquatic macroinvertebrates. Potential habitat was observed for water monitors listed as threatened under the TPWC Act. Potential impacts of the proposed Haul Road development on aquatic habitats include:

- Disturbance to and loss of aquatic habitats;
- Changes to aquatic species composition;
- Reduced fecundity and death of aquatic species;
- Restriction of fish passage;
- Translocation of pests and diseases; and
- Increased sediment loadings and chemical contamination of water bodies.

Consideration should be given to the maintenance of riparian zone and aquatic habits around areas where the proposed Haul Road expansion will cross creek lines; these considerations are addressed in sections 7.1-7.4 and 7.8.

7.3.1 Watercourse buffers

Waterways and wetlands within the proposal footprint should be buffered to assist in maintaining surface and ground water quality and the health of aquatic plants and animals (Department of Land Resource Management, 2016). The minimum widths of waterway buffers are based on stream order classification. Streams within the survey area have been classified as 3rd order creeks and wetlands (see section 4.6). Recommendations for buffers around these areas is summarized below in Table 67 and mapped Figure 4. Stream orders as defined by the Straler stream classification system . and Figure

35. Buffer boundaries are approximate and pre-development targeted assessment of water flow and waterbodies and plant species changes which may indicate buffer width is recommended to determine accurate locations of buffer boundaries required to preserve riparian habitat areas.

Table 67. Recommended waterway buffers according to stream order (Department of Environment and Natural Resources, 2018).

Waterway	Stream order	Minimum buffer width (m)	Measure from
Creeks	Third	100	The outer edge of riparian vegetation, where mapped otherwise the primary bank of the outer stream channel where there is more than one channel, or the stream is braided
Wetlands (e.g. swamps, lakes, billabongs) and mangroves	NA	200	The outer edge of areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, brackish or salt, including areas of coastal marine waters.

7.3.1 Monitoring of Riparian Zones and Aquatic Habitats

Monitoring of riparian zone and aquatic habitats should be undertaken, at sites affected by developments. Monitoring should include:

- Inspection of Haul Road crossings of watercourses throughout construction phase to confirm that appropriate erosion and sediment controls are in place
- Periodic inspections (i.e. monthly during the wet season) should be undertaken following construction to confirm that erosion and sediment control mechanisms are operating effectively;
- Ongoing surface water quality monitoring should be implemented including upstream and downstream monitoring;
- An erosion and sediment control plan should be prepared for the proposal including detailed mitigation measures to minimise erosion and release of sediment; and

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9 APPENDICES

Appendix 1: EPBC Protected Matters Search Tool for the area within a 20 km radius of the survey area

Australian Government
Department of the Environment and Energy

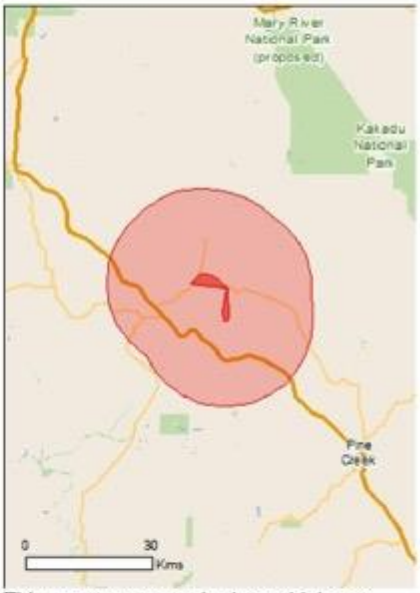
EPBC Act Protected Matters Report

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

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

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 28/11/19 17:49:34



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 20.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	21
Listed Migratory Species:	18

Other Matters Protected by the EPBC Act

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

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

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	24
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	23
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Geophaps smithii smithii Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Antechinus bellus Fawn Antechinus [344]	Vulnerable	Species or species habitat likely to occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Hipposideros inornatus Arnhem Leaf-nosed Bat [86675]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Mesembriomys gouldii gouldii		
Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat known to occur within area
Petrogale concinna canescens		
Nabarlek (Top End) [87606]	Endangered	Species or species habitat likely to occur within area
Phascogale pirata		
Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus		
Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Plants		
Acacia praetermissa		
a shrub [14840]	Vulnerable	Species or species habitat likely to occur within area
Stylidium ensatum		
a triggerplant [86366]	Endangered	Species or species habitat known to occur within area
Reptiles		
Acanthophis hawkei		
Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Marine Species		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Acrocephalus orientalis		
Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis		
Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within

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

Extra Information

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat may occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Pennisetum polystachyon Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat may occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Caveat

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

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

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

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

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-13.4731 131.4758,-13.4691 131.4764,-13.452 131.4941,-13.452 131.5016,-13.4564 131.5206,-13.4817 131.5538,-13.5447 131.556,-13.5515 131.555,-13.5515 131.5453,-13.5304 131.5422,-13.4844 131.5496,-13.4824 131.5465,-13.4733 131.476,-13.4731 131.4758

Acknowledgements

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

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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

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

Appendix 2. Location of sites in the Hayes Creek Project survey area surveyed during May 2017. Co-ordinates are provided in GDA94.

production area	Site	Latitude	Longitude
Fountainhead	FH1	-13.4582	131.5061
	FH2	-13.4591	131.5064
	FH3	-13.4611	131.499
Haul Road	HR1	-13.4777	131.5329
	HR2	-13.4783	131.5323
	HR3	-13.4792	131.5325
	HR4	-13.4782	131.5335
	HR5	-13.4841	131.5659
	HR6	-13.4912	131.5533
	HR7	-13.4994	131.551
	HR8	-13.5049	131.5519
	HR9	-13.5262	131.5491
	HR10	-13.53	131.5468
	HR11	-13.5352	131.5366
Iron Blow	IB1	-13.5149	131.5514
	IB2	-13.5195	131.5522
Mt Bonnie	MB1	-13.5386	131.5488
	MB2	-13.539	131.5488
	MB3	-13.5399	131.5509
	MB4	-13.5401	131.5509
	MB5	-13.5447	131.5487
	MB6	-13.546	131.5491
	MB7	-13.5464	131.5501

Appendix 3. Location of sites in the Hayes Creek Project survey area surveyed during August 2019. Co-ordinates are provided in GDA94.

production area	Site	Latitude	Longitude	production area	Site	Latitude	Longitude
Fountainhead	FH3	-13.4611	131.499	Iron Blow	IB3	-13.513	131.551
	FH4	-13.454	131.494		IB4	-13.516	131.5517
	FH5	-13.4546	131.4968		IB5	-13.5167	131.5501
	FH6	-13.455	131.4975	Mt Bonnie	MB8	-13.5395	131.5512
	FH1	-13.458	131.5061		MB9	-13.5405	131.551
	FH7	-13.459	131.491		MB10	-13.5417	131.5563
	FH8	-13.4625	131.4966		MB11	-13.543	131.554
	FH9	-13.4613	131.5		MB12	-13.544	131.549
	FH10	-13.4661	131.5124		MB5	-13.5447	131.5487
	FH11	-13.4717	131.5033		MB6	-13.546	131.5491
Haul Road	HR12	-13.472	131.484		MB7	-13.5464	131.5501
	HR13	-13.4712	131.4954		MB13	-13.5468	131.5467
	HR14	-13.4716	131.4949		MB14	-13.5474	131.5479
	HR15	-13.474	131.507		MB15	-13.5472	131.5494
	HR16	-13.4789	131.5357		MB16	-13.5498	131.5519
	HR6	-13.4917	131.5531		MB17	-13.5384	131.5473
	HR17	-13.5031	131.5517				
	HR18	-13.5078	131.5509				
	HR19	-13.522	131.551				
	HR20	-13.5307	131.547				
	HR21	-13.5304	131.547				
	HR22	-13.5318	131.5406				
	HR23	-13.532	131.5401				

Appendix 4. Flora species recorded at survey sites during May 2017

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Corymbia polysciada	Paper-fruited bloodwood		X								X	
?*Phyla nodiflora*	Phyla	X										
Acacia auriculiformis	Northern black wattle	X				X				X		
Acacia hemignosta	Club-leaf wattle							X				
Acacia holosericea	Candelabra Wattle		X									
Acacia sp.	Wattle								X		X	
Acacia stipuligera	Scrub wattle					X						
Adiantum sp.	Adiantum									X		
*Aeschynomene Americana**	American joint vetch											X
Aeschynomene indica	Budda Pea									X		
Allopteropsis or Chrysopogon	Grass		X									
Alloteropsis semialata	Cockatoo grass								X			
Alysicarpus sp.	Alysicarpus							X				
Ampelocissus acetosa	Wild grape					X						
Ampelocissus frutescens	Wild grape					X						
Andropogon gayanus	Gamba grass		X									
Antidesma ghesaembilla	Antidesma								X			
Aristida latifolia	Feathertop Wiregrass					X					X	
Aristida sp.	Aristida		X									
Arundinella nepalensis	Reedgrass									X		
Bambusa arnhemica	Bamboo					X				X		

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Blumea saxatilis	Blumea									X		
Blumea sp.	Blumea	X										
Bothriochloa bladhii	Forest Bluegrass						X			X		
Brachychiton megaphyllus	Kurrajong								X		X	
Brachychiton paradoxus	Red-flowering Kurrajong			X								
Breynia cernua	Breynia									X		
Bridelia tomentosa	Bridelia									X		
Buchanania obovata	Green Plum					X		X	X		X	
Buchnera linearis	Dainty bush flower		X	X	X	X		X	X		X	
Calotropis procera	Rubber Bush									X		
Calytrix exstipulata	Kimberley Heather		X								X	
Canscora diffusa	Canscora									X		
Cenchrus sp.	Pennisetum					X						
Chamaecrista sp.	Chamaecrista					X		X				
Cheilanthes nitida	Cheilanthes			X								
Chrysopogon fallax	Golden Beard Grass							X				
Cochlospermum fraseri	Kapok bush			X				X			X	
Corymbia bleeseri	Smooth-stemmed bloodwood			X								
Corymbia disjuncta/confertiflora	Cabbage gum								X			
Corymbia grandifolia	Large-leafed Cabbage Gum								X			
Corymbia latifolia/foelscheana	Bloodwood		X					X	X		X	
Corymbia polycarpa	Long-fruited bloodwood	X				X						

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Corymbia setosa	Rough-leaved bloodwood		X	X								
Crotalaria goreensis	Rattlepod		X									
Crotalaria sp.	Crotalaria			X	X				X			
Cyanthilium cinereum	Vernonia									X		
*Cynodon dactylon**	Couch Grass	X				X						
Cynodon radiatus	Cynodon									X		
Cynodon sp.	Cynodon							X				
Cyperus sp.	Cyperus					X						
Desmodium sp.	Desmodium								X		X	
Dimeria sp.	Dimeria							X				
Drosera petiolaris	Rosette sundew		X									
Ectrosia leporina	Hares-foot grass								X			
Eleocharis brassii	Spike-rush					X						
Eragrostis sp.	Eragrostis	X	X					X	X			
Eriachne avenacea	Wanderrie grass				X							
Eriachne burkittii	Wanderrie grass	X				X						
Eriachne ciliata	Slender Wanderrie		X								X	
Eriachne sp.	Eriachne			X								
Eriosema chinense	Eriosema								X			
Erythrophelum chlorostachys	Ironwood		X	X	X			X	X		X	
Eucalyptus alba	Salmon gum									X		
Eucalyptus apodophylla	Whitebark	X										

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Eucalyptus confertiflora	Broad-leafed Carbeen	X										
Eucalyptus miniata	Darwin Woolybutt							X				
Eucalyptus tectifica	Darwin Box		X		X			X				
Eucalyptus tetrodonta	Darwin Stringybark		X									
Eucalyptus tintinnans	Hills salmon gum			X	X			X			X	
Euphorbia sp.	Euphorbia			X								
Evolvulus nummularius	Evolvulus									X		
Ficus coronulata	River Fig					X						
Ficus hispida	Hairy Fig									X		
Ficus scobina	Sandpaper Fig			X		X					X	
Fimbristylis sp.	Sedge	X										
Flemingia parviflora	Flemingia								X			
Flueggea virosa subsp. melanthesoides	White currant					X						
Forb sp. 1	Unknown forb			X								
Forb sp. 2	Unknown forb			X								
Forb sp. 3	Unknown forb					X						
Forb sp. 4	Unknown forb					X						
Forb sp. 5	Unknown forb					X						
Forb sp. 6	Unknown forb								X			
Galactia sp.	Galactia								X			
Gardenia megasperma	Native gardenia			X	X							
Goodenia pumilio	Goodenia					X						

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Goodenia sp.	Goodenia		X		X			X	X		X	
Grass sp.	Unknown grass								X			
Grevillea decurrens	Grevillea										X	
Gymnanthera oblonga	Gymnanthera									X		
Heteropogon contortus	Bunched Speargrass	X	X			X	X		X			
Heteropogon sp. 1	Speargrass							X			X	
Heteropogon sp. 2	Speargrass	X	X						X		X	
Heteropogon triticeus	Heteropogon				X							
Hibiscus sabdariffa	Hibscus								X			
Hibiscus zonatus	Hibscus					X						
Hygrophila angustifolia	Hygrophila	X				X						
Hymenachne amplexicaulis	Olive hymenachne						X					
Ipomoea eriocarpa	Ipomoea					X						
Ipomoea sp.	Ipomoea									X		
Ischaemum rugosum	Ischaemum	X										
Iseilema vaginiflorum	Red Flinders Grass		X									
Limnophila fragrans	Limnophila					X						
Livistona humilis	Sand Palm								X			
Livistona sp.	Fan Palm										X	
Lobelia diocia	Lobelia		X					X				
Lophostemon lactifluus	Red Paperbark					X						
Ludwigia octovalvis	Willow primrose									X		

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Ludwigia perennis	Upright primrose	X										
Ludwigia sp.	Ludwigia								X		X	
Melaleuca leucadendra	White Paperbark / Cajaput									X		
Melaleuca viridiflora	Green Paperbark	X				X						
Melinis repens	Red natal grass											X
Mesosphaerum suaveolens	Hyptis					X				X	X	
Mnesithea rottboellioides	Northern cane-grass					X	X		X		X	
Nelsonia campestris	Nelsonia	X				X		X				
Owenia vernicosa	Emu Apple				X							
Pandanus aquaticus	River Pandanus					X				X		
Panicum sp.	Panicum					X						
Passiflora foetida	Wild Passionfruit		X									
Petalostigma pubescens	Quinine Bush			X	X	X			X			
Petalostigma quadriloculare	Quinine Bush							X		X		
Phyllanthus baccatus	Phyllanthus									X		
Pimelea punicea	Thecanthes		X					X				
Polycarpaea holtzei	Polycarpaea							X				
Polygala longifolia	Polygala					X		X				
Polygala sp.	Polygala			X		X						
Pseudopogonatherum contortum	Pseudopogonatherum	X				X						
Pseudopogonatherum sp.	Pseudopogonatherum								X			
Pterocaulon sp.	Pterocaulon										X	

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Pycnospora lutescens	Pycnospora		X						X		X	
Rotala mexicana	Rotala							X				
Rotala occultiflora	Rotala					X						
Sacciolepis myosuroides	Sacciolepis					X						
Santalum lanceolatum	Plumbush		X									
Schizachyrium pseudeulalia	Short-leaved silk grass		X									
Scleria novae-hollandiae	Scleria							X				
Senna alata	Candlebush									X		
Senna obtusifolia	Senna									X		
Sida acuta	Spiny-head sida									X		
Sorghum sp.	Sorghum								X			
Sorghum sp. (annual)	Annual sorghum	X		X	X							
Spermacoce sp.	Spermacoce	X	X		X			X			X	
Sphaeromorphaea littoralis	Sphaeromorphaea	X						X	X			
Stachytarpheta sp.	Stachytarpheta						X			X		X
Stackhousia sp.	Stackhousia							X				
Stylidium sp.	Stylidium	X	X		X			X	X		X	
Stylosanthes viscosa	Stylo								X	X		
Syzygium nervosum	Syzygium									X		
Tephrosia polyzyga	Tephrosia			X				X				
Terminalia carpentariae	Billy goat plum									X		
Terminalia ferdinandiana	Kakadu plum			X				X				

Scientific name	Common name	Fountain Head		Haul Road					Iron Blow	Mt Bonnie		
		FH1	FH2	HR11	HR2	HR3	HR5	HR6	IB1	MB4	MB5	Inc.
Terminalia microcarpa	Terminalia									X		
Terminalia sp.	Terminalia										X	
Themeda quadrivalvis	Grader Grass		X									
Themeda triandra	Kangaroo Grass		X	X	X	X		X			X	
Vigna sp.	Vigna		X									
Vine sp.	Unknown vine			X								
Vine sp. 1	Unknown vine						X					
Xanthostemon paradoxus	Xanthostemon			X								
Xyris complanata	Yellow Iris									X		
Zornia sp.	Zornia								X		X	

Appendix 5. Flora species recorded at each survey site and incidentally (Inc.) during the August 2019 field survey of the Hayes Creek Project survey area

Scientific name	Common name	Fountain Head			Haul Road						Iron Blow	Mt Bonnie								
		FH10	FH11	FH8	HR16	HR17	HR18	HR20	HR6	Inc.	IB5	MB10	MB15	MB16	MB17	MB5	MB6	MB7	MB8	Inc.
Acacia auriculiformis	Northern black wattle			X				X											X	
Acacia hemignosta	Club-leaf wattle							X							X					
Acacia holosericea	Candelabra Wattle												X						X	
Acacia plectocarpa	Wattle												X							
Acacia sp.	Wattle										X									
Alloteropsis semialata	Cockatoo grass	X																		
Amaranthus sp.	Amaranth		X																	
Andropogon gayanus	Gamba grass		X	X																
Bambusa arnhemica	Bamboo							X				X							X	
Buchanania obovata	Green Plum	X	X						X											
Calotropis procera	Rubber Bush									X									X	
Calytrix exstipulata	Kimberley Heather	X	X																	
Carallia brachiata	Carallia																	X		
Cenchrus pedicellatus	Pennisetum							X												
Chrysopogon latifolius	Chrysopogon				X			X												
Cochlospermum fraseri	Kapok bush								X											
Coldenia procumbens	Coldenia																X			
Corymbia apparrerinja	Ghost Gum			X																

Scientific name	Common name	Fountain Head			Haul Road						Iron Blow	Mt Bonnie								
		FH10	FH11	FH8	HR16	HR17	HR18	HR20	HR6	Inc.	IB5	MB10	MB15	MB16	MB17	MB5	MB6	MB7	MB8	Inc.
Corymbia bella	Weeping Ghost Gum							X											X	
Corymbia disjuncta	Bloodwood		X	X							X			X						
Corymbia dunlopiana	Dunlop's bloodwood														X					
Corymbia ferruginea	Rusty bloodwood		X																	
Corymbia foelscheana	Smooth-barked bloodwood	X							X											
Corymbia polycarpa	Long-fruited bloodwood						X													
Corymbia sp.	Corymbia		X				X								X					
Crotalaria goreensis	Rattlepod							X												
Cyperus javanicus	Java sedge												X							
Enteropogon dolichostachya	Windmill Grass							X				X							X	
Eragrostis sp.	Eragrostis						X							X						
Eriachne avenacea	Wanderrie grass						X								X					
Eriachne sp. Probably *Eriachne avenacea*	?Eriachne avenacea														X					
Erythrophelum chlorostachys	Ironwood	X	X						X						X					
Eucalyptus bigalerita	Northern Salmon Gum								X											
Eucalyptus miniata	Darwin Woolybutt		X						X					X						
Eucalyptus sp.	Eucalyptus													X						
Eucalyptus tectifica	Darwin Box		X	X										X						
Eucalyptus tintinnans	Hills salmon gum	X	X			X					X				X					

Scientific name	Common name	Fountain Head			Haul Road						Iron Blow	Mt Bonnie								
		FH10	FH11	FH8	HR16	HR17	HR18	HR20	HR6	Inc.	IB5	MB10	MB15	MB16	MB17	MB5	MB6	MB7	MB8	Inc.
Eulalia mackinlayi	Eulalia						X													
Ficus racemosa	Cluster Fig				X							X								
Ficus sp.	Fig							X			X									
Fimbristylis littoralis	Fringe-rush												X							
Galactia sp. (*G. tenuiflora* complex)	Galactia														X					
Grass sp.	Unknown grass								X					X						
Grevillea decurrens	Grevillea							X	X						X					
Grewia asiatica	Grewia											X							X	
Heteropogon contortus	Bunched Speargrass			X		X			X			X		X						
Heteropogon sp.	Speargrass		X																	
Heteropogon triticeus	Heteropogon					X														
Hibbertia sphenandra	Pachynema														X					
Khaya senegalensis	African mahogany				X			X											X	X
Litsea glutinosa	Litsea																		X	
Livistona sp.	Fan Palm		X	X							X									
Malvaceaee - possibly a *Hibiscus* sp.?	?Hibiscus												X							
Melaleuca leucadendra	White Paperbark / Cajaput				X			X											X	
Melaleuca sp.	Tea-tree			X																
Mesosphaerum suaveolens	Hyptis							X				X							X	
Mistletoe	Unknown mistletoe			X																

Scientific name	Common name	Fountain Head			Haul Road						Iron Blow	Mt Bonnie								
		FH10	FH11	FH8	HR16	HR17	HR18	HR20	HR6	Inc.	IB5	MB10	MB15	MB16	MB17	MB5	MB6	MB7	MB8	Inc.
Mnesithea rottboellioides	Northern cane-grass				X			X				X								
Nauclea orientalis	Leichhardt Pine							X				X							X	
Pandanus aquaticus	River Pandanus							X				X							X	
Panicum ?decompositum	Panicum										X									
Paspalum scrobiculatum	Kodo Millet												X							
Passiflora foetida	Wild Passionfruit							X												
Petalostigma pubescens	Quinine Bush		X						X						X					
Phyllanthus baccatus	Phyllanthus																		X	
Polycarpaea sp.	Polycarpaea														X					
Scleria sphacelata	Scleria															X				
Scoparia dulcis	Scoparia												X							
Senna alata	Candlebush							X												
*Sida rhombifolia**	Common Sida							X												
Smilax australis	Smilax											X							X	
Sorghum sp.	Sorghum														X					
Spermacoce sp.	Spermacoce	X																		
Stachytarpheta cayennensis	Snakeweed							X				X							X	
Stylosanthes viscosa	Stylo							X												
Syzygium nervosum	Syzygium											X								
Terminalia ferdinandiana	Kakadu plum													X						

Scientific name	Common name	Fountain Head			Haul Road						Iron Blow	Mt Bonnie								
		FH10	FH11	FH8	HR16	HR17	HR18	HR20	HR6	Inc.	IB5	MB10	MB15	MB16	MB17	MB5	MB6	MB7	MB8	Inc.
Terminalia microcarpa	Terminalia							X												
Terminalia sp.	Terminalia			X																
Themeda quadrivalvis	Grader Grass																		X	
Themeda triandra	Kangaroo Grass		X	X				X	X						X					
Triodia bitextura	Curly Spinifex						X													

Appendix 6. Fauna species recorded at each survey site and incidentally (Inc.) during the May 2017 field survey of the Hayes Creek Project survey area

Group	Scientific Name	Common Name	Fountain Head			Haul Rd						Iron Blow	Mt Bonnie			Inc.
			FH1	FH2	Inc.	HR1	HR11	HR3	HR6	HR7	Inc.	IB1	MB3	MB4	MB5	
Amphibian	*Bufo marinus*	Cane toad		X				X								X
Amphibian	*Limnodynastes convexiusculus*	Marbled frog		X												X
Amphibian	*Limnodynastes ornatus*	Ornate burrowing frog		X												
Amphibian	*Litoria bicolor*	Northern dwarf tree-frog		X												
Amphibian	*Litoria nasuta*	Rocket frog		X												X
Amphibian	*Litoria pallida*	Pale frog		X												
Bird	*Accipiter cirrhocephalus*	Collared sparrowhawk														X
Bird	*Anseranas semipalmata*	Magpie goose			X											
Bird	*Aprosmictus erythropterus*	Red-winged parrot	X		X			X				X				X
Bird	*Aquila audax*	Wedge-tailed eagle														X
Bird	*Ardea alba*	Great egret						X								X
Bird	*Ardea ibis*	Cattle egret														X
Bird	*Ardea pacifica*	White-necked heron			X			X								
Bird	*Artamus leucorynchus*	White-breasted woodswallow			X			X							X	
Bird	*Artamus minor*	Little woodswallow						X	X							
Bird	*Artamus personatus*	Masked woodswallow									X					
Bird	*Burhinus grallarius*	Bush stone-curlew														X
Bird	*Cacatua galerita*	Sulphur-crested cockatoo			X		X	X	X			X				
Bird	*Cacatua roseicapilla*	Galah			X			X				X				X

Group	Scientific Name	Common Name	Fountain Head			Haul Rd						Iron Blow	Mt Bonnie			Inc.
			FH1	FH2	Inc.	HR1	HR11	HR3	HR6	HR7	Inc.	IB1	MB3	MB4	MB5	
Bird	*Calyptorhynchus banksii*	Red-tailed black-cockatoo					X	X						X		X
Bird	*Centropus phasianinus*	Pheasant coucal					X									X
Bird	*Chalcites minutillus*	Little bronze-cuckoo												X		
Bird	*Chlamydera nuchalis*	Great bowerbird										X				
Bird	*Coracina novaehollandiae*	Black-faced cuckoo-shrike														X
Bird	*Coracina papuensis*	White-bellied cuckoo-shrike					X	X	X			X				X
Bird	*Corvus orru*	Torresian crow		X	X		X		X		X				X	X
Bird	*Ctenophorus caudicinctus*	Ring-tailed dragon														X
Bird	*Dacelo leachii*	Blue-winged kookaburra		X	X		X	X				X				X
Bird	*Dendrocygna arcuata*	Wandering whistling-duck			X											
Bird	*Egretta garzetta*	Little egret														X
Bird	*Egretta novaehollandiae*	White-faced heron			X						X					
Bird	*Ephippiorhynchus asiaticus*	Black-necked stork														X
Bird	*Erythrura gouldiae*	Gouldian finch									X					X
Bird	*Falco berigora*	Brown Falcon							X							X
Bird	*Geopelia humeralis*	Bar-shouldered dove		X	X		X	X	X			X	X		X	
Bird	*Geopelia placida*	Peaceful dove	X		X		X	X	X			X			X	X
Bird	*Grallina cyanoleuca*	Magpie-lark	X		X							X				X
Bird	*Grus rubicunda*	Brolga		X	X											
Bird	*Haliastur sphenurus*	Whistling kite			X			X				X				X
Bird	*Himantopus himantopus*	Black-winged stilt			X											X
Bird	*Lichenostomus unicolor*	White-gaped honeyeater						X			X					

Group	Scientific Name	Common Name	Fountain Head			Haul Rd						Iron Blow	Mt Bonnie			Inc.
			FH1	FH2	Inc.	HR1	HR11	HR3	HR6	HR7	Inc.	IB1	MB3	MB4	MB5	
Bird	*Lichmera indistincta*	Brown honeyeater						X	X			X		X	X	X
Bird	*Lonchura castaneothorax*	Chestnut-breasted mannikin													X	
Bird	*Macropus agilis*	Agile wallaby														X
Bird	*Malurus melanocephalus*	Red-backed fairy-wren									X					X
Bird	*Megalurus timoriensis*	Tawny grassbird														X
Bird	*Melithreptus albogularis*	White-throated honeyeater														X
Bird	*Merops ornatus*	Rainbow bee-eater		X	X		X	X	X			X			X	X
Bird	*Microeca flavigaster*	Lemon-bellied flycatcher									X					X
Bird	*Milvus migrans*	Black kite														X
Bird	*Myiagra alecto*	Shining flycatcher												X		
Bird	*Myiagra rubecula*	Leaden flycatcher		X	X									X		X
Bird	*Neochmia phaeton*	Crimson finch									X					X
Bird	*Ninox novaeseelandiae*	Boobook owl														X
Bird	*Pachycephala rufiventris*	Rufous whistler			X		X		X						X	
Bird	*Pardalotus striatus*	Striated pardalote		X	X			X			X	X				
Bird	*Philemon argenticeps*	Silver-crowned friarbird						X								
Bird	*Philemon buceroides*	Helmeted friarbird														X
Bird	*Philemon citreogularis*	Little friarbird										X				
Bird	*Podargus strigoides*	Tawny frogmouth			X			X	X							X
Bird	*Poecilodryas cerviniventris*	Buff-sided robin				X					X					
Bird	*Poephila personata*	Masked finch									X	X				X
Bird	*Rhipidura leucophrys*	Willie wagtail			X			X			X					X

Group	Scientific Name	Common Name	Fountain Head			Haul Rd						Iron Blow	Mt Bonnie			Inc.
			FH1	FH2	Inc.	HR1	HR11	HR3	HR6	HR7	Inc.	IB1	MB3	MB4	MB5	
Bird	*Rhipidura rufiventris*	Northern fantail									X			X		
Bird	*Smicrornis brevirostris*	Weebill						X								
Bird	*Tachybaptus novaehollandiae*	Australasian grebe														X
Bird	*Tadorna radjah*	Radjah shelduck			X			X								
Bird	*Taeniopygia bichenovii*	Double-barred finch									X					X
Bird	*Threskiornis spinicollis*	Straw-necked ibis			X			X								X
Bird	*Todiramphus macleayii*	Forest kingfisher														X
Bird	*Todiramphus sanctus*	Sacred kingfisher									X					
Bird	*Trichoglossus rubritorquis*	Red-collared lorikeet			X							X			X	
Bird	*Vanellus miles*	Masked lapwing			X											
Bird	*Accipiter* sp.	Goshawk														X
Bird	*Ardea* sp.	Egret			X											X
Bird	*Philemon* sp.	Friarbird										X				
Bird	*Coturnix* sp.	Quail					X									
Mammal	*Bos taurus*	Cattle			X											X
Mammal	*Bubalus bubalis*	Water buffalo														X
Mammal	*Canis lupus*	Wild dog														X
Mammal	*Chaerephon jobensis*	Greater northern free-tailed bat					X	X								
Mammal	*Chalinolobus gouldii*	Gould's wattled bat		X			X	X	X			X			X	
Mammal	*Felis catus*	Cat									X					
Mammal	*Macropus agilis*	Agile wallaby	X													X

Group	Scientific Name	Common Name	Fountain Head			Haul Rd						Iron Blow	Mt Bonnie			Inc.
			FH1	FH2	Inc.	HR1	HR11	HR3	HR6	HR7	Inc.	IB1	MB3	MB4	MB5	
Mammal	*Macropus antilopinus*	Antilopine wallaroo											X			
Mammal	*Rattus rattus*	Black rat												X		
Mammal	*Rhinonicteris aurantia*	Orange leaf-nosed bat		X			X	X	X			X			X	X
Mammal	*Saccolaimus flaviventris*	Yellow-bellied sheath-tail bat		X			X	X	X			X			X	
Mammal	*Chiroptera*	Species 1 bat		X			X	X	X			X			X	
Mammal	*Chiroptera*	Species 9 bat						X	X			X			X	
Mammal	*Vespertilionidae*	Bat sp.		X			X	X	X			X			X	
Reptile	*Antaresia childreni*	Children's python														X
Reptile	*Ctenotus robustus*	Robust ctenotus		X				X	X							
Reptile	*Demansia papuensis*	Greater black whip snake					X									
Reptile	*Lophognathus gilberti*	Gilbert's dragon		X			X									
Reptile	*Pseudonaja nuchalis*	Northern brown snake						X								
Reptile	*Varanus primordius*	Northern ridge-tailed monitor							X			X				
Reptile	*Carlia* sp.	Skink						X		X						

Appendix 7. Fauna species recorded at each survey site and incidentally (Inc.) in the Fountain Head area during the August 2019 field survey of the Hayes Creek Project survey area

Group	Scientific Name	Common Name	FH1	FH11	FH4	FH5	FH6	FH7	FH9	Inc.
Amphibian	*Bufo marinus*	Cane toad			X					
Bird	*Accipiter fasciatus*	Brown goshawk		X			X			
Bird	*Alcedo azurea*	Azure kingfisher					X			
Bird	*Aprosmictus erythropterus*	Red-winged parrot		X			X			X
Bird	*Ardea alba*	Great egret	X							
Bird	*Ardeotis australis*	Australian bustard								X
Bird	*Artamus leucorynchus*	White-breasted woodswallow							X	X
Bird	*Artamus minor*	Little woodswallow								X
Bird	*Burhinus grallarius*	Bush stone-curlew								X
Bird	*Butorides striatus*	Striated heron							X	
Bird	*Cacatua galerita*	Sulphur-crested cockatoo	X						X	
Bird	*Calyptorhynchus banksii*	Red-tailed black-cockatoo			X		X		X	X
Bird	*Centropus phasianinus*	Pheasant coucal		X						
Bird	*Certhionyx pectoralis*	Banded honeyeater		X			X			
Bird	*Conopophila rufogularis*	Rufous-throated honeyeater		X			X		X	
Bird	*Coracina papuensis*	White-bellied cuckoo-shrike					X			
Bird	*Corvus orru*	Torresian crow					X			
Bird	*Dacelo leachii*	Blue-winged kookaburra		X						
Bird	*Dicaeum hirundinaceum*	Mistletoebird								X
Bird	*Egretta novaehollandiae*	White-faced heron		X						
Bird	*Ephippiorhynchus asiaticus*	Black-necked stork							X	
Bird	*Falco berigora*	Brown Falcon								X

Group	Scientific Name	Common Name	FH1	FH11	FH4	FH5	FH6	FH7	FH9	Inc.
Bird	*Falco cenchroides*	Nankeen kestrel					X			X
Bird	*Geopelia humeralis*	Bar-shouldered dove	X	X			X		X	
Bird	*Geopelia placida*	Peaceful dove	X	X			X		X	
Bird	*Haliastur sphenurus*	Whistling kite		X			X			
Bird	*Lichenostomus unicolor*	White-gaped honeyeater		X						
Bird	*Lichmera indistincta*	Brown honeyeater			X		X		X	
Bird	*Macropus antilopinus*	Antilopine wallaroo	X							
Bird	*Melithreptus albogularis*	White-throated honeyeater		X					X	
Bird	*Merops ornatus*	Rainbow bee-eater							X	
Bird	*Milvus migrans*	Black kite					X			
Bird	*Myiagra inquieta*	Restless flycatcher							X	
Bird	*Myiagra rubecula*	Leaden flycatcher					X			
Bird	*Neochmia phaeton*	Crimson finch		X					X	
Bird	*Nycticorax caledonicus*	Nankeen night heron			X					
Bird	*Pachycephala rufiventris*	Rufous whistler		X					X	
Bird	*Pelecanus conspicillatus*	Australian pelican		X						
Bird	*Phalacrocorax varius*	Pied cormorant							X	
Bird	*Philemon argenticeps*	Silver-crowned friarbird		X						
Bird	*Philemon buceroides*	Helmeted friarbird					X			
Bird	*Platycercus venustus*	Northern rosella								X
Bird	*Poephila acuticauda*	Long-tailed finch		X						
Bird	*Psephotus dissimilis*	Hooded parrot								X
Bird	*Psitteuteles versicolor*	Varied lorikeet		X						
Bird	*Ramsayornis fasciatus*	Bar-breasted honeyeater					X			

Group	Scientific Name	Common Name	FH1	FH11	FH4	FH5	FH6	FH7	FH9	Inc.
Bird	*Rhipidura leucophrys*	Willie wagtail					X		X	
Bird	*Smicrornis brevirostris*	Weebill		X						
Bird	*Tadorna radjah*	Radjah shelduck							X	
Bird	*Taeniopygia bichenovii*	Double-barred finch							X	
Bird	*Trichoglossus rubritorquis*	Red-collared lorikeet		X						
Mammal	*Chaerephon jobensis*	Greater northern free-tailed bat			X	X		X		
Mammal	*Chalinolobus gouldii*	Gould's wattled bat				X				
Mammal	*Macropus agilis*	Agile wallaby			X					
Mammal	*Myotis macropus*	Large-footed Myotis				X				
Mammal	*Nyctophilus* sp.	(blank)				X				
Mammal	*Ozimops lumsdenae*	Northern Free-tailed Bat				X				
Mammal	*Pipistrellis adamsi/ Miniopterus orianae*	(blank)				X				
Mammal	*Pteropus alecto*	Black flying-fox			X					
Mammal	*Pteropus scapulatus*	Little red flying-fox								X
Mammal	*Saccolaimus flaviventris/ Saccolaimus saccolaimus*	(blank)				X				
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*	(blank)				X				
Mammal	*Taphozous georgianus*	Common Sheath-tail Bat				X				
Mammal	*Saccolaimus flaviventris/ Saccolaimus saccolaimus*				X			X		
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*				X			X		

Appendix 8. Fauna species recorded at each survey site and incidentally (Inc.) along the proposed Haul Road route during the August 2019 field survey of the Hayes Creek Project survey area

Group	Scientific Name	Common Name	Haul Road											
			HR15	HR12	HR13	HR14	HR15	HR16	HR19	HR20	HR21	HR22	HR6	Inc.
Bird	*Accipiter fasciatus*	Brown goshawk			X									
Bird	*Aprosmictus erythropterus*	Red-winged parrot								X				
Bird	*Ardea ibis*	Cattle egret			X									
Bird	*Ardea pacifica*	White-necked heron			X									
Bird	*Artamus cinereus*	Black-faced woodswallow								X				
Bird	*Artamus leucorynchus*	White-breasted woodswallow								X				
Bird	*Artamus minor*	Little woodswallow				X								
Bird	*Artamus personatus*	Masked woodswallow				X								
Bird	*Cacatua galerita*	Sulphur-crested cockatoo				X								
Bird	*Cacatua roseicapilla*	Galah			X									
Bird	*Calyptorhynchus banksii*	Red-tailed black-cockatoo			X	X		X						
Bird	*Centropus phasianinus*	Pheasant coucal								X				
Bird	*Certhionyx pectoralis*	Banded honeyeater			X	X								
Bird	*Chlamydera nuchalis*	Great bowerbird								X				
Bird	*Cisticola exilis*	Golden-headed cisticola								X				
Bird	*Climacteris melanura*	Black-tailed treecreeper								X				
Bird	*Conopophila rufogularis*	Rufous-throated honeyeater			X									
Bird	*Coracina novaehollandiae*	Black-faced cuckoo-shrike						X						
Bird	*Coracina papuensis*	White-bellied cuckoo-shrike			X									
Bird	*Corvus orru*	Torresian crow			X									
Bird	*Cracticus torquatus*	Grey butcherbird								X				

Group	Scientific Name	Common Name	Haul Road											
			HR15	HR12	HR13	HR14	HR15	HR16	HR19	HR20	HR21	HR22	HR6	Inc.
Bird	*Dacelo leachii*	Blue-winged kookaburra			X									
Bird	*Dicrurus bracteatus*	Spangled Drongo						X						
Bird	*Egretta novaehollandiae*	White-faced heron			X									
Bird	*Entomyzon cyanotis*	Blue-faced honeyeater			X									
Bird	*Eurostopodus argus*	Spotted nightjar												X
Bird	*Falco berigora*	Brown Falcon								X				
Bird	*Geopelia humeralis*	Bar-shouldered dove			X									
Bird	*Geopelia placida*	Peaceful dove			X			X		X				
Bird	*Gerygone olivacea*	White-throated gerygone			X									
Bird	*Grallina cyanoleuca*	Magpie-lark			X			X						
Bird	*Haliastur sphenurus*	Whistling kite			X	X								
Bird	*Lalage sueurii*	White-winged triller			X									
Bird	*Lichmera indistincta*	Brown honeyeater			X					X				
Bird	*Malurus melanocephalus*	Red-backed fairy-wren								X				
Bird	*Melithreptus albogularis*	White-throated honeyeater			X									
Bird	*Merops ornatus*	Rainbow bee-eater						X						X
Bird	*Microeca flavigaster*	Lemon-bellied flycatcher			X									
Bird	*Milvus migrans*	Black kite				X								
Bird	*Myiagra inquieta*	Restless flycatcher			X									
Bird	*Myiagra rubecula*	Leaden flycatcher			X	X								
Bird	*Myzomela obscura*	Dusky honeyeater								X				
Bird	*Neochmia phaeton*	Crimson finch			X									
Bird	*Nycticorax caledonicus*	Nankeen night heron			X									

Group	Scientific Name	Common Name	Haul Road											
			HR15	HR12	HR13	HR14	HR15	HR16	HR19	HR20	HR21	HR22	HR6	Inc.
Bird	*Nymphicus hollandicus*	Cockatiel			X									
Bird	*Oriolus sagittatus*	Olive-backed oriole								X				
Bird	*Pachycephala rufiventris*	Rufous whistler			X					X				X
Bird	*Pardalotus striatus*	Striated pardalote			X					X				
Bird	*Pelecanus conspicillatus*	Australian pelican			X									
Bird	*Philemon argenticeps*	Silver-crowned friarbird			X									
Bird	*Philemon buceroides*	Helmeted friarbird				X								
Bird	*Philemon citreogularis*	Little friarbird			X					X				
Bird	*Platalea regia*	Royal spoonbill			X									
Bird	*Poephila acuticauda*	Long-tailed finch				X				X				X
Bird	*Psitteuteles versicolor*	Varied lorikeet						X						
Bird	*Rhipidura albiscapa*	Grey fantail			X					X				
Bird	*Rhipidura leucophrys*	Willie wagtail			X			X						
Bird	*Rhipidura rufiventris*	Northern fantail								X				
Bird	*Smicrornis brevirostris*	Weebill								X				
Bird	*Taeniopygia bichenovii*	Double-barred finch			X	X								
Bird	*Threskiornis molucca*	Australian white ibis			X					X				
Bird	*Threskiornis spinicollis*	Straw-necked ibis			X									
Bird	*Trichoglossus rubritorquis*	Red-collared lorikeet			X					X				
Bird	*Cuculiformes*	Cuckoo sp.								X				
Bird	*Gerygone* sp.				X									
Mammal	*Bos taurus*	Cattle			X	X								
Mammal	*Canis lupus*	Wild dog			X									

Group	Scientific Name	Common Name	Haul Road											
			HR15	HR12	HR13	HR14	HR15	HR16	HR19	HR20	HR21	HR22	HR6	Inc.
Mammal	*Canis lupus dingo*	Dingo				X					X			
Mammal	*Chaerephon jobensis*	Greater northern free-tailed bat		X								X	X	
Mammal	*Chalinolobus gouldii*	Gould's wattled bat								X		X		
Mammal	*Equus asinus*	Donkey										X		
Mammal	*Macropus agilis*	Agile wallaby			X					X				
Mammal	*Myotis macropus*	Large-footed Myotis											X	
Mammal	*Nyctophilus* sp.												X	
Mammal	*Ozimops lumsdenae*	Northern Free-tailed Bat								X				
Mammal	*Pipistrellis adamsi/ Miniopterus orianae*												X	
Mammal	*Pteropus alecto*	Black flying-fox								X	X			X
Mammal	*Pteropus scapulatus*	Little red flying-fox	X											X
Mammal	*Saccolaimus flaviventris/ Saccolaimus saccolaimus*											X	X	
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*											X	X	
Mammal	*Sus scrofa*	Pig			X						X			
Mammal	*Taphozous georgianus*	Common Sheath-tail Bat											X	
Mammal	*Taphozous kapalgensis*	Arnhem Sheath-tail Bat											X	
Mammal	*Vespadelus caurinus*	Northern Cave Bat										X		
Mammal	*Nyctophilus species*									X				
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*			X			X		X	X				
Mammal	*Scotorepens greyi/Chalinolobus nigrogriseus*						X							

Group	Scientific Name	Common Name	Haul Road											
			HR15	HR12	HR13	HR14	HR15	HR16	HR19	HR20	HR21	HR22	HR6	Inc.
Reptile	*Carlia gracilis*	Slender rainbow skink								X				

Appendix 9. Fauna species recorded at each survey site and incidentally (Inc.) in the Iron Blow area during the August 2019 field survey of the Hayes Creek Project survey area

Group	Scientific Name	Common Name	IB4	IB3
Bird	*Cacatua galerita*	Sulphur-crested cockatoo	X	
Bird	*Calyptorhynchus banksii*	Red-tailed black-cockatoo	X	
Bird	*Corvus orru*	Torresian crow	X	
Bird	*Cracticus nigrogularis*	Pied butcherbird	X	
Bird	*Geopelia placida*	Peaceful dove	X	
Bird	*Milvus migrans*	Black kite	X	
Bird	*Philemon citreogularis*	Little friarbird	X	
Bird	*Podargus strigoides*	Tawny frogmouth	X	
Bird	*Smicrornis brevirostris*	Weebill	X	
Bird	*Trichoglossus rubritorquis*	Red-collared lorikeet	X	
Mammal	*Rhinonicteris aurantia*	Orange leaf-nosed bat		X
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*			X

Appendix 10. Fauna species recorded at each survey site and incidentally (Inc.) in the Mt Bonnie area during the August 2019 field survey of the Hayes Creek Project survey area

Group	Scientific Name	Common Name	MB6	MB8	MB9	MB10	MB11	MB12	MB15	MB16	Inc.
Bird	*Accipiter cirrhocephalus*	Collared sparrowhawk									X
Bird	*Accipiter novaehollandiae*	Grey goshawk									X
Bird	*Alcedo azurea*	Azure kingfisher				X					
Bird	*Aprosmictus erythropterus*	Red-winged parrot							X		
Bird	*Ardea ibis*	Cattle egret								X	
Bird	*Artamus cinereus*	Black-faced woodswallow		X							
Bird	*Artamus leucorynchus*	White-breasted woodswallow							X		
Bird	*Artamus minor*	Little woodswallow							X		
Bird	*Cacatua galerita*	Sulphur-crested cockatoo				X					
Bird	*Calyptorhynchus banksii*	Red-tailed black-cockatoo		X					X		
Bird	*Chlamydera nuchalis*	Great bowerbird				X					
Bird	*Cisticola exilis*	Golden-headed cisticola		X							
Bird	*Climacteris melanura*	Black-tailed treecreeper	X	X		X			X		
Bird	*Colluricincla harmonica*	Grey shrike-thrush		X							
Bird	*Conopophila albogularis*	Rufous-banded honeyeater								X	
Bird	*Coracina novaehollandiae*	Black-faced cuckoo-shrike				X			X		
Bird	*Coracina papuensis*	White-bellied cuckoo-shrike		X					X	X	
Bird	*Corvus orru*	Torresian crow							X	X	
Bird	*Cracticus nigrogularis*	Pied butcherbird								X	
Bird	*Dacelo leachii*	Blue-winged kookaburra	X			X			X	X	
Bird	*Dicaeum hirundinaceum*	Mistletoebird		X					X		
Bird	*Egretta novaehollandiae*	White-faced heron				X				X	X

Group	Scientific Name	Common Name	MB6	MB8	MB9	MB10	MB11	MB12	MB15	MB16	Inc.
Bird	*Erythrura gouldiae*	Gouldian finch	X			X			X		
Bird	*Falco cenchroides*	Nankeen kestrel							X		
Bird	*Geopelia humeralis*	Bar-shouldered dove	X	X					X		
Bird	*Geopelia placida*	Peaceful dove		X		X			X		
Bird	*Gerygone olivacea*	White-throated gerygone				X			X	X	
Bird	*Grallina cyanoleuca*	Magpie-lark							X		
Bird	*Haliastur sphenurus*	Whistling kite	X	X					X	X	
Bird	*Lalage leucomela*	Varied triller	X			X					
Bird	*Lalage sueurii*	White-winged triller							X		
Bird	*Lichenostomus unicolor*	White-gaped honeyeater				X			X		
Bird	*Lichmera indistincta*	Brown honeyeater	X	X		X			X	X	X
Bird	*Lonchura castaneothorax*	Chestnut-breasted mannikin	X						X		
Bird	*Melithreptus albogularis*	White-throated honeyeater				X			X		
Bird	*Melopsittacus undulatus*	Budgerigar							X		
Bird	*Merops ornatus*	Rainbow bee-eater				X			X	X	
Bird	*Microeca flavigaster*	Lemon-bellied flycatcher		X							
Bird	*Milvus migrans*	Black kite	X						X		X
Bird	*Myiagra alecto*	Shining flycatcher				X					
Bird	*Myiagra inquieta*	Restless flycatcher							X		
Bird	*Myiagra rubecula*	Leaden flycatcher		X							
Bird	*Neochmia phaeton*	Crimson finch	X			X			X		X
Bird	*Oriolus flavocinctus*	Yellow oriole							X		
Bird	*Oriolus sagittatus*	Olive-backed oriole							X		
Bird	*Pachycephala rufiventris*	Rufous whistler		X		X			X	X	

Group	Scientific Name	Common Name	MB6	MB8	MB9	MB10	MB11	MB12	MB15	MB16	Inc.
Bird	*Pardalotus striatus*	Striated pardalote		X							
Bird	*Phalacrocorax varius*	Pied cormorant							X	X	
Bird	*Philemon argenticeps*	Silver-crowned friarbird				X			X		
Bird	*Philemon citreogularis*	Little friarbird				X			X	X	
Bird	*Poecilodryas cerviniventris*	Buff-sided robin							X		
Bird	*Poephila acuticauda*	Long-tailed finch		X							
Bird	*Poephila personata*	Masked finch				X			X		
Bird	*Pomatostomus temporalis*	Grey-crowned babbler							X		
Bird	*Rhipidura albiscapa*	Grey fantail	X						X		
Bird	*Rhipidura leucophrys*	Willie wagtail	X			X			X		
Bird	*Rhipidura rufiventris*	Northern fantail								X	
Bird	*Smicrornis brevirostris*	Weebill				X					
Bird	*Tachybaptus novaehollandiae*	Australasian grebe								X	
Bird	*Taeniopygia bichenovii*	Double-barred finch	X						X	X	
Bird	*Threskiornis molucca*	Australian white ibis	X								
Bird	*Myiagra* sp.	Flycatcher				X					
Mammal	*Bubalus bubalis*	Water buffalo									X
Mammal	*Chaerephon jobensis*	Greater northern free-tailed bat			X			X			
Mammal	*Macropus agilis*	Agile wallaby								X	
Mammal	*Macropus antilopinus*	Antilopine wallaroo									X
Mammal	*Nyctophilus* sp.				X						
Mammal	*Pipistrellis adamsi/ Miniopterus orianae*				X						
Mammal	*Saccolaimus flaviventris/ Saccolaimus saccolaimus*				X						
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*				X						

Group	Scientific Name	Common Name	MB6	MB8	MB9	MB10	MB11	MB12	MB15	MB16	Inc.
Mammal	*Taphozous georgianus*	Common Sheath-tail Bat			X						
Mammal	*Saccolaimus flaviventris/ Saccolaimus saccolaimus*							X			
Mammal	*Scotorepens greyi/ Chalinolobus nigrogriseus*						X	X			
Reptile	*Crocodylus johnstoni*	Freshwater crocodile	X								

Appendix 11. Detailed assessments of the level of risk of a significant impact on species listed as threatened under the EPBC Act and TPWC Act.

a) Acacia praetermissa

Source of risk	Severity	Likelihood	Level of risk
Lead to a long-term decrease in the size of an important population			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	2	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	2	1	Low
Increased vibration	2	2	Low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Reduce the area of occupancy of an important population			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	2	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	2	1	Low
Increased vibration	2	2	Low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Fragment an existing important population into two or more populations			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low

Source of risk	Severity	Likelihood	Level of risk
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Adversely affect habitat critical to the survival of a species			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	2	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	2	1	Low
Increased vibration	2	2	Low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Disrupt the breeding cycle of an important population			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	2	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	2	2	Low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	2	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low

Source of risk	Severity	Likelihood	Level of risk
Vehicle collision	1	1	Very low
Increased artificial light	2	1	Low
Increased vibration	2	2	Low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	2	1	Low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low
Altered fire regimes	2	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	2	2	Low
Introduce disease that may cause the species to decline			
Vegetation clearing and habitat disturbance	2	1	Low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	3	1	Low
Interfere substantially with the recovery of the species			
Vegetation clearing and habitat disturbance	2	2	Low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low

Source of risk	Severity	Likelihood	Level of risk
Altered fire regimes	3	2	Low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	2	1	Low

b) Curlew sandpiper (*Calidris ferruginea*)

Source of risk	Severity	Likelihood	Level of risk
Lead to a long-term decrease in the size of a population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Reduce the area of occupancy of the species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Fragment an existing important population into two or more populations			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low

Source of risk	Severity	Likelihood	Level of risk
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Adversely affect habitat critical to the survival of a species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Disrupt the breeding cycle of a population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline			
Vegetation clearing and habitat disturbance	1	1	Very low

Source of risk	Severity	Likelihood	Level of risk
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Introduce disease that may cause the species to decline			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Interfere substantially with the recovery of the species			

Source of risk	Severity	Likelihood	Level of risk
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low

c) Gouldian finch (*Erythrura gouldiae*)

Source of risk	Initial assessment			Residual assessment		
	Likelihood	Severity	Level of risk	Likelihood	Severity	Level of risk
Lead to a long-term decrease in the size of a population						
Vegetation clearing and habitat disturbance	3	4	High	3	3	Medium
Surface water quality and quantity	3	3	Medium	2	2	Low
Groundwater quality and quantity	3	3	Medium	2	2	Low
Erosion and sedimentation	5	3	High	2	1	Low
Invasion or increases in populations or activity of weeds and pest animals	4	4	High	2	2	Low
Altered fire regimes	3	4	High	3	3	Medium
Vehicle collision	3	3	Medium	2	2	Low
Increased artificial light	3	2	Medium	2	2	Low
Increased vibration	3	2	Medium	2	2	Low
Increased noise	4	3	High	2	2	Low
Increased dust emissions	3	4	High	2	3	Medium
Reduce the area of occupancy of the species						
Vegetation clearing and habitat disturbance	3	3	Medium	2	2	Low
Surface water quality and quantity	3	3	Medium	2	2	Low
Groundwater quality and quantity	3	3	Medium	2	2	Low
Erosion and sedimentation	3	3	Medium	2	1	Low
Invasion or increases in populations or activity of weeds and pest animals	3	4	High	2	2	Low
Altered fire regimes	3	4	High	2	3	Medium
Vehicle collision	2	2	Low	2	2	Low
Increased artificial light	2	2	Low	2	2	Low
Increased vibration	2	2	Low	2	2	Low

Source of risk	Initial assessment			Residual assessment		
	Likelihood	Severity	Level of risk	Likelihood	Severity	Level of risk
Increased noise	2	2	Low	2	2	Low
Increased dust emissions	2	2	Low	2	2	Low
Fragment an existing population into two or more populations						
Vegetation clearing and habitat disturbance	2	5	High	2	3	Medium
Surface water quality and quantity	3	3	Medium	1	2	Low
Groundwater quality and quantity	1	1	Medium	1	1	Very low
Erosion and sedimentation	2	2	Low	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	2	2	Low	2	2	Low
Altered fire regimes	3	4	High	2	3	Medium
Vehicle collision	1	1	Very low	1	1	Very low
Increased artificial light	1	1	Very low	1	1	Very low
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	1	1	Very low	1	1	Very low
Adversely affect habitat critical to the survival of a species						
Vegetation clearing and habitat disturbance	1	1	Very low	1	1	Very low
Surface water quality and quantity	1	1	Very low	1	1	Very low
Groundwater quality and quantity	1	1	Very low	1	1	Very low
Erosion and sedimentation	1	1	Very low	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low	1	1	Very low
Altered fire regimes	1	1	Very low	1	1	Very low
Vehicle collision	1	1	Very low	1	1	Very low
Increased artificial light	1	1	Very low	1	1	Very low

Source of risk	Initial assessment			Residual assessment		
	Likelihood	Severity	Level of risk	Likelihood	Severity	Level of risk
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	1	1	Very low	1	1	Very low
Disrupt the breeding cycle of a population						
Vegetation clearing and habitat disturbance	3	3	Medium	3	3	Medium
Surface water quality and quantity	3	3	Medium	2	2	Low
Groundwater quality and quantity	2	3	Medium	2	2	Low
Erosion and sedimentation	3	3	Medium	2	2	Low
Invasion or increases in populations or activity of weeds and pest animals	3	3	Medium	2	2	Low
Altered fire regimes	3	3	Medium	2	3	Medium
Vehicle collision	3	3	Medium	1	1	Very low
Increased artificial light	2	2	Low	1	2	Low
Increased vibration	2	2	Low	2	2	Low
Increased noise	2	2	Low	2	2	Low
Increased dust emissions	2	2	Low	1	1	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline						
Vegetation clearing and habitat disturbance	1	1	Very low	1	1	Very low
Surface water quality and quantity	1	1	Very low	1	1	Very low
Groundwater quality and quantity	1	1	Very low	1	1	Very low
Erosion and sedimentation	1	1	Very low	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low	1	1	Very low
Altered fire regimes	1	1	Very low	1	1	Very low
Vehicle collision	1	1	Very low	1	1	Very low

Source of risk	Initial assessment			Residual assessment		
	Likelihood	Severity	Level of risk	Likelihood	Severity	Level of risk
Increased artificial light	1	1	Very low	1	1	Very low
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	1	1	Very low	1	1	Very low
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat						
Vegetation clearing and habitat disturbance	4	3	High	3	2	Medium
Surface water quality and quantity	2	2	Low	2	2	Low
Groundwater quality and quantity	1	3	Low	1	3	Low
Erosion and sedimentation	2	3	Medium	2	1	Low
Invasion or increases in populations or activity of weeds and pest animals	3	3	Medium	2	2	Low
Altered fire regimes	4	3	High	3	3	Medium
Vehicle collision	1	1	Very low	1	1	Very low
Increased artificial light	1	1	Very low	1	1	Very low
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	2	3	Medium	1	1	Very low
Introduce disease that may cause the species to decline						
Vegetation clearing and habitat disturbance	1	1	Very low	1	1	Very low
Surface water quality and quantity	1	1	Very low	1	1	Very low
Groundwater quality and quantity	1	1	Very low	1	1	Very low
Erosion and sedimentation	1	1	Very low	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low	1	1	Very low
Altered fire regimes	1	1	Very low	1	1	Very low

Source of risk	Initial assessment			Residual assessment		
	Likelihood	Severity	Level of risk	Likelihood	Severity	Level of risk
Vehicle collision	1	1	Very low	1	1	Very low
Increased artificial light	1	1	Very low	1	1	Very low
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	1	1	Very low	1	1	Very low
Interfere substantially with the recovery of the species						
Vegetation clearing and habitat disturbance	1	1	Very low	1	1	Very low
Surface water quality and quantity	1	1	Very low	1	1	Very low
Groundwater quality and quantity	1	1	Very low	1	1	Very low
Erosion and sedimentation	1	1	Very low	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low	1	1	Very low
Altered fire regimes	1	1	Very low	1	1	Very low
Vehicle collision	1	1	Very low	1	1	Very low
Increased artificial light	1	1	Very low	1	1	Very low
Increased vibration	1	1	Very low	1	1	Very low
Increased noise	1	1	Very low	1	1	Very low
Increased dust emissions	1	1	Very low	1	1	Very low

d) Red goshawk (*Erythrotriorchis radiatus*), pale field rat (*Rattus tunneyi*), Merten's water monitor (*Varanus mertensi*), Mitchell's water monitor (*Varanus mitchelli*), the floodplain monitor (*Varanus panoptes*), partridge pigeon (*Geophaps smithii*), masked owl (northern) (*Tyto novaehollandiae kimberli*), fawn antechinus (*Antechinus bellus*), ghost bat (*Macroderma gigas*) and northern brush-tailed phascogale (*Phascogale pirata*). These species all had the same risk rating, and as such are displayed in the same table for conciseness.

Source of risk	Severity	Likelihood	Level of risk
Lead to a long-term decrease in the size of an important population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Reduce the area of occupancy of an important population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Fragment an existing important population into two or more populations			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low

Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Adversely affect habitat critical to the survival of a species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Disrupt the breeding cycle of an important population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low

Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Introduce disease that may cause the species to decline			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Interfere substantially with the recovery of the species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low

Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low

e) Migratory species – fork-tailed swift (*Apus pacificus*), sharp-tailed sandpiper (*Calidris acuminata*), red-rumped swallow (*Cecropis daurica*), oriental plover (*Charadrius veredus*), oriental cuckoo (*Cuculus optatus*), oriental pratincole (*Glareola maldivarum*), barn swallow (*Hirundo rustica*), grey wagtail (*Motacilla cinereal*), yellow wagtail (*Motacilla flava*)

Source of risk	Likelihood	Severity	Level of risk
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low
Seriously disrupt the lifecycle (breeding, feeding, migrating or resting behaviour) of an ecologically significant proportion of the population			
Vegetation clearing and habitat disturbance	1	1	Very low
Surface water quality and quantity	1	1	Very low
Groundwater quality and quantity	1	1	Very low
Erosion and sedimentation	1	1	Very low
Invasion or increases in populations or activity of weeds and pest animals	1	1	Very low
Altered fire regimes	1	1	Very low

Source of risk	Likelihood	Severity	Level of risk
Vehicle collision	1	1	Very low
Increased artificial light	1	1	Very low
Increased vibration	1	1	Very low
Increased noise	1	1	Very low
Increased dust emissions	1	1	Very low