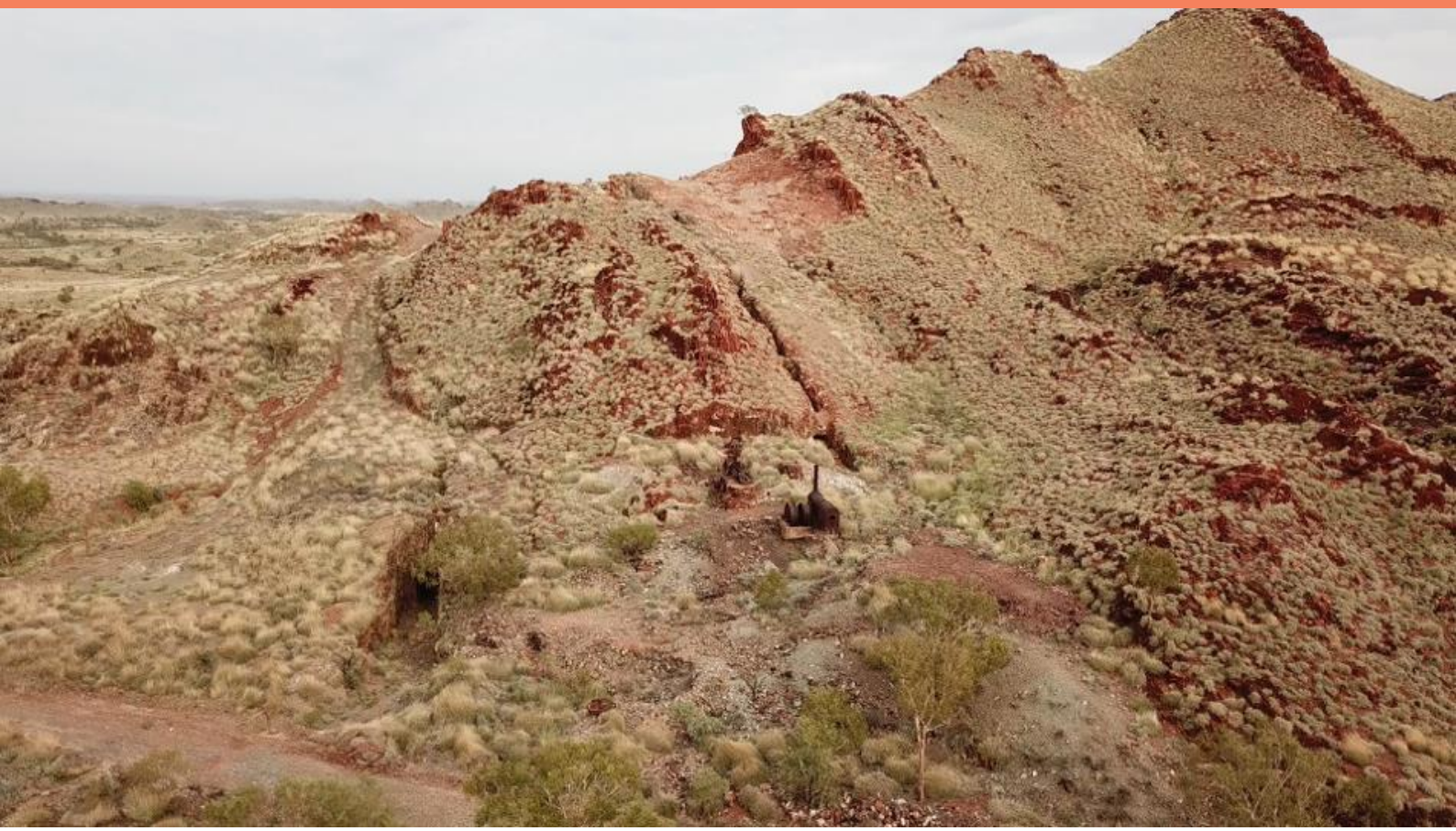
CALIDUS
RESOURCES LIMITED

Warrawoona Gold Project

EPA Referral, Supplementary Information Report



+61 8 6245 2050 info@calidus.com.au
Suite 12, 11 Ventor Ave West Perth WA 6005 AUSTRALIA
calidus.com.au

Calidus Resources Limited
Warrawoona Gold Project
EPA Referral, Supplementary Information Report
29 October 2019

Calidus Resources Limited
ACN 006 640 553
PO Box 1240
West Perth WA 6872
Australia 6005
+61 8 6245 2050
info@calidus.com.au
https://www.calidus.com.au/

This document has been prepared based on assumptions as reported throughout and upon information and data supplied by others.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

Study Team

Calidus acknowledges and thanks the following individuals and groups for contributing to the preparation of this document:

- Approvals, Principal Consultant and Study Manager
  - Rapallo Pty Ltd
- Air Quality Assessment
  - Environmental Technologies & Analytics Pty Ltd
- Blasting Assessment
  - Blast It Global Pty Ltd
  - Peter O'Bryan & Associates
- Closure and Rehabilitation
  - Mine Earth
  - Trajectory
- Geotechnical Analysis
  - Peter O'Bryan & Associates
- Groundwater Assessment
  - Groundwater Resource Management Pty Ltd
- Indigenous Heritage and Culture
  - Njamal Aboriginal Group
  - Njamal Heritage Pty Ltd
  - Sticks and Stones Cultural Resources Management (SandS CRM)
- Invertebrate Fauna (Subterranean and SREs)
  - Biologic Environmental Survey Pty Ltd
- Metallurgy and Testwork
  - Metallurgy Management Services Pty Ltd
  - Nagrom (WA) Pty Ltd
  - ALS (Global) Ltd
- Mine Planning
  - Intermine Engineering Consultants
  - Dionysis Mining Pty Ltd
- Noise Assessment
  - Lloyd George Acoustics Pty Ltd
- Processing Plant and Infrastructure
  - GR Engineering Services Ltd
  - Aerodrome Management Services Pty Ltd
- Spatial Data
  - CAD Resources
- Soil Assessment
  - Mine Earth
- Surface Water Assessment
  - Element Hydrographic Solutions
  - Groundwater Resource Management Pty Ltd

- Tailings Design and Management
    - ATC Williams Pty Ltd
    - Graham Campbell & Associates Pty Ltd
    - Trajectory
- Terrestrial Fauna
    - Bat Call WA (Bob Bullen)
    - Biologic Environmental Survey Pty Ltd
    - Specialised Zoological
- Vegetation and Flora
    - Woodman Environmental Consulting Pty Ltd
- Waste Characterisation
    - Graham Campbell & Associates Pty Ltd
    - Trajectory

EXECUTIVE SUMMARY

Background

Calidus Resources Limited (Calidus) is proposing to develop the Warrawoona Gold Project (the Proposal), a gold mining and processing operation 20km south of Marble Bar in the Pilbara region of Western Australia.

The Proposal is being referred under Section 38 of the *Environmental Protection Act 1986* (EP Act) as it has the potential to significantly affect a key environmental factor, terrestrial fauna, as defined by the Environmental Protection Authority (EPA).

This document serves to provide supplementary information in support of a Section 38 referral under the EP Act, in accordance with the *Instructions for the referral of a Proposal to the EPA under Section 38 of the Environmental Protection Act 1986* (EPA 2018a). The document has also been developed in accordance with the EPA (2018c) *Instructions on how to prepare an Environmental Review Document*, with the aim to review environmental factors relevant to the Proposal and provide the EPA with sufficient information to assess the Proposal.

Proposal

Key Proposal characteristics are summarised in Table ES1, with the location and proposed extent of the Proposals physical and operational elements summarised in Table ES2.

Table ES1: Summary, Warrawoona Gold Project

Title	Warrawoona Gold Project
Proponent Name	Calidus Resources Limited
Short Description	The Warrawoona Gold Project is located approximately 20km south of Marble Bar in Western Australia and will comprise: • An open pit and underground mine at the Klondyke deposit. • A cutback of the existing Copenhagen pit. • A 2Mtpa processing plant at Klondyke. • A 'valley fill' tailings storage facility (TSF) at Klondyke. • A permanent waste rock dump (WRD) at Klondyke. • Borrow pits, topsoil and vegetation stockpiles. • Power supplied from an LNG power station with diesel generator back-up, to meet 8MW demand. • Plant site area will include processing plant, offices, workshop, washdown facilities, hazardous material storage, refuelling station, and contractor area. • Accommodation village will include accommodation blocks, kitchen, first aid, recreational facilities, waste water treatment plant and generator. • Associated mine infrastructure and utilities elements will include stormwater management infrastructure (bunds and diversion drains), magazine, mine access roads, pipelines and power lines. The project will produce gold bar and a gold concentrate and is expected to operate for approximately six years.

Table ES2: Location and proposed extent of physical and operational elements

Element	Location	Proposed extent
Physical Elements		
Open pits, waste rock dump, processing plant, borrow pits, explosives storage, accommodation village, and associated mine elements	Figure 3	Clearing no more than of 253ha within the 1,000ha development envelope.
Tailings Storage Facility	Figure 3	Clearing no more than 145.5ha within the 1,000ha development envelope.
Operational Elements		
Mining Waste Rock – Klondyke	Figure 3	Disposal of no more than 20 million loose cubic metres (LCM) adjacent to permanent surface WRD.
Mining Waste Rock – Copenhagen	Figure 3	Disposal of no more than 300k LCM of permanent surface WRD.
Process Tailings	Figure 3	Disposal of no more than 2Mtpa in a 'valley fill' facility at Klondyke

Impact Assessment

Calidus has undertaken substantial investigations, which have guided the assessment of potential risks to the environment from the Proposal. The investigations have relied on the technical skills and experience of over 25 specialised consultants, and covered a range of factors and aspects relevant to the Proposal, including terrestrial and subterranean fauna; flora and vegetation; air quality (dust); noise; vibration/blasting; geotechnical and geochemical analysis of soils and waste; hydrogeology and hydrology; and ethnographic and archaeological surveys.

The results of these investigations, consultations and risk assessments have all been taken into account in developing the Proposal and preparing this document.

Environmental Factors

One 'key preliminary factor' considered most relevant to the Proposal is terrestrial fauna. This key factor is described in detail in Section 5 and summarised in Table ES3.

Six 'other factors' are summarised in Section 6, and include: 1) inland waters; 2) terrestrial environmental quality; 3) flora and vegetation; 4) social surroundings (Aboriginal heritage and culture); 5) subterranean fauna; and 6) air quality. These other factors are considered unlikely to be significantly impacted by the Proposal and can be largely managed through secondary environmental approval processes and regulatory mechanisms to achieve an appropriate environmental outcome.

A summary of these other factors is provided in Table ES4.

The Proposal will include the implementation of a mining exclusion zone and a blasting buffer, and has developed a series of adaptive management plans and procedures, specifically designed to reduce and mitigate impacts associated with the key environmental factors of the Proposal through monitoring outcomes. These plans and procedures include a Significant Species Management Plan (CRL-ENV-PLN-006-19; Appendix 9-1), Blasting Management Procedure (CRL-ENV-PRO-017-19; Appendix 9-2), Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19; Appendix 9-3), Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19; Appendix 9-4), TSF and Cyanide Management Procedure (CRL-ENV-PRO-019-19;

Appendix 9-5), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6), and WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19; Appendix 9-7).

Given the Proposal design considerations, the implementation of management measures outlined in this document and provisions under other regulatory mechanisms (such as the *Mining Act 1978* (Mining Act), *Rights in Water and Irrigation Act 1914* (RIWI Act), *Aboriginal Heritage Act 1972* (AH Act) and Part V of the EP Act), Calidus is of the view that the Proposal can be implemented consistent with EPA objectives, and without material risk to matters of national environmental significance.

Table ES3: Summary of potential impacts, proposed mitigation and predicted outcomes for Key Factors

FACTOR	TERRESTRIAL FAUNA
EPA Objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Supporting Studies	**Conservation Significant Bats** • Monitoring bats of conservation significance near Marble Bar, Western Australia - November 2016. Specialised Zoological (2017a) • Monitoring bats of conservation significance near Marble Bar, Western Australia - April 2017. Specialised Zoological (2017b) • Pilbara Ghost Bat Genetic Project 2017 (Unpublished report prepared for the BHP Billiton Iron Ore Pty Ltd). Biologic (2017b) • Targeted Bat Assessment, September 2017. Biologic (2018a) • Targeted Bat Assessment, July 2018. Biologic (2018b) • Targeted Bat Assessment, April 2019. Biologic (2019a); Appendix 1-2 • VHF Bat Foraging Studies, July 2018. Biologic (2018c) • VHF Bat Foraging Studies, April 2019. Biologic (2019b); Appendix 1-3 **Terrestrial Fauna** • Level 1 Vertebrate Fauna, and Desktop SRE and Subterranean Assessment, September 2017. Biologic (2017a); Appendix 1-1 • Habitat Assessment and Targeted Vertebrate Fauna Survey, July 2018. Biologic (2019c) • Habitat Assessment and Targeted Vertebrate Fauna Survey, April 2019 (Significant Species Survey and Monitoring). Biologic (2019d); Appendix 1-4 **SRE Invertebrates** • Warrawoona Gold Project SRE Invertebrate Fauna Survey. Biologic (2018d); Appendix 2-1 **Impact Assessment and Proposal Aspects** • Conservation Significant Bat Species Impact Assessment. Biologic (2019f); Appendix 3-1 • Conservation Significant Vertebrate Fauna Impact Assessment. Biologic (2019g); Appendix 3-2 • Assessment of Blasting on the Klondyke Queen. A roost site for Pilbara-Leaf-nosed Bat and Ghost Bat. Blast It Global (2018); Appendix 3-3 • Klondyke Deposit Geotechnical Review of Blasting Report. Peter O'Bryan and Associates (2019); Appendix 3-4 • Environmental Noise Assessment: Warrawoona Gold Project, Marble Bar. Lloyd George Acoustics (2019); Appendix 3-5 • Warrawoona Gold Project Assessment of Dust Emissions. Environmental Technologies and Analytics (2019); Appendix 3-6

Receiving Environment	**Conservation Significant Bats**
	Based on an intensive sampling effort across the Proposal area and surrounds since 2016, the key outcomes of the Bat studies are:
	• Confirmed Ghost Bats and Pilbara Leaf-nosed Bats within the Proposal area, utilising old mine workings.
	• Confirmed regional significance of roosts in proximity to the Proposal area, including of the Klondyke Queen, Bow Bells South and Comet roosts:
	  ○ Klondyke Queen roost (200m west of proposed Klondyke pit) contains a colony of both Ghost Bats and Pilbara leaf-nosed Bat, and is considered a permanent diurnal roost for Pilbara Leaf-nosed Bat and a permanent maternity roost for the Ghost Bat.
	  ○ Bow Bells South roost (4km northwest of proposed Klondyke pit) contains a large colony of Pilbara Leaf-nosed Bats, and is considered a permanent diurnal roost (possible maternity roost) for the Pilbara Leaf-nosed Bat and an occasional diurnal roost for the Ghost Bat.
	  ○ Comet (20km north west of proposed Klondyke pit and outside of the Proposal area) contains a large colony of Ghost Bats and is a permanent maternity roost for this species.
	• Preferred foraging grounds for both bat species is outside the Proposal area, north of the Warrawoona Ranges.
	Other Conservation Significant Fauna
	A total of 35 species were recorded during field surveys across the Proposal area, of which four species are conservation significant (Biologic 2019d):
	• Northern Quoll: 10-12 individuals recorded over 3 sampling events within Hillcrest/Hillslope and Minor Drainage Line habitat types.
	• Western Pebble-mound Mouse: Five mounds (two of which were active) from Hillcrest/Hill slope habitat
	• Pilbara Olive Python: One individual was recorded in the Klondyke Queen old mine workings
	• Brush-tailed Mulgara: One individual was recorded over multiple nights in Sandplain habitat.
	No evidence was found of the Night Parrot, Greater Bilby or other conservation significant species considered likely or possibly occurring within the Proposal area, despite multiple targeted surveys in preferred habitats.
	SRE Invertebrate Fauna
	No specimens collected in the Proposal area were considered 'confirmed SRE invertebrate fauna'. Four groups of taxa that could be considered 'potential SREs' based on generic identification included *Araneomorphae, Pseudoscorpiones, Gastropoda* and *Isopoda*. It is highly unlikely that any SRE invertebrates are restricted to the Proposal area, with the SRE habitat types recorded extending beyond the disturbance footprint and are of lower complexity than those found in surrounding areas (Biologic 2018d).

Potential Impacts	• Direct loss of fauna habitat • Habitat fragmentation • Habitat modification and reduced habitat quality • Increased predation and competition from introduced species • Death or injury to individuals • Altered behaviour of populations and/or individuals • Altered fire regimes
Mitigation	Key mitigation strategies are summarised below. For more detail refer to Section 5.7. • Avoid removal of core breeding and roosting bat habitat (i.e. Klondyke Queen roost) • Minimise impacts to core habitat of other conservation significant fauna and SREs (i.e. the 'rocky breakaway' habitat type). • Establish a mining exclusion zone inside the development envelope to protect core habitat and provide a dam of fresh water during operations to detract from other, potentially lower quality water sources within the Proposal area. • Establish a 200m buffer between mining activities (in particular blasting) and core breeding and roosting habitat at the Klondyke Queen roost.

	• Blasting between 200m and 350m from Klondyke Queen roost will require 102mm diameter blast holes. At distances greater than 350m from the Klondyke Queen roost, 127mm or 165mm diameter blast holes will be used.
	• All blasts within 1,000m of Klondyke Queen roost will be monitored between the roost and the open pit, recording both air overpressure and ground vibration for all nearby blasts.
	• A cyanide reduction/destruction process (detoxification) will be established during secondary processing to reduce the concentration of weak acid dissociable (WAD) cyanide discharge to less than 30 milligrams per litre (mg/L) (40% lower than current industry standards for wildlife protection (DoIIS 2016)), which, following volatilization of cyanide post discharge, is likely to be even lower.
	• Implement the following procedures, to manage and monitor potential impacts and support the ongoing adaptive management approach for terrestrial fauna:
	  ○ Significant Species Management Plan (CRL-ENV-PLN-006-19; Appendix 9-1), which contains specific management and monitoring targets for fauna of conservation significance, to be reviewed on a regular basis.
	  ○ Blast Management Procedure (CRL-ENV-PRO-017-19; Appendix 9-2), which includes ongoing geotechnical assessment of Klondyke Queen roost following blasting activities and adaptive management and contingencies, depending on assessment outcomes.
	  ○ TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5) identify cyanide management and monitoring within the Proposal area.
	  ○ Ground Disturbance Permitting Procedure (CRL-ENV-PRO-002-19) will ensure disturbance remains within authorised boundaries.
	• Prevent unauthorised access to habitats of conservation significance, including the Klondyke Queen mining exclusion zone.
	• Design artificial lighting to limit illumination of the surrounding landscape, such as water sources and substantial rocky outcrops.
	• Conduct opportunistic monitoring and control of feral animals and implement measures to reduce the abundance of feral species in the Proposal area.
	• Employ housekeeping measures such as covering up landfill and bin management.
	• Prepare and implement best practice fire control strategies to manage unplanned fires.
	• Progressively rehabilitate disturbed habitat as soon as possible.

Predicted outcome	**Conservation significant bats** The Proposal will not remove any diurnal roosts. Proposed disturbance to bat habitat is limited to five old mine workings, considered temporary and low value refuge sites (R. Bullen, Bat Call WA, pers. comm. 2019; Biologic 2019f), as well as foraging habitat types typical of the drainage lines and plains that are well represented throughout the broader Pilbara IBRA region. Neither the temporary refuge sites or the foraging habitat types within disturbance footprint are considered critical to the survival of the local Pilbara Leaf-nose Bat and/or Ghost Bat colonies (Biologic 2019f). Mine pit dewatering at the proposed Klondyke mine will cause groundwater levels in the vicinity to decrease, which may influence the humidity levels at nearby bat roost sites. Dewatering is not expected to significantly impact the local colony of Ghost Bats at the Klondyke Queen roost as they are known to tolerate a wide range of roosting conditions (R. Bullen, Bat Call WA, pers. comm. 2019). However, the Pilbara Leaf-nosed Bats are considered more sensitive to changes in roosting conditions, and if humidity levels at Klondyke Queen reduce, the local population may vacate the Klondyke Queen roost in favour of the other alternative local diurnal roost sites concurrently used by the colony, including Bow Bells South, the main maternity roost in the local area for this species (R. Bullen, Bat Call WA, pers. comm. 2019; Biologic 2019f). Bow Bells South roost is approximately 4km from the Klondyke mine and is expected to maintain a significant saturated thickness (Groundwater Resource Management 2019b). Poor water quality at the TSF and the eventual mine pit lake at Klondyke was also considered an important potential impact. By committing to a concentration of WAD cyanide discharge less than 30mg/L, which is significantly lower than the 50mg/L currently recognised as a safe level for wildlife (Donato 1999; DoIIS 2016), Calidus will avoid any toxicity related impacts at the TSF. The pit lake that will form following mining at proposed Klondyke mine is expected to reach salinity levels that exceed that tolerated by bats within 3 to 4 years of mine closure. In the 3-4 years post closure, but prior to salinity levels reaching intolerable levels for bats, the arsenic levels (naturally occurring in the local groundwater) in the pit lake will be at a concentration that would require bats to consume large volumes of mine pit lake water each day (i.e. body weight equivalent of pit lake water each day) for

	acute poisoning to occur, which is considered highly unlikely by R. Bullen (Bat Call WA, pers. comm. 7 October 2019). The Proposal will establish a mining exclusion zone, which is a Calidus initiative that will ensure the long-term protection of important diurnal roost sites for Ghost Bat and Pilbara Leaf-nosed Bat colonies in proximity to the proposed Klondyke pit, including the Klondyke Queen roost complex. **Other conservation significant species, including SREs** Two habitat types of the Proposal area are considered high value habitat types for other conservation significant fauna known from (or potentially from) the Proposal area, and disturbance to these habitat types has been avoided where possible. It is proposed to clear less that 12ha of these high value habitat types, which represents just 3% of the total disturbance footprint. The two high value habitat types of the Proposal area include: • The Rocky Breakaway habitat type, which provides high density denning and foraging habitat for the Northern Quoll, and foraging habitat for the Pilbara Olive Python, Ghost Bat, Pilbara Leaf-nosed Bats and SREs. The Proposal will disturb 0.8ha of this habitat type, which represents just 4.6% of the rocky breakaway habitat type recorded across the Proposal area, and only 0.2% of the total disturbance footprint. This habitat type is well represented outside the Proposal area, across the Warrawoona Ranges and throughout other rangelands of the Pilbara IBRA region. • The Sandplain habitat type in the southern portion of the Proposal area supports Brush-tailed Mulgara, and potentially the Night Parrot and Greater Bilby (the latter two species are not confirmed within the Proposal area, despite multiple targeted surveys by Biologic (2019f)). The Proposal will disturb 11.1ha of this high value habitat type, which represents 8.1% of the recorded sandplain habitat type in the Proposal area, and only 2.8% of the total disturbance footprint. This habitat type is also well represented outside the Proposal area, across the plains north and south of the Warrawoona Range and throughout the plains of the Pilbara IBRA region. **General outcomes** Overall, there will be no loss of any Threatened Ecological Community or Priority Ecological Community and no loss of important populations of conservation significant fauna. The Proposal will not conflict with the intent of the *Biodiversity Conservation Act 2016*, as no terrestrial vertebrate or invertebrate fauna species will experience a change in conservation status as a result of the Proposal. Regional biodiversity is also unlikely to be affected by the implementation of the Proposal. **Management** The Proposal will protect high value habitat for many conservation significant species through the establishment of a mining exclusion zone within the development envelope. This exclusion zone will provide protection from mining for important bat roosting sites, including maternity and diurnal roosts for the Ghost Bat and the Pilbara Leaf-nosed Bat, as well as core denning and foraging habitat for other species of conservation significance such as the Northern Quoll and the Pilbara Olive Python. Other key mitigation strategies include blast procedures with drill hole diameter and 200m setback/buffer restrictions, and cyanide reduction (detoxification) processes that will reduce the concentration of WAD cyanide discharge to well below industry standards for wildlife protection (DoIIS 2016). Potential direct and indirect impacts to conservation significant bats and other terrestrial fauna of the Proposal area are expected to be managed through the implementation of the Significant Species Management Plan (CRL-ENV-PLN-006-19), the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19), the Blast Management Procedure (CRL-ENV-PRO-017-19) and the Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19). By avoiding core habitat for many of the conservation significant species, implementing adaptive management that responds to ongoing monitoring and adopting the measures detailed in the management and monitoring procedures developed by Calidus, the residual impact is not considered significant, and the Proposal will effectively meet the EPAs objective "to protect terrestrial fauna so that biological diversity and ecological integrity are maintained".

Table ES4: Summary of potential impacts, proposed mitigation and predicted outcomes for 'Other Factors'

FACTOR	INLAND WATERS
EPA Objective	To maintain the quality of groundwater and surface water so that environmental values are protected.
Supporting Studies	• Hydrogeological Investigations Report. Groundwater Resource Management (2019b); Appendix 4-2 • Hydro-Meteorological and Surface Water Management Study. Groundwater Resource Management (2019a); Appendix 4-1 • Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management. GCA (2019a); Appendix5-1 • Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management. GCA (2019b); Appendix 5-2 • Tailings storage facility design report. ATC Williams (2019); Appendix-5-3 • Metalliferous Drainage Management Procedure. CRL-ENV-PRO-022-19 (Trajectory 2019); Appendix 9-6
Receiving Environment	**Conceptual hydrogeological model** Following hydraulic testing at the Proposal area, a conceptual hydrogeological model was developed for the Klondyke deposit, which describes the hydrogeological characteristics of Klondyke as follows: • The rocks comprise a northwest trending sequence of metamorphosed basalt, ultramafic with pelitic schists. • The fresh bedrock has generally low to very low permeability and storage, where it is unfractured. • Average groundwater levels in the higher elevations along the Warrawoona Range can be around 25mbgl. • Transmissivity around the proposed Klondyke pit, away from major fracture zones, is generally low, however the Klondyke shear, which strikes northwest through the centre of the deposit provides a zone of preferential flow and permeability. • Transmissivity values along parts of the Klondyke Shear are moderately high, but varied, suggesting that the width of the more permeable zones along the Klondyke Shear may vary significantly over short distances. The results of the drilling at Copenhagen found that the permeability around the Copenhagen pit is low to very low with no significant permeable structures intersected. **Groundwater quality** The groundwater quality at Copenhagen and Klondyke pit areas is fresh to slightly brackish, and slightly alkaline. Concentrations of dissolved metals in the groundwater is generally low, apart from arsenic and iron (Groundwater Resource Management 2019b; Appendix 4-2.), with all sites well below the guideline value of 0.5mg/L for livestock watering. **Waste material characterisation** Geochemical characterisation, in accordance with the DMIRS *Draft Guidelines on Materials Characterisation*, was undertaken for all waste rock types at the Proposal area. Results found that all lithologies within the Proposal area are classified as Non-Acid Forming (NAF). One lithological unit, the Nickel Arsenic lithological zone (NAZ) was identified as having the potential to leach soluble arsenic at neutral pH from the waste rock. **Catchment** The Proposal is located within the Coongan River catchment, which is situated in the larger De Grey River Basin. Although located within the Pilbara Surface Water Area, the creek systems associated with the Proposal do not intersect any proclaimed Surface Water Management Areas or Irrigation Areas. The Proposal straddles the Warrawoona Range, a ridgeline that forms the local catchment divide between the Brockman Hay Cutting Creek/Sandy Creek/Camel Creek system to the south, and the Brockman Creek in the north (Groundwater Resource Management 2019a, Appendix 4-1).

	The total area of catchment loss across all three catchments is approximately 6.8km^2, which represents an almost 0.10% loss to the Coongan River catchment. No permanent pools are evident within the Brockman Creek/ Brockman Hay Cutting Creek/Sandy Creek or Camel Creek catchment, and no permanent pools have been located within the Proposal area, despite searches during extensive flora and fauna surveys and discussions with local pastoralists and land managers.
Potential Impacts	• Groundwater drawdown • Pit lake water quality • Altered catchment area and surface water flow • Altered surface water quality

Mitigation	Key mitigations strategies are summarised below. For more detail refer to Section 6.1.
	• Licence all groundwater abstraction under the RIWI Act and manage in accordance with licence conditions.
	• Implement the following procedures to manage and monitor potential impacts and support the ongoing adaptive management approach for inland waters:
	  ○ Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19; Appendix 9-4), which will incorporate groundwater levels and water quality monitoring.
	  ○ Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19; Appendix 9-3), which will include baseline surface water flow monitoring in drainage lines of the Proposal area.
	  ○ Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6); which focuses on identification, segregation, storage, encapsulation and monitoring.
	  ○ Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19).
	• Backfill pits at St George (two small satellite pits immediately north of Klondyke pit) and Copenhagen to prevent exposure of groundwater to evaporation.
	• Enclose and manage all chemical, oil and other hazardous material storage areas within the Proposal area in accordance with the relevant codes and standards.
	• Direct run-off from disturbed catchment areas upstream of the TSF to the reclaim pond and return to the plant for re-use.
	• Operate the TSF as a "zero-discharge" facility during operations
	• Provide sufficient freeboard on the TSF embankment to store runoff from upstream areas in addition to the tailing's impoundment for the 1% AEP 72-hour duration event (280 mm).

Predicted outcome	Groundwater will be affected primarily through dewatering at the proposed Klondyke pit and the subsequent development of a pit lake at closure. Future hydrological investigations to identify additional production bore targets will also be used to further refine both the groundwater flow model and the adaptive management strategies required to monitor and protect the local groundwater environment. Management of groundwater and surface water resources will be based on licence requirements issued under the RIWI Act, Mining Act (including approved Mine Closure Plan) and Part V of the EP Act, and will occur in consultation with DWER and DMIRS. Management requirements for inland waters will also be achieved through the implementation of a number of monitoring and management procedures, including a Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19), Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19), TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19), Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19) and a Hydrocarbon (and chemical) Spill Management Procedure (CRL-ENV-PRO-005-19). Through appropriate planning and management, overseen by DWER and in consultation with DMIRS, this Proposal will meet the EPA objective to "maintain the quality of groundwater and surface water so that environmental values are protected."
FACTOR	**TERRESTRIAL ENVIRONMENTAL QUALITY**
EPA Objective	To maintain the quality of groundwater and surface water so that environmental values are protected.
Supporting Studies	• Soils and Landform Assessment. Mine Earth (2019); Appendix 6-1 • Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management. Graeme Campbell and Associates (GCA 2019a); Appendix 5-1

	• Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management. Graeme Campbell and Associates (GCA 2019b); Appendix 5-2 • Tailings Storage Facility Design Report. ATC Williams (2019); Appendix 5-3
Receiving Environment	**Soils and landform assessment** A baseline soil assessment by Mine Earth (2019) identified five soil-landform associations within the Proposal area: 'drainage channels', valley floor', 'low hills / rises', 'ridgelines / rocky outcrops' and 'sandplain / stony flats'. The assessment of physical and chemical characteristics of surface soil found although soil depth varied between soil-landform associations, there was an overall consistency in the soils across the proposal area, with all soils presenting the following characteristics: • Relatively coarse grained • Generally low clay contents (a minor increase in clay with depth) • Non- to slightly-saline • Neutral to moderately alkaline pH • Non-sodic • Non- or only partially-dispersive • Free draining (moderate hydraulic conductivity) • Typically, low in organic carbon and plant-available nutrients. **Waste characterisation** Waste material characterisation identified one lithological unit, the Nickel Arsenic Zone (NAZ), as having the potential to produce metalliferous drainage. The report concluded that the NAZ requires particular management so that weathering is restricted and the risk for leaching soluble arsenic is minimised (GCA 2019a). Characterisation of mine tailings slurry concluded that the tailings in the TSF is classified as non-acid forming (NAF) and geochemically benign (GCA 2019b). **Tailings storage facility design** The proposed TSF is described as a valley facility whereby a cross valley containment embankment will be constructed across the alignment of the ephemeral Brockman Hay Cutting Creek (ATC Williams 2019). Seepage and stability analyses indicate the embankment will be geotechnically stable under design static and dynamic loading conditions with the mafic schist rock mass underlying the TSF is inferred to be of low permeability (ATC Williams 2019).
Potential Impacts	• Poor revegetation outcomes. • Impacts from uncontrolled surface water flow. • Metalliferous drainage from waste rock. • Poor water quality in open pits. • Poor geotechnical stability.

Mitigation	Key mitigations strategies are summarised below. For more detail, refer to Section 6.2.
	• Develop and implement Mine Closure Plan in accordance with DMIRS guidelines.
	• Ensure appropriate surface water management is incorporated into the final mine design, in accordance with the following design principles:
	  ○ Direct local natural surface water around mine infrastructure by means of drainage channels, earth bunds and road culverts with adequate scour protection where necessary.
	  ○ Runoff from the waste dumps will be directed to the TSF to allow water to be reclaimed back to the Plant via the decant pond.
	• Backfill St George and Copenhagen pits above the water table.
	• Contain hydrocarbons in accordance with AS1940:2004: *The Storage and Handling of Flammable and Combustible Liquids*, this includes sitting and bunding/containment restrictions, provision and maintenance of relevant material safety data sheets (MSDS) and regular inspections.

	• Implement the following procedures to manage and monitor potential impacts and support the ongoing adaptive management approach for terrestrial environmental quality:
	  ○ WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19; Appendix 9-7)
	  ○ Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19; Appendix 9-3)
	  ○ Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19, Appendix 9-6)
	  ○ Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19)
	  ○ Hydrocarbon (and chemical) Spill Management Procedure (CRL-ENV-PRO-005-19)
	  ○ Bioremediation Management Procedure (CRL-ENV-PRO-006-19)
	• Design, construct and rehabilitate TSF and WRDs to meet appropriate geotechnical standards, as per WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19) and the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19).

Predicted outcome	The Proposal is typical of mined landforms established in the Pilbara and all potential impacts relating to closure and rehabilitation at the Proposal area are also typical of gold mining operations throughout Western Australia. Management of terrestrial environmental quality will be largely driven by an approved Mining Proposal and Mine Closure Plan, to be developed in consultation with DMIRS and DWER. Management requirements for terrestrial environmental quality will also be managed through a comprehensive series of procedures, key to this are WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19, Appendix 9-7), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19, Appendix 9-6) and the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5). Through the implementation of management and monitoring strategies described above and with the development of an approved Mine Closure Plan, the risk of significant contamination from problematic waste material and the degradation of the terrestrial environment is low. Calidus expects that the EPA's objective for Terrestrial Environmental Quality, to "maintain the quality of land and soils so that environmental values are protected", can therefore be met.
FACTOR	**FLORA AND VEGETATION**
EPA Objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Supporting Studies	• Warrawoona Gold Project Flora and Vegetation Survey. Woodman Environmental (2019a); Appendix 7-1. • Memo of recommendations for referral of Warrawoona Gold Project, assessment against Clearing Principles. Woodman Environmental (2019b); Appendix 7-2.
Receiving Environment	**Flora** • A total of 266 discrete vascular flora taxa (including 11 introduced taxa), one known and three putative hybrids, representing 45 families and 122 genera (Woodman Environmental (2019a and 2019b). • Five conservation significant (Priority) flora taxa were recorded: *Eragrostis crateriformis* (P3); *Euphorbia clementii* (P3), *Heliotropium murinum* (P3), *Josephinia* sp. Woodstock (A.A. Mitchell PRP 989) (P1) and *Ptilotus mollis* (P3). • Two other significant (potentially undescribed) flora taxa were recorded: *Abutilon* aff. *hannii* and *Portulaca ?digyna*. • No Threatened taxa, listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or BC Act (Woodman Environmental 2019a and 2019b). • One Declared Pest recorded (**Calotropis procera*) (as listed under Department of Primary Industries and Regional Development 2019), but no taxa recorded were listed as Weeds of National Significance (as listed under Australian Weeds Committee 2019). Six introduced taxa which are ranked as having High ecological impact for the DBCA Pilbara Region (Woodman Environmental 2019a). • The diversity of the flora of the Proposal area is considered 'Moderate', in comparison with survey results from other similar Proposal areas in the Pilbara (Woodman Environmental 2019a).

	Vegetation • Two vegetation system associations (Abydos Plain 93 and George Ranges 82) (Government of Western Australia 2019) and three land systems were recorded (Macroy, Rocklea and Talga) (Van Vreeswyk *et al.* 2004), none of which are considered rare or restricted in the Pilbara region (Woodman 2019b). • Ten Vegetation Types (VTs) were recorded, of which five are considered to be of potential local significance (VTs 2, 3, 4, 8, 9) and one of potential regional significance (VT 8); • No listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs), listed under the EPBC Act; or BC Act. • One vegetation type containing localised areas of potentially groundwater-dependent vegetation occurs in the Proposal area (VT 3).
Potential impacts	• Clearing vegetation of significance • Increased weeds

Mitigation	• Avoid placing mine infrastructure in areas identified as being of high conservation significance as far as practicable
	• Locate WRD and TSF to avoid significant vegetation as far as practicable
	• Implement a ground-disturbance permitting procedure to ensure disturbance remains within authorised boundaries.
	• Make available maps of the approved disturbance envelopes to all persons involved in mine planning and initial ground-disturbance authorisation
	• Define clearing boundaries with on-ground markings (i.e. flagging) and as GPS coordinates in earth moving equipment.
	• Incorporate vegetation protection specifications in all construction-related contracts and subcontracts.
	• Implement weed hygiene measures for mobilisation and demobilisation of mining equipment entering and leaving the area and weed control in areas to be disturbed.
	• Include the following information in employee and contractor inductions:
	  ○ protection of flora and vegetation
	  ○ restriction of activities to within approval clearing boundaries
	  ○ identification and reporting of weeds
	  ○ hygiene procedures to minimise to introduction and spread of weeds

Predicted outcome	No Threatened species or ecological communities listed under the BC Act were recorded within the Proposal area. No DBCA listed Priority Ecological Communities occur within the Proposal area. The vegetation of the Proposal area is not considered to be strongly phreatophytic. Three Priority species (*Eragrostis crateriformis* P3; *Heliotropium murinum* P3; *Ptilotus mollis* P4) will be disturbed by the Proposal. These three species were all recorded in very high numbers throughout the Proposal area and have a high likelihood of occurrence on similar soil types and geologies outside the Proposal area (Woodman Environmental 2019a and 2019b). Similarly, all vegetation types that are within the proposed disturbance footprint are considered widespread or have a high probability of occurrence in the wider Pilbara IBRA region, either through their occurrence on relatively widespread geology, soil types and landforms or through their known occurrence in other studies (Woodman Environmental 2019b). Existing statutory controls for management of potential impacts to flora and vegetation resulting from dust, groundwater abstraction, hydrocarbon contamination and clearing, together with management controls to be prepared by Calidus, are sufficient to manage potential impacts to vegetation and flora. Flora and vegetation will not be significantly impacted by the Proposal and can effectively meet the EPA objective to "protect flora and vegetation so that biological diversity and ecological integrity are maintained."

FACTOR	SOCIAL SURROUNDINGS (ABORIGINAL HERITAGE)
EPA Objective	To protect social surroundings from significant harm
Supporting Studies	• Calidus Warrawoona Gold Project Archaeological Site Avoidance Survey. Archaeological Survey Report – Site Avoidance Level. Sands CRM (2019); Appendix 8-1 • Calidus Warrawoona Gold Project Ethnographic Site Avoidance Survey. Ethnographic Survey Report – Site Avoidance Level. SandS CRM (2018); Appendix 8-2
Receiving Environment	Consultation with Traditional Owners has not identified any significant issues to date, and no Aboriginal sites within the Proposal area have been entered onto the Department of Planning Lands and Heritage (DPLH) Register of Aboriginal Sites for the Proposal area. An archaeological site avoidance survey of the Proposal area, undertaken in conjunction with Njamal Peoples Trust and SandS CRM Archaeologists, recorded nine archaeological places within the survey area. An Ethnographic survey was undertaken (concurrently to the Archaeological survey) across the Proposal area. All Njamal participants confirmed the Proposal area did not contain any specific ethnographic sites or places. Note, because of recorded engraving sites in the Proposal area (Sands CRM 2019), it was agreed to recommend that if any archaeological sites that may have ethnographic importance are identified during future archaeological surveys, senior Njamal representatives are afforded the opportunity to be consulted about the cultural importance of any such place.
Potential Impacts	Disturbance of Aboriginal heritage sites
Mitigation	• The indicative disturbance footprint will avoid known archaeological places • Ensure all areas of proposed disturbance have been surveyed for Aboriginal heritage (ethnographic and archaeological) prior to disturbance. • In the event that an Aboriginal heritage site or place cannot be avoided, Calidus will submit a Section 18 application and obtain consent from the Minister for Aboriginal Affairs under the AH Act prior to disturbance. • In the event that an item of indigenous heritage is identified during construction or operations, ground disturbance will cease and the item of interest will be left in-situ until such time that the area can be appropriately viewed. Approval for recommencement of ground disturbing activities will only occur after consultation with native title claimants or their representatives and the DPLH as required.
Predicted outcome	Through archaeological and ethnographic surveys and consultation with Traditional Owners, areas of significance to the Aboriginal cultural heritage have been identified with the Proposal area and disturbance to these areas will be avoided. All potential impacts on Aboriginal cultural heritage are most appropriately managed through the ground disturbance procedures. Management of indigenous cultural heritage is primarily driven by corporate-level policy and by meeting obligations and requirements under the AH Act. If required, any mitigation strategies for cultural management will be undertaken through consultation with Traditional Owners and the DPLH. Through the protection afforded by processes under the AH Act, the Proposal will meet the EPA objective "to protect social surroundings from significant harm".
FACTOR	**SUBTERRANEAN FAUNA**
EPA Objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained
Supporting Studies	• Subterranean Fauna Survey. Biologic (2019e); Appendix 2-2 • Level 1 Vertebrate Fauna, Desktop SRE, Subterranean Assessment. Biologic (2017a); Appendix 1-1
Receiving Environment	A Level 2 subterranean fauna assessment within the Proposal area resulted in 1979 subterranean fauna specimens, with 99% stygofauna (1955 specimens) and 1% troglofauna (24 specimens). **Troglofauna** Relative to other subterranean fauna surveys within the wider east Pilbara region, the troglofauna species assemblage recorded within the Proposal area is considered depauperate (Biologic 2019e).

	Overall, one taxon recorded is widespread in the Pilbara, one taxon was recorded from multiple sites, and two taxa were recorded as singleton records (with the two remaining groups unable to be resolved to species-level). **Stygofauna** The stygofauna specimens resulted in 28 morphospecies and five indeterminate taxa, representing a rich stygofauna species assemblage compared to nearby surveys. Fourteen stygofauna taxa were widespread and known to occur throughout the wider catchment or regionally. Ten stygofauna taxa were recorded from multiple locations within the Proposal area, with known linear ranges spanning from 0.13km to 17 km. Three stygofauna taxa were singleton taxa or known only from a single site, whereas the remaining taxon represented a unique higher-level taxon that could not be identified to species level. **Subterranean invertebrate habitat** Overall, the current geological and hydrogeological information suggests that the potential habitats for troglofaunal and stygofaunal species found in the Proposal area is likely to extend beyond the pit boundaries, particularly at Klondyke pit to the north, north-west and south-east via shear zones and to the west via faults and fractures (Biologic 2019e).
Potential Impacts	Removal of troglofaunal habitat

Mitigation	• Licence all groundwater abstraction under the RIWI Act and manage in accordance with licence conditions.
	• Implement the following procedures to manage and monitor potential impacts to subterranean fauna:
	  ○ Ground Disturbance Permit Procedure (CRL-ENV-PRO-001-19)
	  ○ Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19)
	  ○ Hydrocarbon (and chemical) Spill Management Procedure (CRL-ENV-PRO-005-19)
	  ○ Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19)

Predicted outcome	Habitat connectivity for subterranean invertebrate fauna throughout the surrounding aquifers and geologies is considered likely and not restricted to the Proposal area (Biologic 2019e). The current geological and hydrogeological information suggests that the potential habitats for subterranean invertebrate species found at both Klondyke and Copenhagen pits is likely to extend beyond the pit boundaries (Biologic 2019e). At Klondyke, habitat connectivity is expected to the north, north-west and south-east via shear zones and to the west via faults and fractures. Copenhagen subterranean habitat is also connected through surface detritals/colluvials. Proposed water abstraction and mine pit dewatering is not considered to pose a conservation risk to subterranean fauna, given the high likelihood that habitat extends beyond the modelled extent of drawdown (both lateral and vertical) as defined in Section 5 and Section 6.1. This Proposal is expected to meet the EPA's objective for subterranean fauna "to protect subterranean fauna so that biological diversity and ecological integrity are maintained."
FACTOR	**AIR QUALITY**
EPA Objective	To maintain air quality and minimise emissions so that environmental values are protected.
Supporting Studies	• Warrawoona Gold Project Assessment of Dust Emissions. Environmental Technologies and Analytics. Environmental Technologies and Analytics (2019); Appendix 3-6 • Hydro-Meteorological and Surface Water Management Study. Groundwater Resource Management (2019a); Appendix 4-1
Receiving Environment	An air emissions desktop assessment has been completed for the Proposal area, which included characterising the local climate and meteorology and assessing potential atmospheric emissions for the Proposal, in support of the environmental regulatory approval. It is expected that the Proposal will create dust emissions due to construction, blasting, haulage and general traffic activities, the impacts of which may not be confined to the development envelope. Mean annual wind roses show that easterly's and south-easterly's predominate in the morning, and north-westerly's and northerlies in the afternoon. For the morning observation time it was noted that it was calm for about 7% of the year, while afternoons are nearly always windy with calm conditions noted only about 0.5% of the time (Groundwater Resource Management 2019a).

	It is expected that with the conventional measures in conjunction with the adopted exclusion zone and setback to sensitive roost locations, airborne dust emissions will be maintained within acceptable levels at sensitive receptor locations (Environmental Technologies and Analytics 2019).
Potential Impacts	Generation of dust affecting sensitive nearby roosts

Mitigation	• Areas subject to topsoil stripping will be minimised reducing the surface area exposed
	• Water trucks will be used to apply water to disturbed surfaces and unsealed road surfaces
	• Unsealed road surfaces will be maintained regularly to retain surface integrity
	• Vehicle speeds will be limited to minimise wheel generated dust
	• Dust suppression water sprays will be installed and operating at the processing plant – primary crusher, conveyor to surge bin, surge bin to emergency conveyor, emergency conveyor to stockpile, surge bin to apron feeder, reclaim hopper to conveyor, and conveyor to SAG Mill.
	• Calidus has also developed a series of procedures to mitigate potential impacts, of which the following are relevant to air quality:
	  ○ Blast Management Procedure (CLR-ENV-PRO-017-19, Appendix 9-2)
	  ○ Dust management procedure (CRL-ENV-PRO-015-19)
	  ○ Significant Species Management Plan (CRL-ENV-PLN-006-19, Appendix 9-1)
	  ○ WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19, Appendix 9-7)

Predicted outcome	Dust generation is unavoidable during construction and operations, but it is not considered significant if industry standard controls are implemented. Conventional dust management measures have been incorporated into the design of the Proposal. It is expected that, with conventional dust management measures and the proposed mining exclusion zone and 200m buffer to sensitive roost locations, airborne dust emissions will be maintained within acceptable levels at sensitive receptor locations. As the Proposal will not significantly affect air quality and will implement measures to minimise impacts on environmental values, this Proposal is expected to meet the EPA's objective for air quality, "to maintain air quality and minimise emissions so that environmental values are protected."

1 INTRODUCTION

This section provides an overview of the Proposal, including information about the proponent and the land tenure of the Proposal area. It also describes the purpose and scope of this supplementary information document. Finally, a description of the environmental impact assessment process is provided, along with a comprehensive list of the supporting studies that have contributed to the impact assessment of this Proposal.

1.1 Purpose and scope

Calidus Resources Limited (Calidus) is proposing to develop the Warrawoona Gold Project (the Proposal), a gold mining and processing operation 20km south of Marble Bar in the Pilbara Region of Western Australia (Figure 1).

The Proposal is being referred under Section 38 of the *Environmental Protection Act 1986* (EP Act) as it has the potential to significantly affect a key environmental factor, as defined by the Environmental Protection Authority (EPA).

This document serves to provide supplementary information in support of a Section 38 referral under the EP Act, in accordance with the *Instructions for the referral of a Proposal to the EPA under Section 38 of the Environmental Protection Act 1986* (EPA 2018a). The document has also been developed in accordance with the EPA (2018c) *Instructions on how to prepare an Environmental Review Document*, with the aim to review environmental factors relevant to the Proposal and provide the EPA with sufficient information to assess the Proposal.

1.2 Proponent

Calidus is a company incorporated in Australia and has shares listed on the ASX (ABN 98 006 640 553). All compliance and regulatory requirements regarding this assessment document should be forwarded to the following address:

Name:	David Reeves
Company:	Calidus Resources Limited
Title:	Managing Director
Address:	Level 1,11 Ventnor Ave, West Perth WA 6005
Phone:	+61 8 6245 2051
Mobile:	+61 420 372 740
Email:	dave@calidus.com.au

1.3 Land tenure

The proposed operations sit wholly within the mining leases, exploration leases and prospecting leases outlined in Table 1 and presented in Figure 2. Also included is miscellaneous licence L45/523 which overlaps parts of E45/3381, E45/4905, and E45/4906m and is therefore not included in the total area calculation.

Approximately 39.7% of the Warrawoona project tenements are situated within mining common R7979 and 5% is within timber reserves (4.4%), as well as water reserves and road reserves (0.3% each). Approximately half the project tenements are situated within pastoral stations, with Eginbah (Limestone) Station containing 47% and Corunna Downs Station with 8.2% (Figure 2).

Table 1 Warrawoona project tenements

Tenement	Holder(s)	Grant date	End date	Area (ha)
M45/240	Keras (Pilbara) Gold Pty Ltd	15/11/1986	17/11/2028	6.1
M45/547	Keras (Pilbara) Gold Pty Ltd	30/04/1993	2/05/2035	17.7
M45/552	Keras (Pilbara) Gold Pty Ltd	18/01/1993	18/01/2035	9.7
M45/668	Keras (Pilbara) Gold Pty Ltd	29/12/1995	28/12/2037	242.4
M45/669	Keras (Pilbara) Gold Pty Ltd	29/12/1995	28/12/2037	102.1
M45/670	Keras (Pilbara) Gold Pty Ltd	29/12/1995	28/12/2037	113.2
M45/671	Keras (Pilbara) Gold Pty Ltd	29/11/1995	29/11/2037	118.8
M45/682	Keras (Pilbara) Gold Pty Ltd	16/04/1996	17/04/2038	236.2
E45/3381	Beatons Creek Gold Pty Ltd	17/03/2011	16/03/2021	7965.6
E45/4666	Beatons Creek Gold Pty Ltd	24/11/2016	23/11/2021	3164.0
E45/4905	Keras (Pilbara) Gold Pty Ltd	30/11/2017	29/11/2022	638.9
E45/4906	Keras (Pilbara) Gold Pty Ltd	30/11/2017	29/11/2022	319.5
P45/2781	Beatons Creek Gold Pty Ltd	11/06/2012	10/06/2020	2.4
L45/523	Keras (Pilbara) Gold Pty Ltd	Pending	Pending	172.5*
Total area (ha)				**12,936.7**

*L45/523 overlaps with parts of E45/3381, E45/4905, and E45/4906m and is therefore not included in the total area calculation

1.4 Environmental impact assessment process

1.4.1 Primary environmental approvals

The principle legislation in Western Australia governing the environmental assessment of the Proposal is the EP Act.

Calidus has referred the Proposal under Section 38 of the EP Act (supported by this document). In the instance that the EPA decide not to assess the Proposal, a Native Vegetation Clearing Permit (NVCP) would therefore be required under Section 51(E) of the EP Act.

The principle Commonwealth legislation governing the environmental assessment of the Proposal is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Under the EPBC Act, actions that have, or are likely to have, a significant impact on matters of national environmental significance (MNES) require approval from the Australian Government Minister for the Environment.

The Proposal will be referred to the Minister for the Environment under the EPBC Act directly following EPA referral. In order to provide for assessment of the Proposal under the EPBC Act, this document also describes the potential impacts and mitigation measures relevant to MNES.

Figure 1: Location Plan, Warrawoona Gold Project

Source: DBCA - Nature Reserves, DPLH - Aboriginal Reserves
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_01, Rev: A

1.4.2 Secondary approvals

Secondary environmental approvals include all other statute requirements that address environmental risk and provide for the regulation of key environmental aspects, including:

- Mining Proposal under the *Mining Act 1978* (Mining Act), administered by the Department of Mines, Industry Regulation and Safety (DMIRS).
- Environmental Licences under Part V of the EP Act to operate the prescribed premises required for the Proposal, administered by the Department of Water and Environmental Regulation (DWER).
- Groundwater Licences under the *Rights in Water and Irrigation Act 1913* (RIWI Act), administered by DWER.

Relevant approvals and regulations required in support of the Proposal are summarised in Table 2. A summary of further legislative approvals and regulations that may be required is summarised below.

Table 2 Approval and regulations relevant to environmental aspect of the Proposal

Proposal activities	Tenure	Approval Type	Relevant Legislation	Government Agency
Disturbance, resulting in significant impact to MNES	Mining tenure under the Mining Act	*Environmental approval	EPBC Act (Commonwealth)	Department of Environment and Energy (DoEE)
Gold Mine Proposal Development	Mining tenure under the Mining Act	*Ministerial Statement	EP Act (Part IV)	DWER EPA Services
Clearing/land disturbance	Mining tenure under the Mining Act	Native Vegetation Clearing Permit	Clearing Permit: Only required where the Proposal is not assessed by the EPA under Part IV of the EP Act.	DWER and/or DMIRS
Mining	Mining tenure under the Mining Act	Mining Proposal and approved Mine Closure Plan	Mining Act	DMIRS
Processing or beneficiation of metallic ore	Mining tenure under the Mining Act	Environmental Licence	EP Act (Part V)	DWER
Mine dewatering	Mining tenure under the Mining Act	Environmental Licence	EP Act (Part V)	DWER
Vat or in situ leaching of metal	Mining tenure under the Mining Act	Environmental Licence	EP Act (Part V)	DWER
Sewage facility	Mining tenure under the Mining Act	Environmental Licence	EP Act (Part V)	DWER
Class II or III putrescible landfill facility	Mining tenure under the Mining Act	Environmental Licence	EP Act (Part V)	DWER
Construct/ Install groundwater Bore	Mining tenure under the Mining Act	License to construct a groundwater Bore	*Rights in Water and Irrigation Act 1913* (RIWI Act) (Section 26D)	DWER
Groundwater Abstraction	Mining tenure under the Mining Act	Licences to take water	RIWI Act (Section 5C)	DWER

Proposal activities	Tenure	Approval Type	Relevant Legislation	Government Agency
Disturbance of Aboriginal heritage sites	Mining tenure under the Mining Act	Approval to disturb registered Aboriginal heritage sites	*Aboriginal Heritage Act 1972* (AH Act) (Section 18)	Department of Planning, Lands and Heritage (DPLH)

*Primary approvals

Further legislative approvals and regulations that may also be required include:

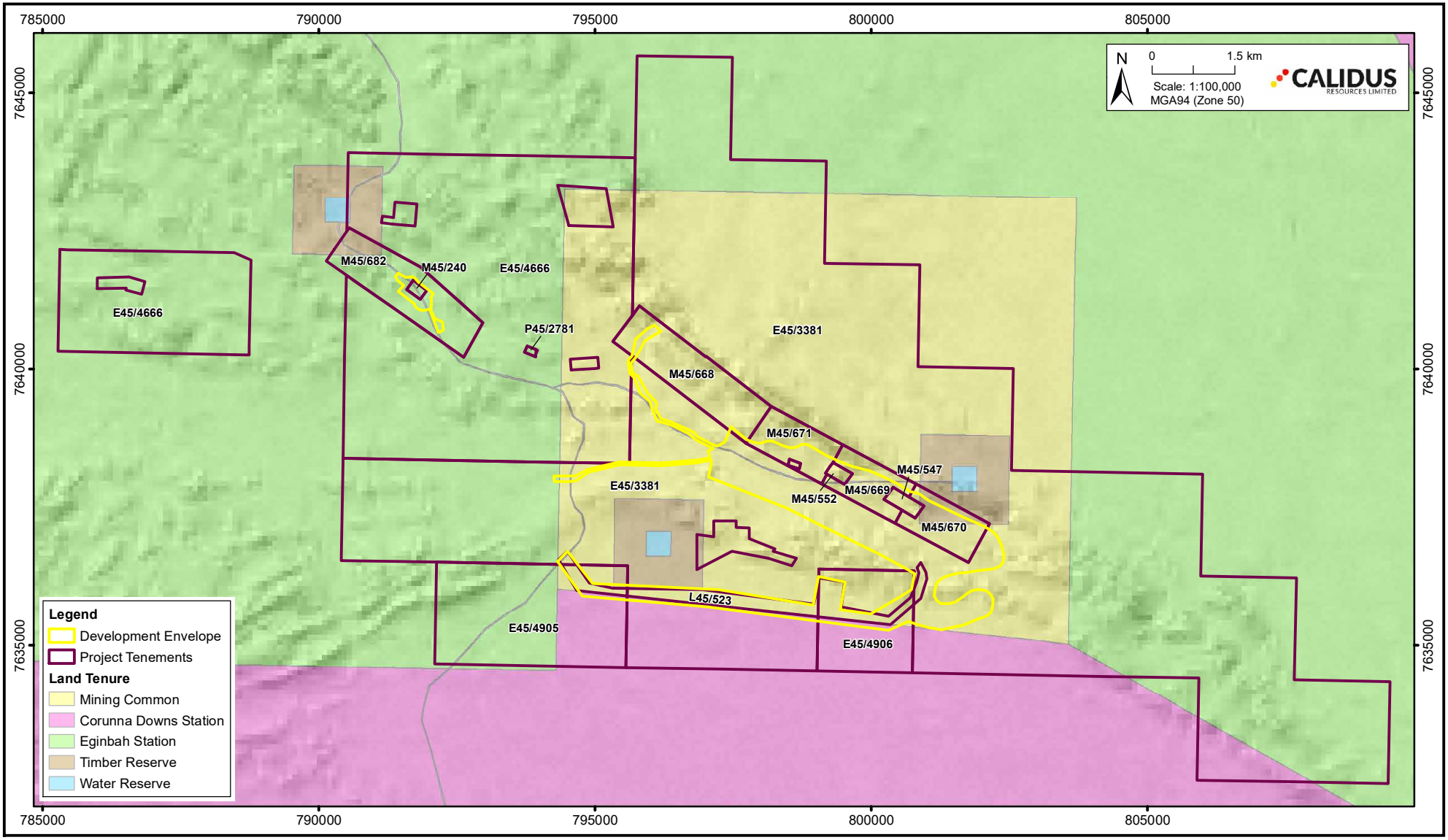
- *Agriculture and Related Resources Protection Act 1976* (administered by Department of Primary Industries and Regional Development, DPIRD): Management of Declared Weeds.
- *Mine Safety and Inspection Act 1994* (administered by DMIRS): Defines safety standards within the mining industry, including noise, dust, vibration etc.
- *Occupational Safety and Health Act 1984* (administered by DMIRS): Provides for the safety and health of persons in the workplace, including standards relating to noise, dust vibration etc.
- *National Greenhouse and Energy Reporting Act 2007* (Cwlth) (administered by Department of Environment and Energy, DoEE): Reporting requirements with respect to greenhouse gas emissions, reductions, removals and offsets, and energy consumption and production.
- *Environmental Protection (Noise Regulations) 1997* (administered by DWER): Specifies noise levels and air blast criteria.
- *Environmental Protection (Controlled Waste) Regulations 2004* (administered by DWER): Transportation and disposal of controlled (generally hazardous) wastes.
- *Environmental Protection (Unauthorised Discharges) Regulations 2004b* (administered by DWER): Requirements with respect to materials that must not be burnt or discharged of into the environment.
- *Planning and Development Act 2005* (administered by Department of Jobs, Tourism, Science and Innovation): Approval of buildings, including accommodation, workshops, administrative buildings and other similar structures (takes into account such matters as flood, surface water controls/drainage, noise, and other health-related matters).
- *Health Act 1911* (administered by Department of Health): Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974 provides for approval to construct or install an apparatus for the treatment of sewage, and the disposal of wastewater (sewage).
- *Dangerous Goods License under the Dangerous Goods Safety Act 2004* (administered by DMIRS): Approval to store fuel and/or chemicals above prescribed volume.

1.5 Supporting studies

The environmental impact assessment process is designed to investigate key environmental factors, consider the potential impacts to these factors from the Proposal and incorporate a responsible set of management controls to mitigate potential impacts.

Calidus has undertaken substantial investigations across a wide range of environmental factors and has completed a detailed assessment of the risks that the Proposal poses to the environment. Investigations that support the detailed environmental assessment undertaken in this document are summarised in Table 3.

Figure 2: Tenement Plan - Project tenements and local stations



Souce: DMIRS - Tenements, Land Tenure
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_02, Rev: A

Table 3 Summary of studies completed across the Proposal area

Investigation/Study	Year	Reference	Appendix
1. Terrestrial fauna			
Level 1 Vertebrate Fauna, Desktop SRE and Subterranean Assessment	2017-18	(Biologic 2017b)	Appendix 1-1
Monitoring bats of conservation significance near Marble Bar, Western Australia: November 2016	2016	(Specialised Zoological 2017a)	
Monitoring bats of conservation significance near Marble Bar, Western Australia: April 2017	2017	(Specialised Zoological 2017b)	
Targeted Bat Assessment, September 2017	2017	(Biologic 2018a)	
Targeted Bat Assessment, July 2018	2018	(Biologic 2018b)	
Targeted Bat Assessment, April 2019	2019	(Biologic 2019a)	Appendix 1-2
VHF Bat Foraging Studies 2018	2018	(Biologic 2018c)	
VHF Bat Foraging Studies 2019	2019	(Biologic 2019b)	Appendix 1-3
Habitat Assessment and Targeted Vertebrate Fauna Survey	2018-19	(Biologic 2019c)	
Significant Species Monitoring Survey Report (June 2019)	2019	(Biologic 2019d)	Appendix1-4
2. Invertebrate fauna			
Short Range Endemic (SRE) Invertebrate Fauna Survey	2018	(Biologic 2018d)	Appendix 2-1
Subterranean Fauna Survey	2018-19	(Biologic 2019g)	Appendix 2-2
3. Significant fauna impact assessment			
Conservation Significant Bat Species Impact Assessment	2019	(Biologic 2019e)	Appendix 3-1
Conservation Significant Vertebrate Fauna Impact Assessment	2019	(Biologic 2019h)	Appendix 3-2
Assessment of Blasting at the Klondyke Queen for Pilbara Leaf-nosed Bat and Ghost Bat (including 2019 underground mining addendum)	2019	(Blast It Global 2018)	Appendix 3-3
Warrawoona Project – Klondyke Deposit Geotechnical Review of Blasting Report	2019	(Peter O'Bryan and Associates 2019)	Appendix 3-4
Environmental Noise Assessment: Warrawoona Gold Project, Marble Bar	2019	(Lloyd George Acoustics 2019)	Appendix 3-5
Assessment of Dust Emissions	2019	(Environmental Technologies and Analytics 2019)	Appendix 3-6

Investigation/Study	Year	Reference	Appendix
4. Hydrology and Hydrogeology			
Hydro-Meteorological and Surface Water Management Study	2019	(Groundwater Resource Management 2019a)	Appendix 4-1
Hydrogeological Investigations	2019	(Groundwater Resource Management 2019b)	Appendix 4-2
5. Waste Characterisation and Management			
Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management	2019	(GCA 2019a)	Appendix 5-1
Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management	2019	(GCA 2019b)	Appendix 5-2
Tailings Storage Facility Design Report	2019	(ATC Williams 2019)	Appendix 5-3
Metalliferous Drainage Management Procedure	2019	(Trajectory 2019)	Appendix 9-6
6. Soils and Landforms			
Soils and landform assessment	2019	(Mine Earth 2019)	Appendix 6-1
7. Flora and vegetation			
Warrawoona Gold Project Flora and Vegetation Survey	2018-2019	(Woodman Environmental 2018); (Woodman Environmental 2019a)	Appendix 7-1
Memo of recommendations for referral of Warrawoona Gold Project, assessment against Clearing Principles	2019	(Woodman Environmental 2019b)	Appendix 7-2
8. Aboriginal Culture and Heritage			
2019 Calidus Warrawoona Gold Project Archaeological Site Avoidance Survey	2019	(Sands CRM 2019)	Appendix 8-1
2018 Calidus Warrawoona Gold Project Ethnographic Site Avoidance Survey	2018	(Sands CRM 2018)	Appendix 8-2

2 PROPOSAL

The section defines the Proposal, providing details on the key characteristics of the Proposal and describing the mining, processing and operations, including conceptual layout figures of the mine area and processing plant. Also provided is a description of the resources and a rationale for the implementation of the Proposal.

2.1 Background

The Proposal is located within the Warrawoona greenstone belt, which contains over 200 historic workings (mostly small shafts, stopes, and diggings) that have operated since the late 1800s.

The Warrawoona Gold Project comprises part of the Warrawoona Syncline which accommodates several quartz lode gold deposits. Mineralisation generally comprises thick sub-vertical shear zones potentially amenable to both open-pit and underground mining, with mineralisation outcropping at surface.

The deposits are hosted within three main shear zones: the Klondyke, Copenhagen and Fielding's Find shear zones. The Proposal is based on resources at the Klondyke deposit, which contains a number of old mine workings, and the Copenhagen deposit, which includes an historic pit.

The Klondyke Pit and Underground Prospect has a current 2012 JORC Code compliant Inferred Resource of 20 Mt at 1.79g/t Au for 1.15 million ounces.

The Copenhagen satellite deposit has a current 2012 JORC Code compliant Inferred Resource of 0.3 Mt @ 4.65g/t Au for 39,000 ounces.

2.1.1 Location

The Proposal is located in the Pilbara region of Western Australia, approximately 20km south of Marble Bar (Figure 1).

2.2 Justification

Australia contains 17% of the worlds known gold resources and is the second largest gold producer in the world (Minerals Council of Australia 2016, 2019). Gold mining in Australia the second largest employer in the mining sector, providing jobs (directly and related) for more than 55,000 Australians (Minerals Council of Australia 2016). As Australia's third largest export industry, the gold industry generates annual exports in excess of $19.8 billion (Minerals Council of Australia 2016 and 2019).

Economic and community benefits directly resulting from this Proposal, include but are not limited to:

- Contribution in royalties to the Western Australian Government in the order of $26 million.
- Corporate taxation income of more than $66 million to the Commonwealth Government.
- Initial capital investment of $125 million, with follow on economic output in the Pilbara region and state-wide.
- Total expenditure over the life of the project in the order of $1 billion, employing up to 300 people during construction and approximately 200 people over the initial proposed 6-year Project.

Mining from existing pits and old workings (such as those at Copenhagen and Klondyke) that have already experienced a high level of disturbance, has considerable efficiencies and benefits

environmentally. Mines that have received little to no historic rehabilitation can be a substantial risk to the environment, community and economy. A renewed interest in mining activities from these sites will also ensure they can be successfully rehabilitated in accordance with current best practice.

2.3 Description

2.3.1 Proposal characteristics

Key Proposal characteristics are summarised in Table 4, with the proposed development envelope and conceptual site layout plan presented in Figure 3.

The Proposal's indicative disturbance footprint is estimated to be 398.5ha within an estimated 1,000ha development envelope, as summarised in Table 5 and presented in Figure 3.

A detailed description of each of the components listed as key characteristics (Table 4) of the Proposal is provided from Section 2.3.2.

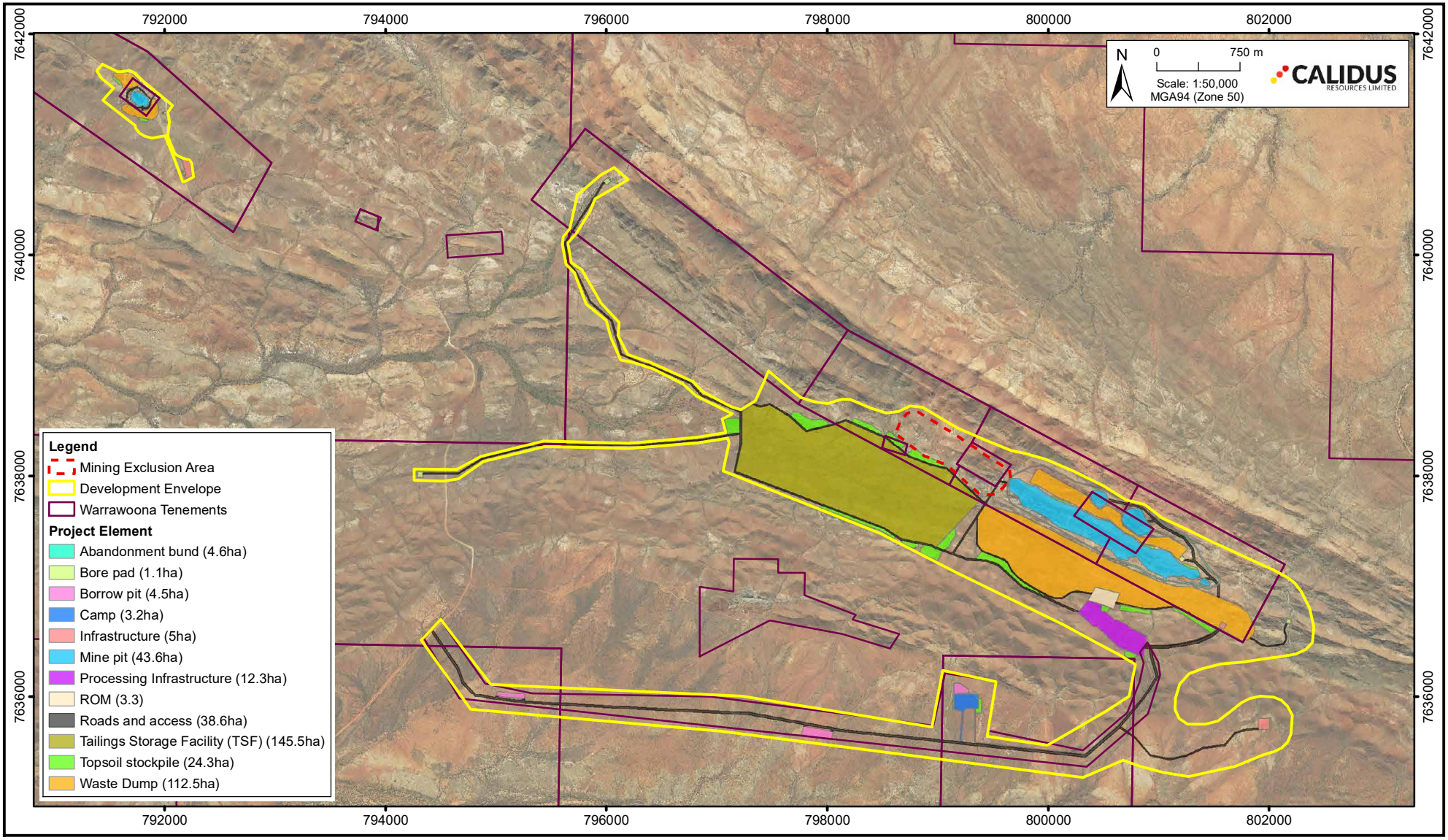
Table 4 Key characteristics, Warrawoona Gold Project (the Proposal)

Summary of the Proposal			
Proposal Title	Warrawoona Gold Project		
Proponent	Calidus Resources Limited		
Short Description	The Warrawoona Gold Project, approximately 20km south of Marble Bar Western Australia, will comprise: • An open pit and underground mine at the Klondyke deposit. • A cutback of the existing Copenhagen pit • A 2Mtpa processing plant at Klondyke • A 'valley fill' tailings storage facility (TSF) at Klondyke • A permanent waste rock dump (WRD) at Klondyke • Borrow pits, topsoil and vegetation stockpiles. • Power supplied from an LNG power station with diesel generator back-up, to meet 8MW demand. • Plant site area will include processing plant, offices, workshop, washdown facilities, hazardous material storage, refuelling station, and contractor area. • Accommodation village will include accommodation blocks, kitchen, first aid, recreational facilities, waste water treatment plant and generator. • Associated mine infrastructure and utilities elements will include stormwater management infrastructure (bunds and diversion drains), magazine, mine access roads, pipelines and power lines. The project will produce gold bar and gold concentrate and is expected to operate for approximately six years.		
Element		**Location**	**Proposed Extent Authorised**
Physical Elements			
Open pits, WRD, processing plant, borrow, explosives storage, village, and associated mine elements		Figure 3	Clearing no more than 253ha within the 1,000ha development envelope.
Tailings Storage Facility		Figure 3	Clearing no more than 145.5ha within the 1,000ha development envelope.
Operational Elements			
Mining Waste Rock – Klondyke		Figure 3	Disposal of no more than 20 million loose cubic metres (LCM) of permanent surface WRD.
Mining Waste Rock – Copenhagen		Figure 3	Disposal of no more than 300k LCM of permanent surface WRD.
Process Tailings		Figure 3	Disposal of no more than 2Mtpa in a 'valley fill' facility at Klondyke.

Table 5 Estimated land disturbance for key Proposal components

Proposal Components	Estimated Total Disturbance Area (ha)
Abandonment bunds	4.6
Bore pads	1.1
Borrow pits	4.5
Camps	3.2
Infrastructure	5.0
Mine pits	43.6
Processing Infrastructure and ROM	15.5
Roads and access corridors	38.6
Tailings Storage Facility (TSF)	145.5
Topsoil stockpiles	24.3
Waste dumps	112.5
Total	**398.5ha**

Figure 3: Conceptual site layout and development envelope



Source: DMIRS - Tenements
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_03, Rev: A

2.3.2 Mining

2.3.2.1 Open pits

The main deposit to be mined is the Klondyke Pit, with Copenhagen Pit (a cut-back of the existing mine, 8 kilometres north west of Klondyke) the secondary deposit.

The Klondyke open pit will be approximately 2km long by 200 metres wide. Final pit floor elevations will be approximately 150m deep (Figure 4).

The Klondyke deposit will be mined using conventional open pit mining methods comprising:

- Clearing, stripping and stockpiling of near surface material in the area of the pit and proposed waste storage facility;
- Initial pioneering work in pit areas with high topographic relief to establish suitable sized working bench areas for the proposed mine fleet;
- RC grade control programmes to further delineate ore boundaries;
- Blasting will occur using 102mm diameter holes (when occurring between 200m and 350m from Klondyke Queen roost). At distances greater than 350m from the Klondyke Queen roost, 127mm or 165mm diameter blast holes will be used. All blasts within 1km of Klondyke Queen roost will be monitored with a permanent blast monitors located between the roost and the open pit.
- Load and haul using 130t excavators and 100t rigid trucks using 2.5m flitch heights;
- Haulage of ore to the ROM pad stockpiles to be fed to the crusher.

Following mine closure, a pit lake will remain at the Klondyke pit, forming a hydraulic (groundwater) sink. From year 3 to 100 years post closure, the pit lake level is predicted to fluctuate between 178mRL and 204mRL (Groundwater Resource Management 2019b). Current elevation at the proposed Klondyke pit area and edge is between 278.1mRL and 304.8mRL (Groundwater Resource Management 2019b).

The Copenhagen cutback pit will extend a further 35m from its current perimeter and 25m deeper.

No pit lake will remain at Copenhagen or the Klondyke satellite pits (St George pits, directly north of Klondyke pit), as these will be backfilled.

2.3.2.2 Underground

The Underground mine at Klondyke deposit will be accessed via a portal. Key characteristics of the underground mine design approach include:

- Access via a 5.5mW x 5.7mH decline, commencing from a dedicated box cut adjacent to the processing plant, administration area and workshops;
- The planned mining method is uphole benching, retreating to a crosscut (Figure 5);
- A floor to floor level interval of 25m with a decline standoff at least 30m from the orebody;
- A network of underground escapeway rises will provide a continuous second egress;
- Primary ventilation will be via raise bores collared within the open pit. The initial raise from surface is designed at 4.0m diameter;

A long-section of the proposed Klondyke orebody is shown in Figure 5 with the view-oriented west (left) to east (right).

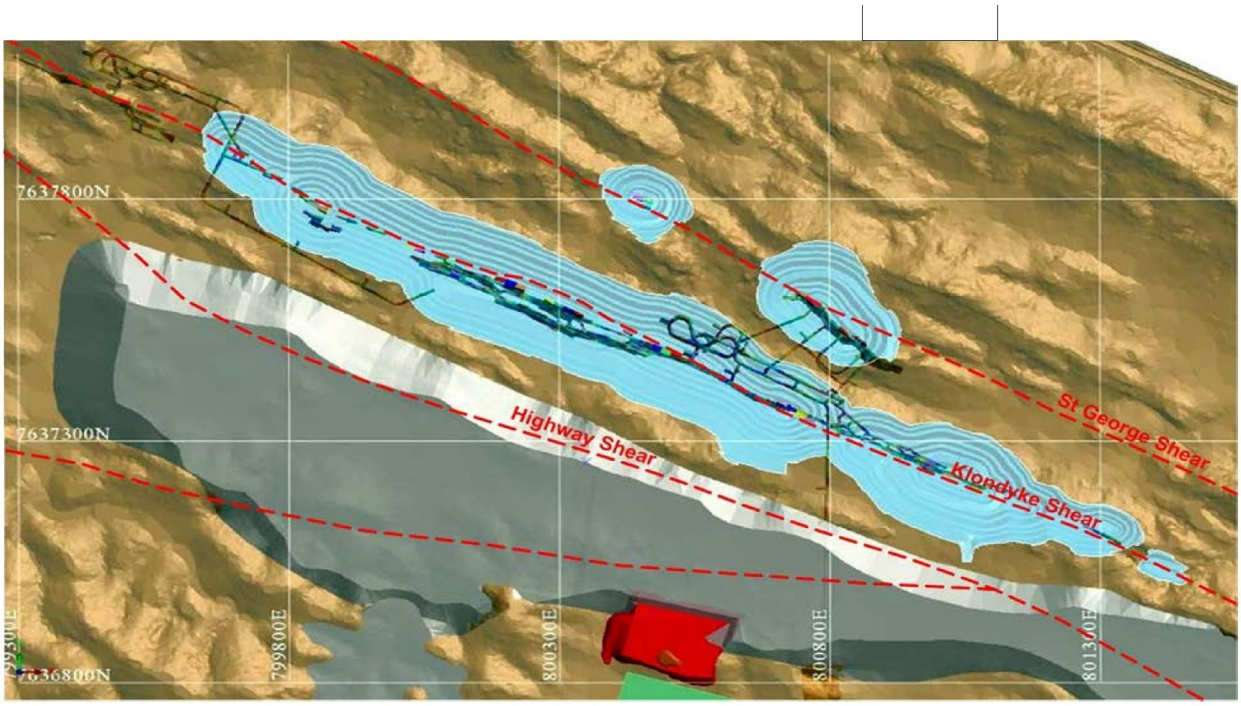


Figure 4 Klondyke deposit mine pit (and the 'St George' satellite pits) and underground design

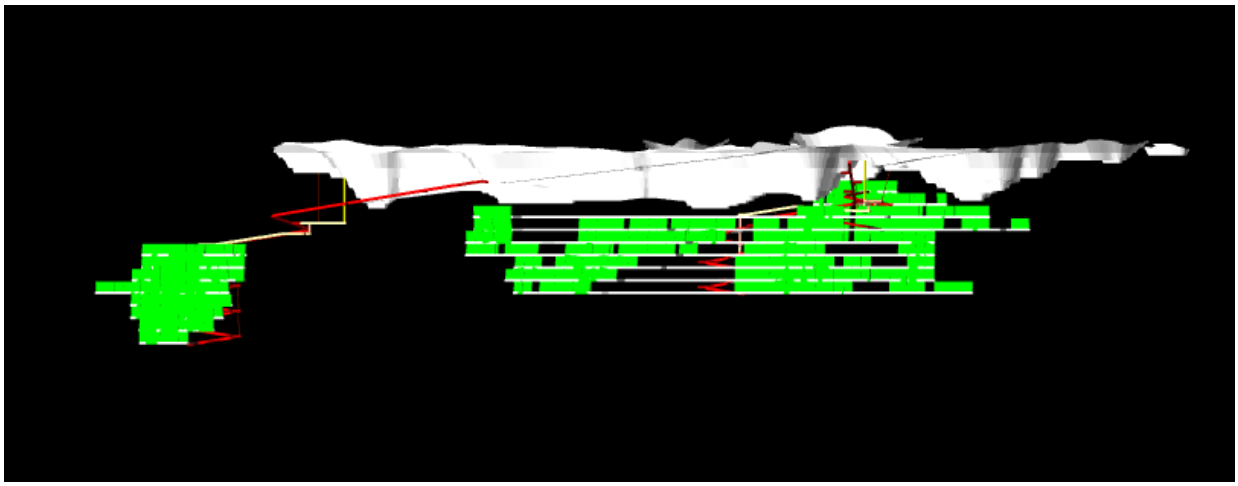


Figure 5 West-east long-section of the proposed Klondyke pit

2.3.2.3 Blasting and buffer

A set of blast parameters were modelled for potential blast vibration, airblast overpressure and flyrock and based on blast parameters that will not compromise nearby bat roosts (Blast It Global 2018).

A 200m buffer will exist between the main project Klondyke Pit and bat roosts (Figure 6). The 200 metres is an expansion of 185m recommended by Blast It Global (2018) to achieve a blast vibration limit of 10mm/second. Refer to Section 5.7.3.4 and Section 5.7.3.5 for more detailed recommendations on blasting management.

More information on bat roosts is provided in Section 5.

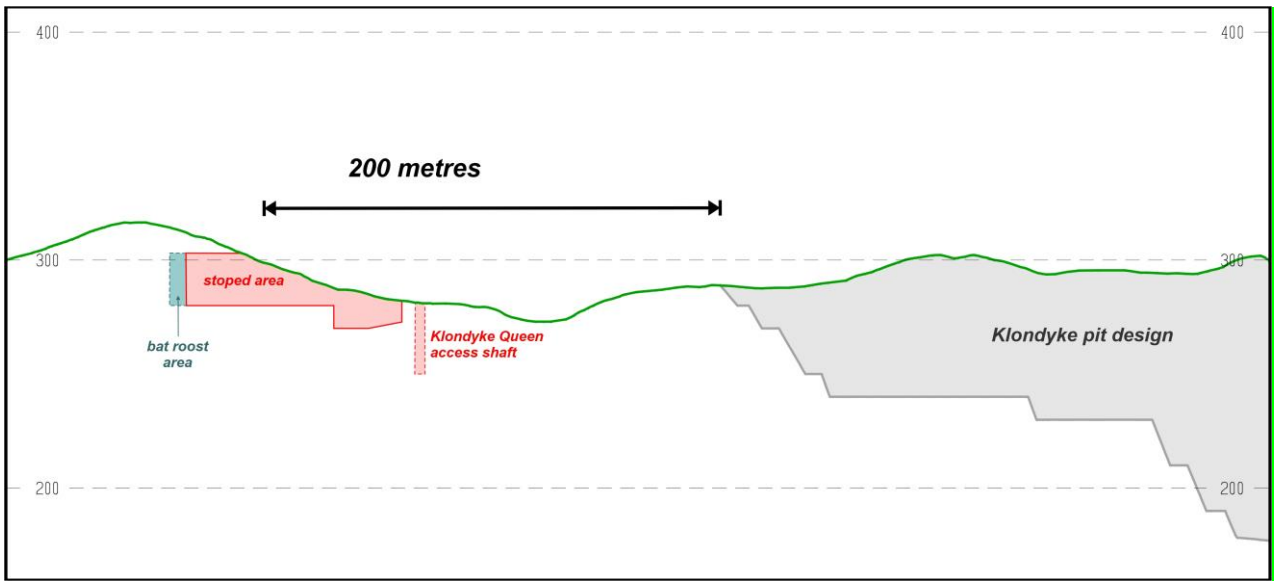


Figure 6 West-east long-section of the proposed Klondyke pit in relation to Klondyke Queen roost site

2.3.2.4 Mining exclusion zone

In addition to the 200m buffer described above, a further mining exclusion zone covering 32 hectares is proposed to protect sensitive bat roosts in the vicinity of Klondyke mine. This is shown on Figure 3. No mining will occur within this exclusion zone to protect several historical workings with known bat populations.

The exclusion zone, which includes the important Klondyke Queen workings is deemed an adequate protection (R. Bullen, Bat Call WA, pers. comm. 2019) because of the topography between the Klondyke workings and the Klondyke pit crest. The proposed pit is located at the western end of the Klondyke Queen workings on a separate hill on the opposite side of a gully which acts as a natural shield and further reduces noise and vibration impacts.

For more information on the Klondyke Queen roost complex and the environmental values of the mining exclusion zone, refer to Section 5 and Appendix 9-1, Significant Species Management Plan (CRL-ENV-PLN-006-19).

2.3.3 Waste rock disposal

The waste rock dump (WRD) at Klondyke will be constructed in proximity to the pit for disposal of approximately 20 million LCM of waste rock. The proposed location for this landform, as shown in Figure 3, has been designed and located in order to:

- avoid detrimental geotechnical conditions.
- avoid potential mineralised areas.
- minimise footprint and vegetation disturbance.
- minimise drainage impacts
- avoid watercourses and areas of potential flooding.
- avoid heritage sites or areas of cultural importance.
- avoid impacts on conservation significant flora and fauna.
- consider the local hydrology (sheet flow) through the area
- use the natural relief to blend the waste rock dump (no waste rock above the height of natural topographic highs).
- shed water towards the TSF so that water can be captured in the TSF decant and utilised for process water.
- to be recontoured at mine closure to shed water towards the Klondyke Open Pit which will be an evaporative sink (modelled for 100 years).

The WRDs at Copenhagen will be backfilled into the Copenhagen pit at closure. Due to swell factor, a small WRD will remain at Copenhagen.

2.3.3.1 Drainage

The Klondyke WRD has been located and specifically designed to minimise impacts on the existing drainage system by constructing waste rock dumps, where possible, within the uppermost parts of the local catchments.

The strategy for the Copenhagen deposit will be to construct a temporary WRD around the pit, which will be backfilled at closure. The backfilled pit will also encapsulate potentially hostile waste rock material that, if left on the surface, may produce metalliferous drainage. This is further addressed in Section 6.1, with mitigation measures provided in the Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19) (Trajectory 2019; Appendix 9-6).

2.3.4 Ore processing

2.3.4.1 Primary processing

The proposed processing plant (Figure 3, Figure 7) is a 2Mtpa treatment facility utilising a single stage crusher with semi-autogenous-grinding (SAG) mill and conventional carbon-in-leach (CIL) circuit. Tailings are thickened before going through cyanide detoxification (Section 2.3.5.7) and discharged to the valley fill TSF (Section 2.3.5).

The plant has been designed in accordance with accepted industry practice and the above facilities are discussed further in the following sections. A block flow diagram of the primary processing plant is shown below in Figure 8.

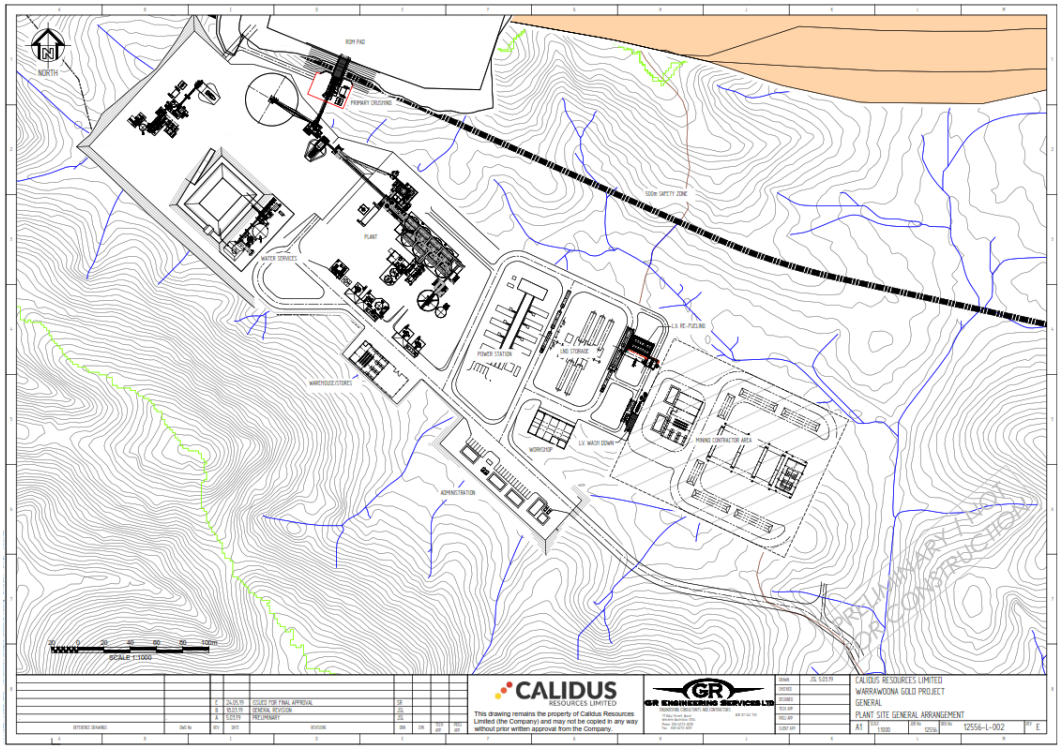


Figure 7 **Proposed plant site general arrangement**

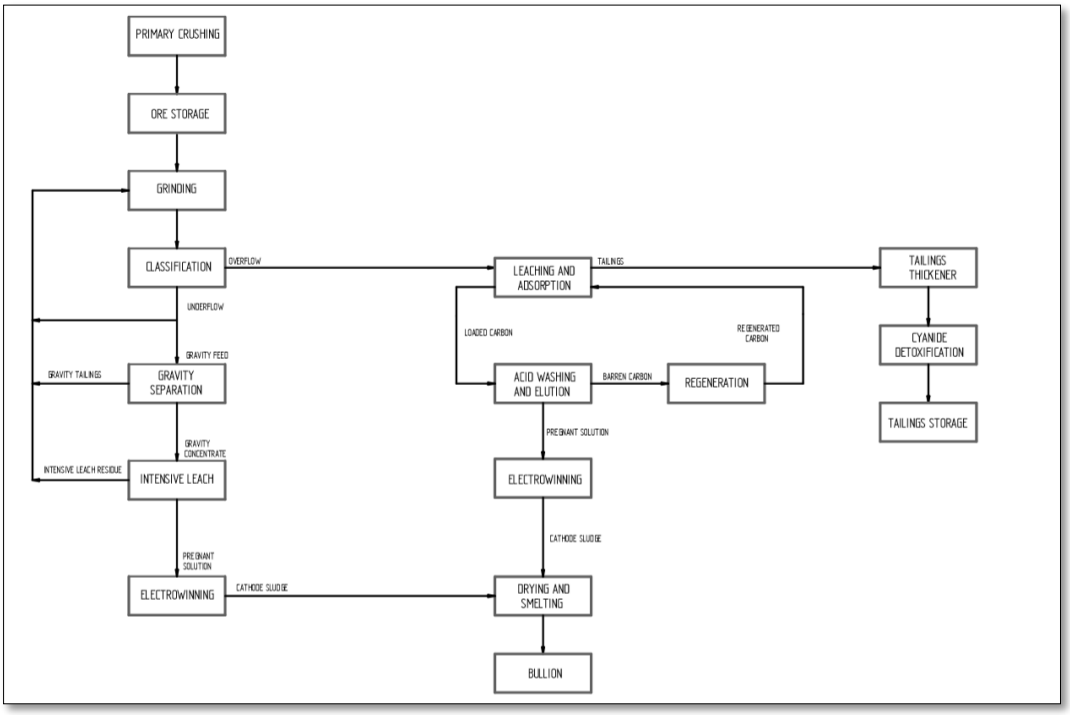


Figure 8 **Primary Plant Block Flow Diagram**

2.3.4.2 Secondary processing

A small 100ktpa milling and flotation circuit is proposed for treatment of the high-grade refractory Copenhagen deposit. The plant will produce an approximate 130g/t Au concentrate that will be shipped to a third-party processing plant.

The sulphide circuit will be a small standalone, modular and transportable plant consisting of flotation cells, concentrate thickener and filter press. The concentrate would be loaded into "bulka bags" for transporting off site in a sealed sea container. It is expected that material will be feed to the plant via a mobile crushing plant and that the plant will be capable of being operated by a single person.

Tails from the Sulphide Circuit at Klondyke would report to the main CIL processing plant tails thickener for thickening and Cyanide Detoxification to reduce weak acid dissociable (WAD) cyanide levels to below 30 milligrams per litre (mg/L). This slurry is then pumped to the tailings (see Section 2.3.5.7 for more information) (Figure 8).

2.3.4.3 Drainage

Drainage will include installation of appropriate surface water management infrastructure (e.g. construction of sediment ponds, installation of bunds and diversion of clean water around plant).

Water management/sedimentation ponds will be designed to store runoff from the 10% annual exceedance probability (AEP) 24-hour rainfall event i.e. 130 mm rainfall, without discharge.

Sedimentation ponds will have a minimum live settling depth of 1m and an aspect ratio (length: width) of not less than 3:1 and preferably 5:1. Sufficient provision for settled sediment storage and freeboard will also be made (Groundwater Resource Management 2019b).

2.3.4.4 Reagents and services

The following reagents and consumables will be used in the process:

- Quicklime
- Sodium cyanide
- Hydrochloric acid
- Sodium hydroxide
- Activated carbon
- Grinding media;
- Liquefied natural gas (LNG)
- Leach aid
- Smelting fluxes

Reagents are received and used as delivered, except for cyanide which is received as a bulk solid and will be dissolved with water in a closed sparge system to a concentration of 27% by weight and transferred to a storage tank.

All chemical reagents will be stored within tanks in appropriately bunded facilities whereby 110% of the largest vessel is contained and 25% of the total volume is contained according to Australian Standards AS1940 and AS1692. Stocks of reagents will be stored in a designated storage shed, appropriately designed to comply with all relevant legislation.

Sodium cyanide solid will be delivered to site by truck, mixed and transferred to the storage tank. Cyanide solution will be circulated through the leach and CIL circuit in a ring main, using separate control valves to regulate the addition of cyanide to the various tanks. The addition of cyanide solution to the intensive leach reactor and to the elution circuit will be made by dosing valves off the ring main.

Hydrochloric acid will be dosed to the elution column and diluted in-stream with fresh water to a concentration of 3% by weight for washing of the loaded carbon.

The addition of sodium hydroxide solution to the intensive leach reactor and to the elution circuit will be made using dosing valves off the ring main.

Flocculant will be mixed in an automated mixing system and aged prior to transferring into the storage tank. Dedicated duty/standby dosing pumps will supply the flocculant to the thickener where it is diluted 10-fold with raw water prior to use in the thickener.

Grinding balls will be added directly to the emergency feeder to maintain the ball charge in the mill.

2.3.5 Tailings storage facility (TSF)

Following cyanide detoxification (see Section 2.3.5.7) and thickening to approximately 65% solids, the process tailings will be pumped to a 'valley fill' TSF northwest of the plant as shown in Figure 3. Preliminary designs indicate that approximately 10.5 Mt of tailings will be stored in the TSF over the life of the project.

2.3.5.1 Location

The location of the proposed tailings storage facility (TSF) site was selected based on the following factors:

- It is adjacent to the processing plant.
- The valley size is suitable to store the full volume of tailings and evaporate excess water within the one location, therefore minimising the requirement for additional associated elements.
- No heritage sites or areas of cultural importance have been identified within the footprint.
- No Threatened flora or communities listed under the *Biodiversity Conservation Act 2016* (BC Act) or EPBC Act are recorded on the footprint.
- No underground workings that are utilised by Significant Bats have been identified within these footprints.
- No high value habitat within footprint.
- A valley fill dam minimises engineered embankments and has been recommended by DIMRS as the best form of dam for closure (refer to Section 3.3, Stakeholder communications).

2.3.5.2 Concept

TSF design will comply with the following:

- ANCOLD May 2012 - Guidelines on Tailings Dams - Planning, Design, Construction and Closure.
- Department of Mines and Petroleum (DMP) 2013, "Tailings Storage Facilities in Western Australia - Code of Practice", Resources Safety and Environmental Divisions
- Department of Mines and Petroleum (DMP) 2015, Guide to the Preparation of a Design Report for Tailings Storage Facilities (TSFs)

The TSF concept involves a down-valley discharge from a single point discharge at the eastern end of the TSF area. Tailings will then flow down existing drainage lines and accumulate against the main cross-valley TSF embankment.

The TSF has been designed to store 1:10 AEP notional wet season in addition to a 1:100 AEP, 72 hrs storm event.

All decant and runoff water collecting on the tailings beach will be conveyed via a decant tower constructed on the upstream side of the main TSF embankment, accessible via a causeway.

The facility has an overall catchment of 5.7 km^2 including the tailings storage area and adjacent waste dump. Bleed water from the tailings and excess rainfall run-off from the catchment will be stored within the TSF area, before being pumped back to the process plant.

The TSF embankment will be constructed in two stages. Stage 1 will have a design life of approximately 4 years, and Stage 2 will have a design life of 3 years. Stage 2 will be constructed using downstream construction techniques. The Life of Mine (LOM) embankment is expected to be approximately 17m high and 260m long.

Each stage will include an emergency spillway constructed in competent natural ground. The LOM/Closure spillway will be located approximately 200m to the north of the embankment in an area where the natural topography provides a suitable spillway location.

Geotechnical investigations indicate that the embankment foundation will comprise rock (weathered schist) at shallow depth (ATC Williams 2019; Appendix 5-3). Superficial gravelly clayey sand deposits were identified in the vicinity of the embankment which may be suitable for construction of a low permeability zone in the embankment and locally excavated schist may be suitable to construct the bulk of the embankment; however, in the event that insufficient material is available, the alternative is to build the embankment with mine waste rockfill material with an upstream filter / cushion layer upon which an impermeable Bituminous Geomembrane (BGM) will be placed.

2.3.5.3 Seepage

Significant lateral seepage through the embankment is not anticipated; nevertheless, the subgrade for the low permeability zone or BGM liner will be designed to act as a filter for the tailings, such that the potential for ingress of tailings or water which could potentially migrate further through the embankment will be mitigated.

Any lateral seepage through the foundations of the TSF embankment will be intercepted and collected at a seepage interception trench at the downstream side of the embankment. This seepage will then be pumped back into the TSF decant pond area (or to the plant process water pond).

Additional seepage control contingencies may include installation of seepage recovery bores, placement of an upstream low permeability blanket or foundation grouting.

Mine dewatering will develop a strong local hydraulic gradient towards the Klondyke pit over time, such that any potential seepage from the TSF, which reaches the water table, will likely migrate towards it (Groundwater Resource Management 2019b).

2.3.5.4 Chemical properties

Based on the tailings test work results (GCN 2019b) the tailings in the TSF will also be geochemically benign and is classified as non-acid forming (NAF). A modest enrichment in arsenic should occur, chiefly associated with arsenopyrite. Secondary Fe/Ca-arsenates formed during weathering should constrain tailings-pore-fluid-As concentrations to within the sub-mg/L range (GCN 2019b, Appendix 5.2).

2.3.5.5 Monitoring

Approximately 5-10 groundwater monitoring bores will be installed around the TSF area to monitor groundwater level and quality. The bores will be sampled quarterly to provide data throughout the life of the project.

Approximately 4-6 Vibrating Wire Piezometers (VWPs) will also be installed within the TSF embankment footprint area. The purpose of the VWPs is to monitor development of any pore pressure within the embankment.

A series of monitoring instruments will be installed on the crest of the embankment to monitor crest settlement of the embankments over time. It is expected that 8–10 prisms may be required for the embankment. Additional prisms will be installed after the embankment raise.

For more information on monitoring, refer to the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5).

2.3.5.6 Drainage

Run-off from disturbed and undisturbed catchment areas upstream of the TSF will report to the reclaim pond where it will be temporarily stored before being returned to the Plant for use. The TSF will function as a "zero-discharge" facility during operations and sufficient freeboard will be provided on the embankment to store runoff from upstream areas in addition to the tailings impoundment for the 1% AEP 72-hour duration event (280 mm).

At the cessation of mining, runoff from the southern faces of the Klondyke WRD (156,000m^2), undisturbed areas upstream of the TSF impoundment (3,330,000m^2) and the ultimate tailings surface (1,339,000m^2) will report off-site via the TSF closure spillway (Groundwater Resource Management 2019b).

The top surface of the TSF will be managed with drainage containment cells between 1-2ha in size and of a height of approximately 0.7m to contain a probable maximum precipitation. This will contain the majority of runoff directed towards the TSF, prevent erosion and allow for water infiltration. A closure spillway will be constructed to convey runoff from natural ground and portions of the tailings surface not configured into containment cells. This spillway will be constructed over high durability, natural ground and the area not covered by cells and the spillway will be covered with durable waste rock to act as a sedimentation trap.

2.3.5.7 Cyanide detoxification

Cyanide is used in the leaching of gold from ore and the elution of gold from carbon. The cyanide solution will be pumped from the storage tank to the leaching circuit, where it will be added to the ore slurry. Automated cyanide detection in the plant will frequently test for WAD cyanide concentration in the hopper(s).

The potential for cyanide to impact on the conservation significant fauna of the Proposal area has been identified as an environmental risk (refer to Section 5). To mitigate the risk of cyanide impacts, the Proposal will establish a cyanide reduction/destruction process and implement cyanide management procedures.

In recognition of the two species of conservation significant bats within the Proposal area, Calidus commits to a concentration of WAD cyanide discharge below 30mg/L, which following volatilization of cyanide post discharge, WAD cyanide in the supernatant is likely to be even lower. This is well below the current recommended value of 50mg/L, which is the industry guidelines for wildlife protection (DoIIS 2016).

Preliminary test work has also confirmed that post cyanide destruction can increase the conductivity of the tailings slurry (GCA 2019b). Increased salinity of the tailings discharge as part of the chemical reaction of

the cyanide destruction/reduction process will further lower the risk of fauna such as bats consuming tailings liquid, as bats are known to avoid saline water environments (R. Bullen, Bat Call WA, pers. comm. 2019; Biologic 2019f). This assumption will be monitored and mitigation measures introduced as part of an adaptive management approach. Cyanide protocols will also allow for adaptive management of WAD cyanide discharge concentrations as the project progresses and data becomes available.

2.3.5.8 Containment of cyanide process waters

Tanks used to hold the process solutions (i.e. leach tanks) will be located on bunded concrete containments. The processing plant will be designed such that process water containing cyanide is recycled and therefore kept within the area encompassed by the processing plant run-off collection drain and storage. In the event of spillages, all solutions will be contained within the process plant bunding, and the appropriate spill response procedure will be initiated. Portable pumps will be provided within the processing area for the pumping of spills within the bunded areas back to the storage tanks or emergency holding tanks.

The tailings delivery and return water lines will be contained within bunded pipeline corridors. The tailings slurry will be pumped to the TSF. Daily inspections of the tailings delivery and water return pipelines will be undertaken for physical integrity and to identify any minor leaks. In addition, an automatic, pressure activated shut-down mechanism will be provided on the tailings discharge pipeline to enable the early detection and stoppage of significant leaks or failures. The tailings pipeline will be fitted with a low flow alarm linked to the central control room with automatic shutdown capability.

Monitoring levels of cyanide in the environment is an essential part of leading practice cyanide management. Calidus has developed a TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19), which will track cyanide concentrations across different aspects of the Proposal and feed immediately into adaptive management strategies and contingencies measures if required.

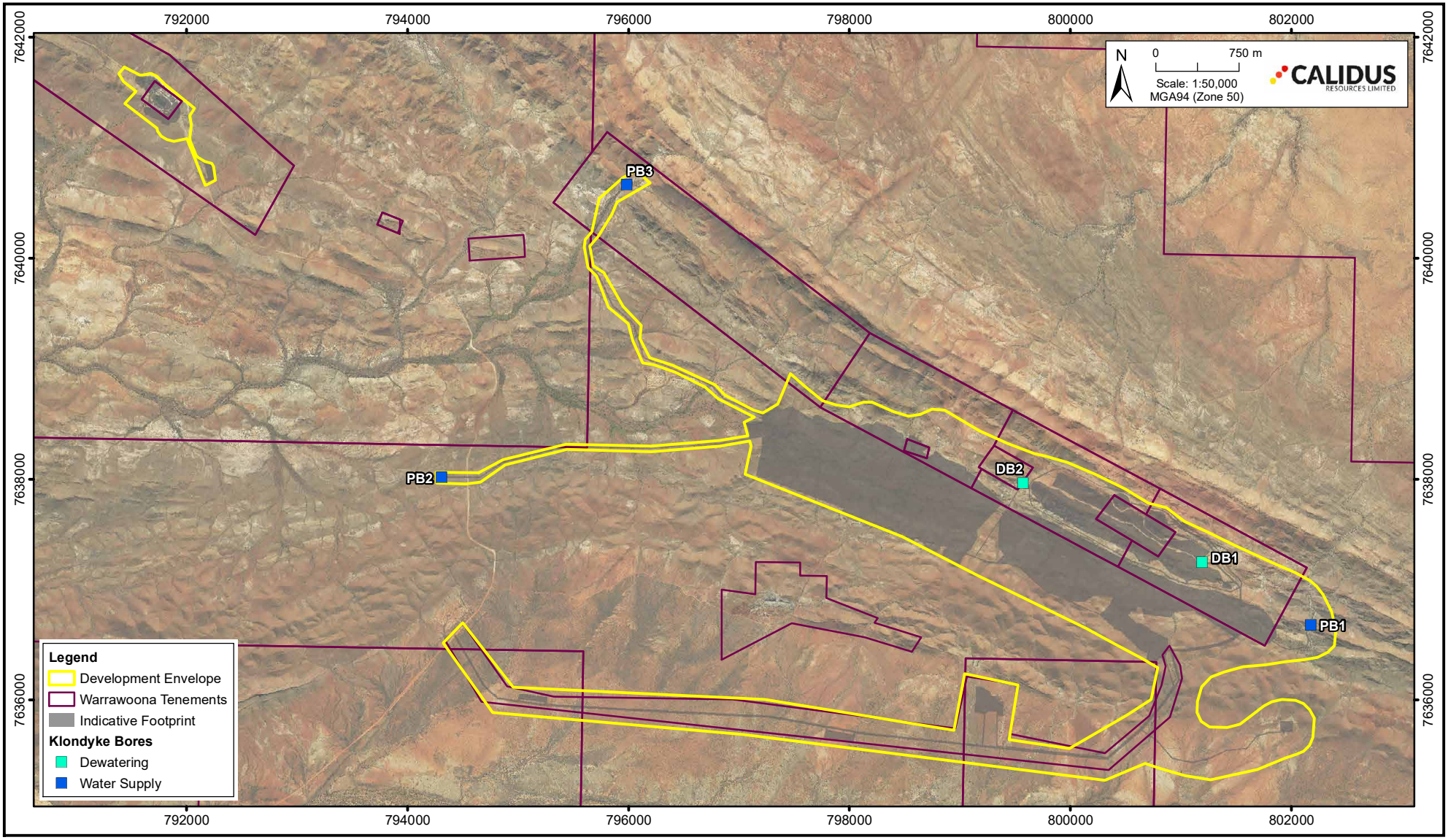
2.3.6 Water requirements

Water requirements for the mine, camp, and any make-up water at the processing plant is estimated to be 1.6GLpa (or 50L/s). Water requirements will be met through a combination of dewatering bores and dedicated production bores. In the early years of the mine life, up to 30L/s will be required from the production bores, but this will increase as dewatering rates increase. Figure 9 presents the indicative location of production borefield target areas within the Proposal area.

No water will be discharged from site and any surplus water from mine dewatering will be reused for processing and dust suppression.

Mine pit dewatering will be required at both Klondyke and Copenhagen deposits. Dewatering will commence in advance of mining. All water produced during dewatering activities will be used on site, either for processing or dust suppression. For more details on mine pit dewatering, refer to Section 6.1 and Appendix 4-2 (Groundwater Resource Management 2019b).

Figure 9: Indicative bore field layout at Klondyke mine (abstraction and dewatering)



Source: DMIRS - Tenements
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_09, Rev: A

2.3.7 Support facilities

Support facilities proposed are summarised below. Final locations have considered the following factors:

- Avoiding potential mineralised areas.
- Heritage sites.
- Presence of conservation significant flora and fauna habitats.
- Locations of watercourses and associated flood zones.
- Landform and topography.
- Distances to other Proposal elements.
- Separation distances to protect human health.

2.3.7.1 Power supply

Power will be supplied from an LNG power station with diesel generator back up, located at the plant site (Figure 3 and Figure 7). Total site power demand is 7-8MW. The current philosophy for the power station is a Build Own Operate (BOO) Contract with a power station supplier with Calidus purchasing power on a $/kWh arrangement. Gas is anticipated to be delivered by road.

The power station and associated fuel storage facilities will be located adjacent to the processing facilities to allow easy access for fuel unloading and a clear path for high voltage distribution to the process plant.

Power will be provided to the accommodation village via a utilities corridor, located adjacent the access road between the camp and the processing plant. There will also be a generator located at the accommodation village area.

The TSF decant and bore fields are expected to be operated by either standalone diesel generators or overhead power. Open pit mining dewatering will utilise trailer mounted pumps with a standalone generator.

2.3.7.2 Fuel storage

The facility will include a fuel unloading system, access, lighting and all necessary safety systems

All hydrocarbons will be stored within appropriately bunded vessels or within bunded areas. Spill kits will be located at storage areas and in-service vehicles and all personnel will be trained in their use. Hydrocarbon storages and machinery will be regularly inspected for leaks and any spills will be cleaned up immediately, with contaminated material disposed of appropriately.

Calidus has developed a Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19), which will be implemented to reduce any potential risk of contamination into the surrounding environment.

2.3.7.3 Plant buildings

A number of support buildings including a laboratory, gold room administration office, first aid centre, crib room, mine office, plant office, workshop/warehouse, control room, ablutions and reagent storage will be constructed for the project within the accommodation village and plant site areas at Klondyke.

2.3.7.4 Accommodation village

A permanent camp will be established on site as per Figure 3. The Proposal will be operated on a Fly-in-Fly-Out basis via the Marble Bar or Corunna Downs Airport.

2.3.7.5 Wastewater treatment

Up to three package wastewater treatment plants will be installed: 1) Camp; 2); Processing plant; and 3) site office area.

2.3.7.6 Landfill and Biofarm

Two landfills will be established on site (one for inert waste and one for putrescible waste). The landfill and bio farm will be located within the waste rock dump area and will be managed via Calidus' Landfill Management Procedure (CRL-ENV-PRO-014—19) and Bioremediation Management Procedure (CRL-ENV-PRO-006-19), which have been developed to appropriately manage all activities associated with landfill, bioremediation and the Biofarm.

2.3.7.7 Washdown facility

A washdown facility will be constructed within the plant site area, consisting of light/heavy vehicle drive through areas with high pressure spray water for cleaning. Solids and dirty washdown water will drain to a primary settlement sump where the solids settle out. Oily water will overflow to an adjacent cell where oil will be separated using an oil skimmer and the oil will be pumped directly to a small waste oil tank.

Waste oil will be removed from site by a licenced contractor for disposal at a licenced facility in Port Hedland or Marble Bar. Excess water will be pumped to a runoff water pond within the bunded plant site for either evaporation or reuse, as per the Bioremediation Management Procedure (CRL-ENV-PRO-006-19).

2.3.7.8 Roads

Roads shall generally be 16m wide for two-way traffic and constructed with drains on either side to allow for runoff water. The roads will be designed to accommodate heavy vehicles supplying construction equipment, deliveries of fuel, consumables, reagents and other general goods. Several additional (internal) site roads will also be required to connect site elements. These will fall entirely within the footprints of these respective elements.

2.3.7.9 Drainage

All of the plant, camp and access roads (aside from Copenhagen) are located within the Sandy Creek catchment area).

Runoff from undisturbed catchment areas around all proposed mine facilities will be diverted to avoid potential impacts to quality. Diversion channels around mining areas will be designed for the 1% AEP event or for the 10% AEP event for diversions around less sensitive facilities. Flow velocities along all diversion channels will be limited to minimise erosion and the generation of sediment (Groundwater Resource Management 2019b).

The proposed mine access road will be approximately 5km long and will extend in a generally west to east direction from a junction with the Corunna Down Road to the start of the plant access road as shown in Figure 3. The mine access road will cross several ephemeral creeks that rise in the Warrawoona Ridge and flow in a south-westerly direction towards Sandy Creek and will require floodway crossings to ensure adequate serviceability.

2.3.8 Closure and rehabilitation

The Proposal will be subject to a Mine Closure Plan (MCP), to be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). The MCP will be a dynamic document, which having

identified post-mining land use objectives, will be reviewed and updated regularly, taking into consideration ongoing stakeholder consultation and further studies and research.

The integration of rehabilitation and closure planning into operating mine planning will ensure cost-effective measures and mechanisms to reduce liability and risks with mine closure are identified and implemented.

The MCP will be submitted to DMIRS as part of the mining approval process and will include detailed information relating to key elements of mine closure including:

- Closure specific obligations and commitments;
- Key closure issues and management;
- Stakeholder consultation;
- Site-specific closure implementation plan including closure related tasks, materials required and allows for planned and unplanned scenarios;
- Post-mining land use and closure objectives;
- Site-specific and measurable completion criteria and monitoring program; and
- Financial costs associated with closure and rehabilitation.

The life of mine for the Proposal is expected to be initially 6 years. It is envisaged that mining of each pit will occur concurrently and consecutively with some areas potentially available for rehabilitation while mining is occurring. Rehabilitation will be implemented wherever possible during the operation of the Proposal as areas become available.

The principal conceptual closure objective for the Proposal is to establish a physically safe, geotechnically stable and non-polluting landform, capable of sustaining the agreed post-mining land use.

Information relating to mine closure and rehabilitation will be provided in the mine closure plan once site layout and landform design specifications have been further refined. Investigations to date that have dealt with aspects of mine closure and rehabilitation, critical to the development of a successful MCP include:

- Soils and landform assessment (Mine Earth 2019; Appendix 6-1)
- Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management (GCA 2019a; Appendix 5-1)
- Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management (GCA 2019b; Appendix 4-2)
- Feasibility Study – Tailings Storage Facility Design Report (ATC Williams 2019; Appendix 5-3)
- Hydro-Meteorological and Surface Water Management Study (Groundwater Resource Management 2019a; Appendix 4-1).
- Warrawoona Gold Project Flora and Vegetation Survey (Woodman Environmental 2018; Appendix 7-1)
- Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19, Trajectory 2019; Appendix 9-6)
- WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19; Appendix 9-7)

2.4 Local and regional context

2.4.1 Physical environment

2.4.1.1 Climate

The Pilbara climate is highly variable and can either be dominated by tropical cyclones or severe drought conditions.

Marble Bar has a desert climate and is one of the hottest towns in Australia. The mean maximum daily temperatures range from 38°C to 42°C in summer and 27°C to 36°C in winter.

Precipitation in the Marble Bar area occurs mainly in the summer months with the peak of the wet season between December and March. Most of the rainfall results from thunderstorms and occasional tropical cyclones that cross the coast intermittently. The average monthly rainfall varies from 0.5 mm to 104 mm, with the mean long-term annual precipitation for the Marble Bar area about 386 mm. The highest average number of rainy days occurs is January (6.9), with the lowest number of rainy days in August (0.2).

An assessment of cyclones in the vicinity of the Proposal area showed that over the last 48-year recording period, 22 cyclones crossed within a 100km (approximately one every two or three years) and ten cyclones passed within 50km of the Proposal area (approximately one every five years). In the majority of cases, cyclones bring heavy rainfall, causing runoff to occur in local watercourses (Groundwater Resource Management 2019a).

2.4.1.2 Geology

The Pilbara region is formed of a basement of Archaean granite and volcanics, overlain by massive deposits of Proterozoic sediments and volcanics (Beard 1990).

The Klondyke deposit lies within the Warrawoona Greenstone Belt of the East Pilbara Terrane. The rocks in the Proposal area are assigned to the Warrawoona Group and comprise high-magnesium with lesser tholeiitic basalt, ultramafics and chert metamorphosed to greenschist facies. Locally, the Warrawoona Group rocks have been intruded between the Mt Edgar Granitoid Complex to the north and the Corunna Downs Granitoid Complex to the south.

A number of deformation events are recognised in the Klondyke area which have developed several steep dipping to sub-vertical shears, including the Klondyke shear which strikes northwest and through the centre of the Klondyke deposit. Gold mineralisation is associated with this shear in a fuchsite bearing unit, with associated thin quartz veining. Several shears parallel the Klondyke shear including the St George and Coronation shears. Gold mineralisation along the Klondyke shear is coarse grained and can develop in higher grade shoots in quartz boudins within subordinate sub-vertical shears. These high-grade zones were the focus of numerous historic workings dotted along the Warrawoona Range.

2.4.1.3 Landforms and soils

This region is generally mountainous, rising to 1250m (metres), with hard alkaline red soils on plains and pediments, and shallow and skeletal soils on ranges. The Proposal area traverses two physiographic regions as defined by (Beard 1975); the Abydos Plain and the Gorge Ranges. This area is also equivalent to the Chichester IBRA subregion.

The Abydos Plain is alluvial in origin near the coast, and of Archaean granite origin further inland. It consists of a variety of features including alluvial plains, pediplains, low stony hills and dissected pediments, low granite outcrops and tors, and basic dykes. It is divided into a number of isolated sections by the Gorge

Ranges. The main soils are hard alkaline red soils, some areas with coarse textured A-horizons to 45 cm thick, while other areas have shallow stony A-horizons in addition to patches of calcrete. On the eastern part of the plain near the De Grey River, the soils are chiefly neutral and acidic red earths, while on the inland plains behind the Gorge Ranges the chief soils are earthy loams and coarse sands overlying granite within 90 cm of the soil surface. The alluvial plains along the coast generally consist of red earthy sands with extensive areas of red earths, and hard red soils along creek lines. Deep cracking clays occur in the vicinity of residuals of basic and ultrabasic rocks in the Roebourne area (Beard 1975).

The Gorge Ranges are a rough, steep and abrupt range dissected by a number of rivers through narrow gorges. These ranges consist of Archaean and Lower Proterozoic rocks of sedimentary and volcanic origin, with basic lavas along with dolomites, tuff, banded-iron formations and dolerite dykes, with some narrow valley-plains and high-level gently undulating areas of limited extent. The soils are generally shallow and stony, with large areas without soil cover. Chief soils are brown loams with significant areas of earthy loams soils, with hard alkaline red soils occurring on lower slopes, and cracking and non-cracking clays on valley floors (Beard 1975).

2.4.1.4 Land systems

The land systems of the Pilbara region are classified according to similarities in landform, soil, vegetation, geology and geomorphology, following van Vreeswyk *et al.* (2004). Three land systems (Talga, Rocklea and Macroy) are mapped across the Warrawoona Project, categorised predominately by hills, ranges and stony plains with spinifex grasslands (Table 6; Figure 10).

The most dominant land system within the Proposal area is the Talga land system, defined as hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands (Figure 10).

Table 6 Land systems intersecting the Proposal area (van Vreeswyk *et al*. 2004)

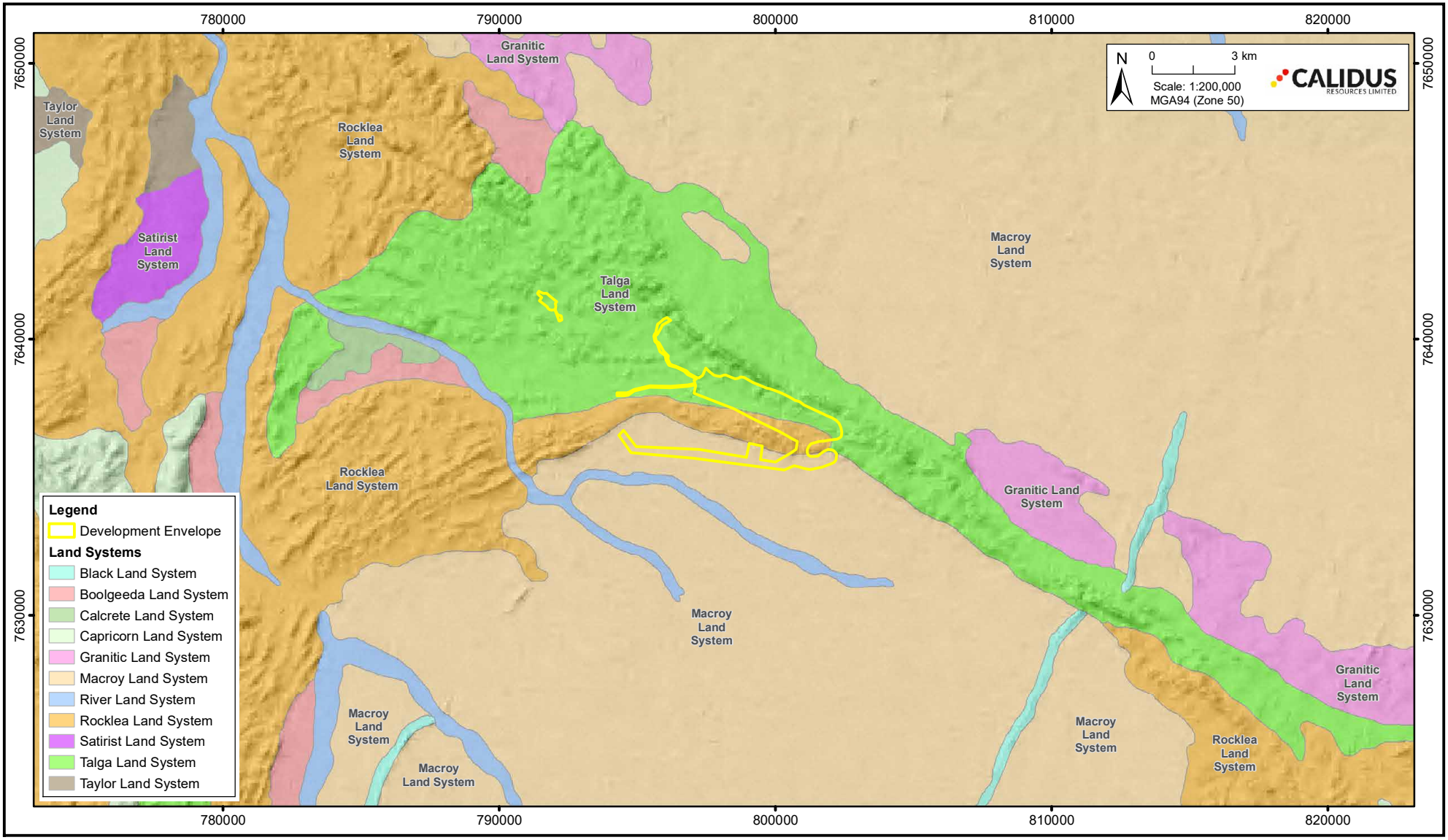
Land System	Extent (ha)	Description of Land System
Macroy	1,309,500	Stony plains, occasional tor fields based on granite supporting hard and soft spinifex grasslands
Rocklea	2,299,300	Basalt hills, lower slopes and minor stony plains supporting hard and soft spinifex grasslands
Talga	212,400	Hills and ridges of greenstone and chert, stony plains of hard and soft spinifex grasslands

2.4.1.5 Topography

The topography of Klondyke is related to the Warrawoona Ridge which provides ~80 metres relief with ground elevation of ~250mAHD on the plains on either side of the ridge to about 330mAHD at the highest point in the immediate vicinity of the proposed Klondyke mining area. Copenhagen occurs on the plains.

Plate 1. Topography of the proposal area, showing the Warrawoona Ridge.

Figure 10: Landsystems of the Proposal area



Souce: DoAF - Land Systems
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_10, Rev: A

2.4.1.6 Groundwater

Groundwater recharge in the Klondyke area is likely to be significant but episodic, and mostly as a result of summer storms or cyclone events. Recharge will likely be by direct infiltration though exposed outcrop, with secondary infiltration through the base of the local creek systems during runoff events. North of the Warrawoona Range, the regional hydraulic gradient is northward towards the De Grey River. While south of the range, a southward gradient develops towards the Coongan River.

Fractured rock aquifers are the most significant aquifers of the Proposal area, along with smaller alluvial aquifers at the base of the main creek drainages and along the Coongan River, providing sufficiently thick alluvium sequences are developed.

In the Proposal area, fractured rock aquifers generally develop around structural features such as faults and shears, especially where they intersect notable cross cutting structures. Secondary porosity from weathering of less resistive units can also enhance aquifer development. The fractured rock aquifers can have moderate to high permeability, although storage can be variable depending on the size of individual structures and fracture zones, and the degree of hydraulic connection between them.

The Proposal area has a number of intruded dolerite dykes of various sizes and orientations, including a large north-northeast striking dyke between Klondyke and Copenhagen prospects (Figure 11). This dyke has a discernible air-magnetic signature, with a strike length of over 20 km. The dolerite dykes may have enhanced permeability along their margins in some places. However, the larger dykes (at least) probably form barriers to local groundwater flow.

2.4.1.7 Surface water

The northwest striking Warrawoona Ridge forms a local surface water (and groundwater) divide in the Proposal area. Runoff from the range reports to either the Brockman Creek catchment to the north, which discharges to the Talga River. Or in a southerly direction to the Camel Creek catchment, which discharges to the Coongan River.

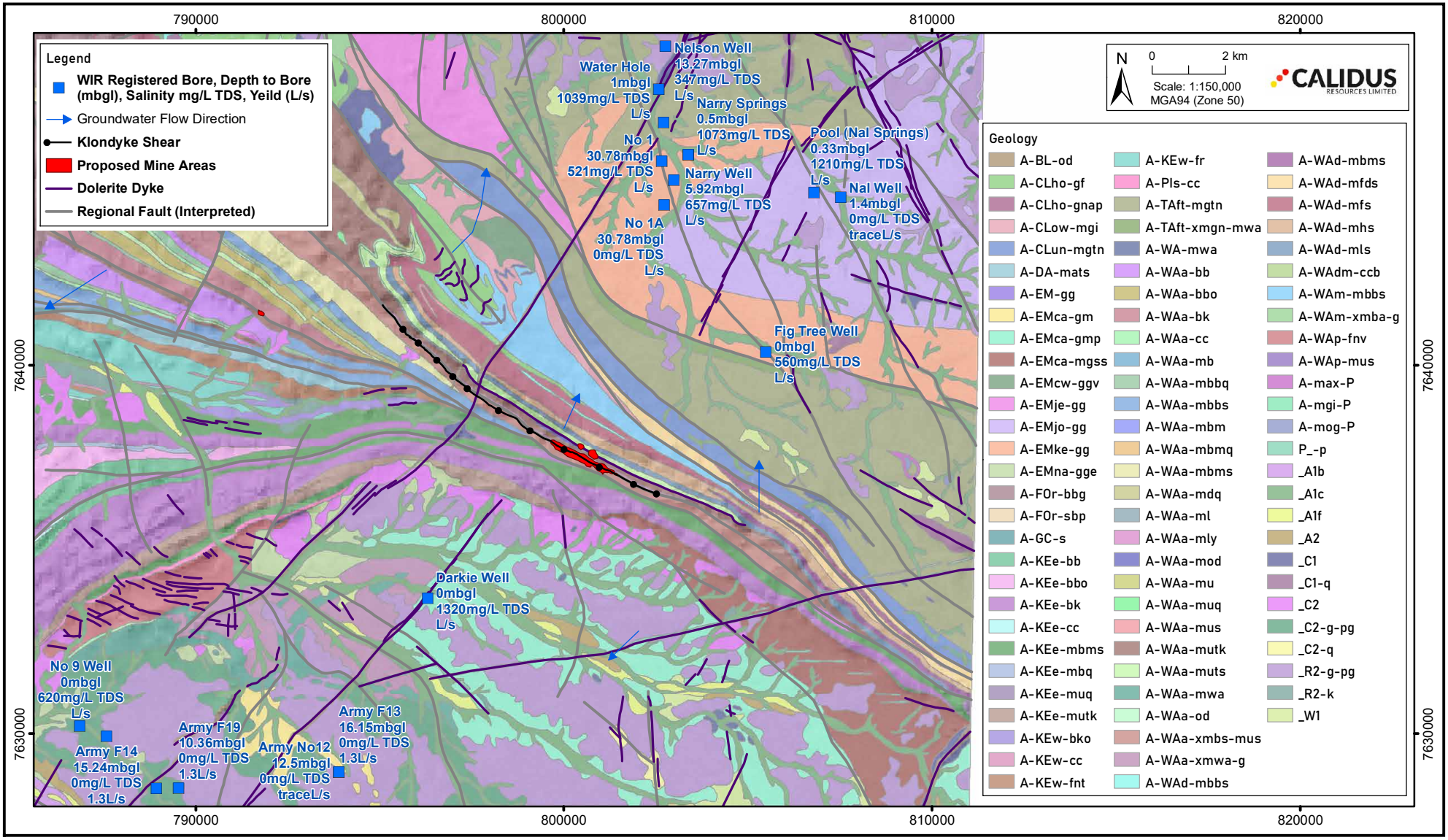
The proposal area is located centrally within the Coongan River catchment, which itself is situated centrally within the much larger De Grey basin catchment (Figure 12).

Typically, annual streamflow occurs during January, February and March with local rivers usually drying up during the dry season around July or August and leaving a series of disconnected permanent pools which are recharged by groundwater. Surface water flow in the local rivers and flood plains recharges the alluvium through the river bed during the wet season. During the dry season, river flow is initially maintained by groundwater discharge, until declining levels drop below the river bed.

There are several relatively minor ephemeral watercourses and drainage lines that cross the Proposal area on the south side of the Warrawoona Ridge. There are no permanent pools in the Proposal area, however there are regionally, some ephemeral pools between 3-15km from the Proposal area. Note, no ephemeral pools are within the proposed drawdown cone of depression from mine pit dewatering.

Prolonged periods without significant rainfall or runoff can occur in the Pilbara. For example, the Shaw River, 66km northwest of the Proposal area has recorded no flow for 28 months, with no-flow periods on creeks draining smaller areas likely to be considerably longer (Groundwater Resource Management 2019a).

Figure 11: Hydrogeology of the Proposal area

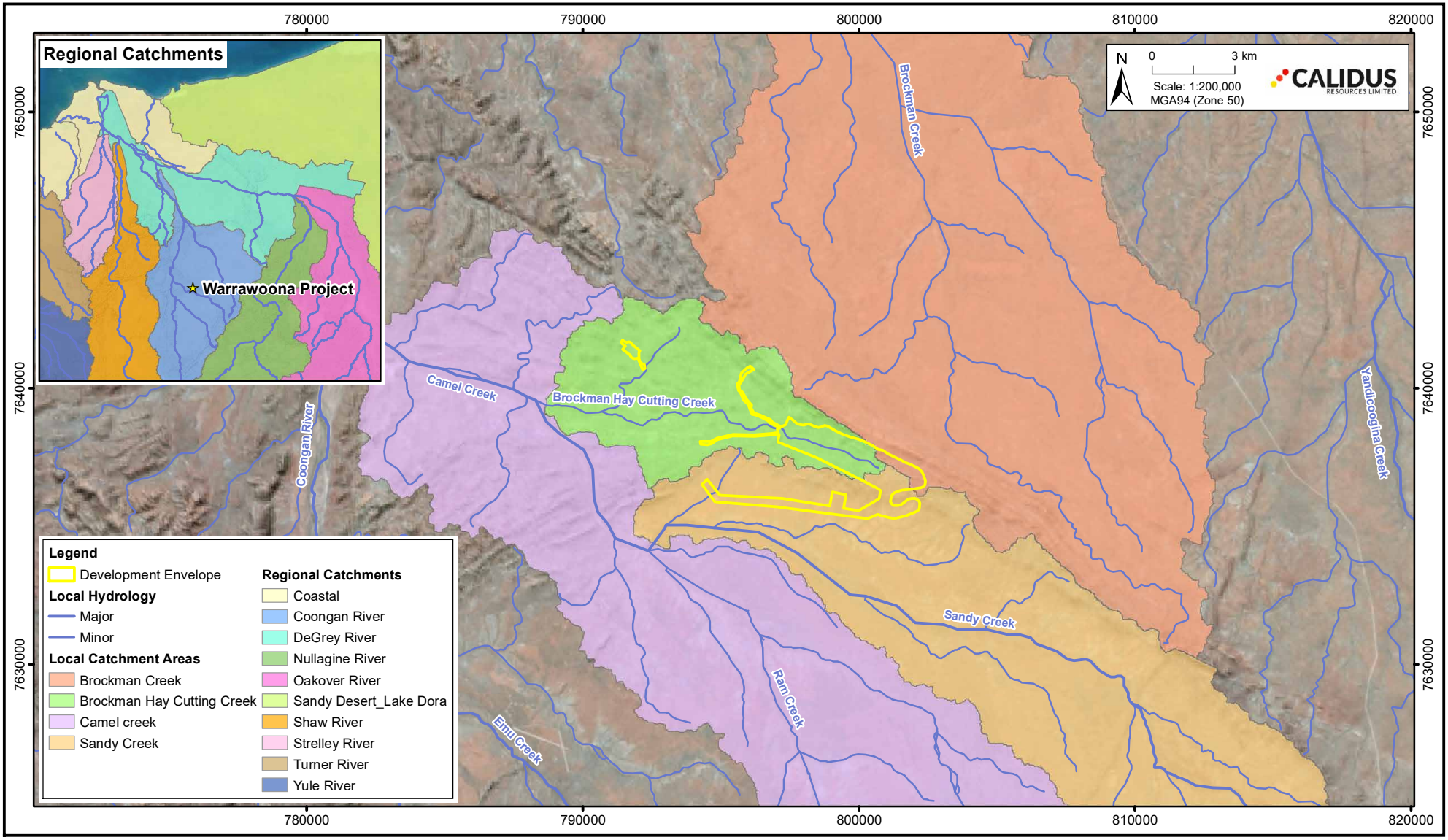


Souce: DMIRS - Geology, Groundwater Res. Management - Bores
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_11, Rev: A

Code	Description
A-BL-od	Dolerite dyke; local gabbro; weakly metamorphosed
A-CLho-gf	Alkali-feldspar granite; medium- to coarse-grained; includes local diorite and granodiorite; massive to weakly foliated;
A-CLho-gnap	Porphyritic microgranite and microgranodiorite; mainly in subvolcanic intrusions; euhedral feldspar and quartz phenocrysts
A-CLow-mgi	Meta quartz diorite; foliated to gneissic
A-CLun-mgtn	Banded tonalite, granodiorite, and monzogranite gneiss and migmatite; strongly sheared
A-DA-mats	Serpentinite, schistose
A-EM-gg	Granodiorite; metamorphosed
A-EMca-gm	Biotite monzogranite to granodiorite; fine to medium grained, seriate; minor pegmatite; weakly foliated and metamorphosed
A-EMca-gmp	Biotite monzogranite; feldspar porphyritic; common mafic xenoliths; weakly metamorphosed
A-EMca-mgss	Strongly foliated metagranite and granitic schist
A-EMcw-ggv	Muscovite granodiorite; fine- to medium-grained; weakly foliated; metamorphosed
A-EMje-gg	Biotite granodiorite; medium- to coarse-grained; foliated; metamorphosed
A-EMjo-gg	Biotite granodiorite; local tonalite and monzogranite; locally porphyritic; variably foliated; metamorphosed
A-EMke-gg	Biotite--hornblende granodiorite; local monzogranite and tonalite; foliated; local mafic xenoliths and schlieren; metamorphosed
A-EMna-gge	Biotite--hornblende granodiorite to tonalite; equigranular; contains inclusions of Tambina Supersuite tonalite; metamorphosed
A-FOr-bbg	Massive, porphyritic, vesicular, and amygdaloidal basalt; some pillow basalt
A-FOr-sbp	Polymict boulder conglomerate with clasts of granite, vesicular metabasalt, chert, and plagioclase-phyric basalt of the Mount Roe Basalt
A-GC-s	Sandstone, siltstone, conglomerate, shale, chert, and banded iron-formation; metamorphosed
A-KEe-bb	Massive basalt; metamorphosed
A-KEe-bbo	Pillowed basalt; includes local massive basalt, dolerite, and komatiitic basalt; metamorphosed
A-KEe-bk	Komatiitic basalt; massive and pillowed lavas and subvolcanic intrusions; local pyroxene spinifex texture; metamorphosed
A-KEe-cc	Chert; metamorphosed
A-KEe-mbms	Mafic schist derived from komatiitic basalt
A-KEe-mbq	Silicified metamafic volcanic rock
A-KEe-muq	Silicified meta-ultramafic volcanic rock
A-KEe-mutk	Talc--carbonate rock derived from meta peridotite; includes volcanic protoliths
A-KEw-bko	Pillowed komatiitic basalt; metamorphosed
A-KEw-cc	Chert; metamorphosed
A-KEw-fnt	Felsic volcanic sandstone; tuffaceous; local quartz sandstone; metamorphosed
A-KEw-fr	Porphyritic rhyolite and rhyodacite; local felsic volcaniclastic rocks; metamorphosed
A-PIs-cc	White, grey, and blue-black layered chert; mainly silicified carbonate rocks, local sandstone and felsic volcaniclastic rocks;
A-TAft-mgtn	Banded metatonalite, metagranodiorite, and local metatrondhjemite, monzogranite and syenogranite gneiss, and migmatite
A-TAft-xmgn-mwa	Interlayered granitic gneiss and mafic amphibolite; local leucocratic granitic veins
A-WA-mwa	Amphibolite derived from mafic intrusive or extrusive rock
A-WAa-bb	Basalt; tholeiitic and massive; commonly pillowed and locally schistose; metamorphosed
A-WAa-bbo	Pillowed and massive basalt; includes minor dolerite; metamorphosed
A-WAa-bk	Komatiitic basalt, massive and pillowed lavas and subvolcanic intrusions; local pyroxene spinifex texture; weakly metamorphosed
A-WAa-cc	Chert; metamorphosed
A-WAa-mb	Metamafic rock
A-WAa-mbbq	Silicified metabasalt
A-WAa-mbbs	Strongly sheared chloritic schist after metabasalt
A-WAa-mbm	Meta komatiitic basalt
A-WAa-mbmq	Silicified komatiitic basalt
A-WAa-mbms	Mafic schist derived from komatiitic basalt; tremolite--chlorite--serpentine rock
A-WAa-mdq	Silicified metamorphosed siliciclastic sedimentary rock
A-WAa-ml	Pelite
A-WAa-mly	Silicified mylonitized pelite; includes secondary chert
A-WAa-mod	Metadolerite
A-WAa-mu	Meta-ultramafic rock
A-WAa-muq	Silicified meta-ultramafic rock
A-WAa-mus	Ultramafic schist
A-WAa-mutk	Talc--carbonate rock derived from metaperidotite; includes volcanic protoliths
A-WAa-muts	Talc- or serpentine-schist; local tremolite--chlorite--serpentine--carbonate schist; sheared and serpentized ultramafic rocks including peridotite
A-WAa-mwa	Medium-grained amphibolite and amphibolitic schist; derived from basalt and dolerite
A-WAa-od	Fine- to medium-grained dolerite; metamorphosed
A-WAa-xmbs-mus	Interlayered mafic schist derived from metabasalt and ultramafic schist
A-WAa-xmwa-g	Interlayered amphibolite and granitic rocks; commonly schistose; includes granite and pegmatite veins
A-WAd-mbbs	Schist derived from metabasalt
A-WAd-mbms	Mafic schist derived from meta komatiitic basalt
A-WAd-mfds	Quartzofeldspathic and quartz--muscovite--biotite--andalusite--staurolite schist; sheared dacitic lava and felsic volcaniclastic rocks
A-WAd-mfs	Felsic schist derived from felsic volcanic rocks
A-WAd-mhs	Interlayered psammitic and pelitic schist; metamorphosed shale, silstone, and sandstone
A-WAd-mls	Pelitic schist; metamorhosed shale and minor siltstone
A-WAdm-ccb	Red, white and grey layered chert; metamorphosed
A-WAm-mbbs	Mafic schist derived from sheared metabasalt; locally interleaved with felsic schist
A-WAm-xmba-g	Interlayered amphibolite derived from basalt and granitic rocks; commonly schistose; includes granite and pegmatite veins
A-WAp-fnv	Felsic volcaniclastic rock; includes debris-flow deposits, autobreccia, agglomerate, and tuffaceous rocks; minor chert; local basaltic andesite
A-WAp-mus	Ultramafic schist
A-max-P	Metapyroxenite
A-mgi-P	Metadiorite
A-mog-P	Medium- to coarse-grained metagabbro; foliated
P_-p	Kimberlite dyke
_A1b	Sand, silt, and gravel in the beds of major active drainage channels
_A1c	Sand, silt, and gravel in active drainage channels; includes clay, silt, and sand in poorly defined drainage courses on floodplains
_A1f	Floodplain deposits; sand, silt, clay, and gravel adjacent to main drainage channels
_A2	Consolidated alluvial sand, silt, and gravel; dissected by present-day drainage
_C1	Colluvial sand, silt, and gravel in outwash fans; scree and talus; proximal mass-wasting deposits; unconsolidated
_C1-q	Colluvial quartz debris in sand, silt, and clay; derived from proximal mass-wasting of quartz-veins
_C2	Partly consolidated colluvial sand, silt, and gravel in proximal outwash fans; scree and talus; dissected by present-day drainage
_C2-g-pg	Variably consolidated quartzofeldspathic sand, silt, clay, and rock fragments derived from granitic rocks; dissected by present-day drainage
_C2-q	Variably consolidated quartz-rich sand, silt, and gravel derived from mass-wasting of quartz veins; dissected by present-day drainage
_R2-g-pg	Variably consolidated eluvial and colluvial sand, gravel, and silt overlying, and derived from granitic rocks; dissected by present-day drainage
_R2-k	Residual calcrete: massive, nodular, and cavernous limestone; variably silicified; dissected by present-day drainage
_W1	Silt, sand, and pebbles in distal sheetwash fans; no defined drainage

Figure 11 Legend description

Figure 12: Regional catchments



Souce: Geoscience Aust. - Hydrology, DWER - Catchments
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_12, Rev: A

2.4.2 Biological environment

2.4.2.1 Biogeographic region

The Proposal area lies within the Pilbara IBRA region, specifically within the Chichester IBRA subregion (PIL01) (Kendrick and McKenzie 2001).

The Chichester subregion accommodates an area of 8,374,728ha in the northern section of the Pilbara Craton. The subregion is described as undulating Archaean granite and basalt plains and basaltic ranges. The plains are known to support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* (formerly *Triodia pungens*) hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges (Kendrick and McKenzie 2001).

2.4.2.2 Vegetation and flora

The Abydos Plain is characterised by four broad associations: Shrub steppe, Dwarf-shrub steppe, Grass plains and the Coastal Complex. Of these, shrub steppe is the only association relevant to the Proposal area. Shrub steppe is the main community of the granite plain, which is dominated by the *Acacia pyrifolia-Triodia epactia* (formerly *T. pungens*) association, with hummock grasses dotted with widely-spaced shrubs. The plain is broken by stony rises and hills with small ranges, with *T. epactia* usually replaced by *T. wiseana*, *T. longiceps* or *T. angusta*, with scattered shrubs. Larger ranges tend to possess mainly *Triodia*, with only a few scattered shrubs and trees. Major creeks and rivers are wooded with *Eucalyptus camaldulensis* and *Melaleuca argentea* (formerly *M. leucadendron*) (Beard 1975).

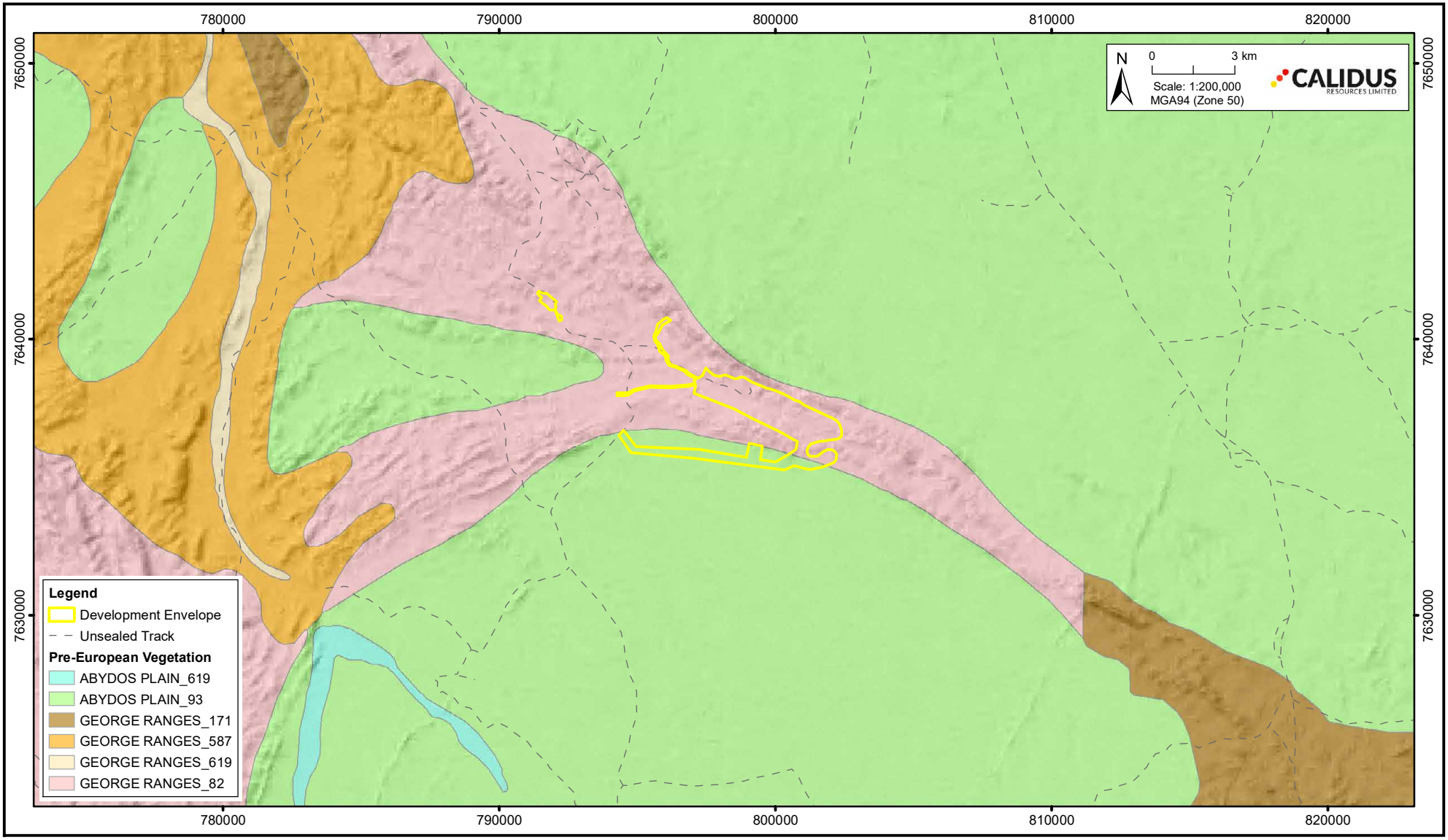
The Gorge Ranges consist of tree steppe on the high rocky parts, often with only a sparse occurrence of trees, dominated by *Eucalyptus leucophloia* (formerly *E. brevifolia*) and hummock grasses of *Triodia epactia* and *T. brizoides*. The lower slopes are generally comprised of shrub steppe of *Acacia bivenosa* and *T. epactia*, while the valleys contain *A. pyrifolia* (Beard 1975).

The two vegetation system associations occur in the Proposal area as summarised in Table 7 and presented on Figure 13. Table 7 also presents the current extent of each vegetation system association in relation to its pre-European extent, and the percentage is protected for conservation. Both vegetation system associations have been subject to very limited clearing (less than 1 %) since European settlement. However, neither vegetation system association is protected for conservation (Table 7).

Table 7 Vegetation System Associations Intersecting the Proposal area (Government of WA 2018)

Vegetation System Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Abydos Plain_93	Hummock grasslands, shrub steppe; kanji over soft spinifex	432,038.31	99.94%	0
George Ranges_82	Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*	316,855.11	99.90%	0

Figure 13: Vegetation association of the Proposal area



Souce: Geoscience Aust. - Tracks, DPIRD - Pre-European Veg
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_13, Rev: A

2.4.3 Social environment

2.4.3.1 Current land use

Land use in the area is generally mineral exploration and low-intensity cattle grazing. The majority of the Proposal area is situated on mining common R7979, with a small section of the Klondyke mining pit and abandonment bund overlapping timber reserve R13674. The Copenhagen pit, waste dumps and laydown areas are situated on Eginbah Station (Figure 3 and Figure 4). The Proposed development envelope overlaps a minor part of Corunna Downs station, with no project elements planned on the lease.

2.4.3.2 Indigenous cultural heritage

The Njamal Group is the registered Native Title claimant group of the Proposal area (WC1999/008).

No registered sites occur within the development envelope; however registered sites are known to occur within 20km of the Proposal area (Figure 14 and Figure 15) (Table 8). Note, heritage surveys have been conducted by the Njamal Group within the Proposal area (detailed in Section 3 and Section 6.4).

Table 8 Aboriginal Heritage Sites Known to occur within 20km of the Proposal area.

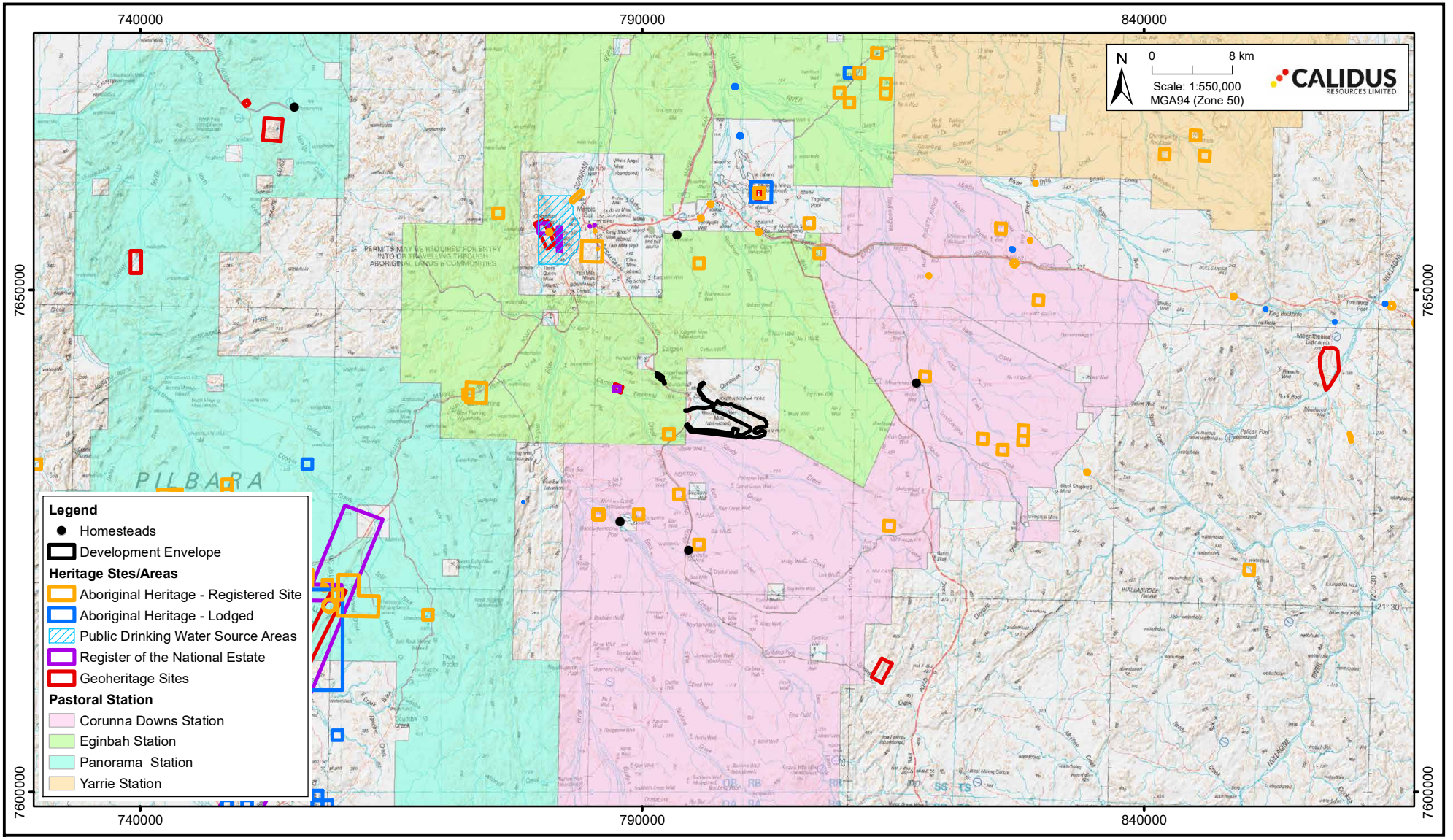
Place ID	Name	Location notes	Type
7128	Pipunya Springs Burial	On tenement E4505172	Skeletal Material / Burial
7217	Marble Bar pool		Engraving, Grinding Patches / Grooves
7264	Coodabinya		Artefacts / Scatter, Ceremonial, Grinding Patches / Grooves
8935	Wine Tree	On tenement E4505172	Artefacts / Scatter, Camp, Meeting Place, Plant Resource, Water Source
11084	Corunna Homestead: Hill B	On tenement E4505374	Engraving
11085	Corunna Homestead: Hill C	Same as 11084	Engraving
11086	Corunna Homestead: Hill D	Same as 11084	Engraving
11087	Corunna Homestead: Hill E	Same as 11084	Engraving
11088	Corunna Homestead: Hill F	Same as 11084	Engraving
11089	Corunna Aerodrome	On tenement E4505374	Engraving
11091	Sandy Creek Junction	On tenement E4504905	Engraving
11092	Corunna Downs: Radar Hill		Engraving
11093	Eginbah (Limestone) Station		Engraving
11095	Corunna Homestead: Hill A		Artefacts / Scatter, Engraving
12146	Corunna Downs: Rose Pool	On tenement E4504857	Engraving
8934	Marble Bar Burial	On tenement E4505172 (within place ID 7128)	Skeletal Material / Burial

2.4.3.3 Non-indigenous and natural heritage

Databases, including National Heritage List; Register of the National Estate; Commonwealth Heritage List; World Heritage List; and Western Australian State Heritage Register all revealed limited results in and around the Proposal area. No National or State registered European heritage or Geoheritage Sites have been noted. One site listed on the Register of the National Estate, the Camel Creek geological site, is within part of the Warrawoona tenements, 3-4 kilometres from the Proposal area. The State Heritage listed Corunna Downs Station and Former Wartime Airbase, is located ~10km south-west of the Proposal.

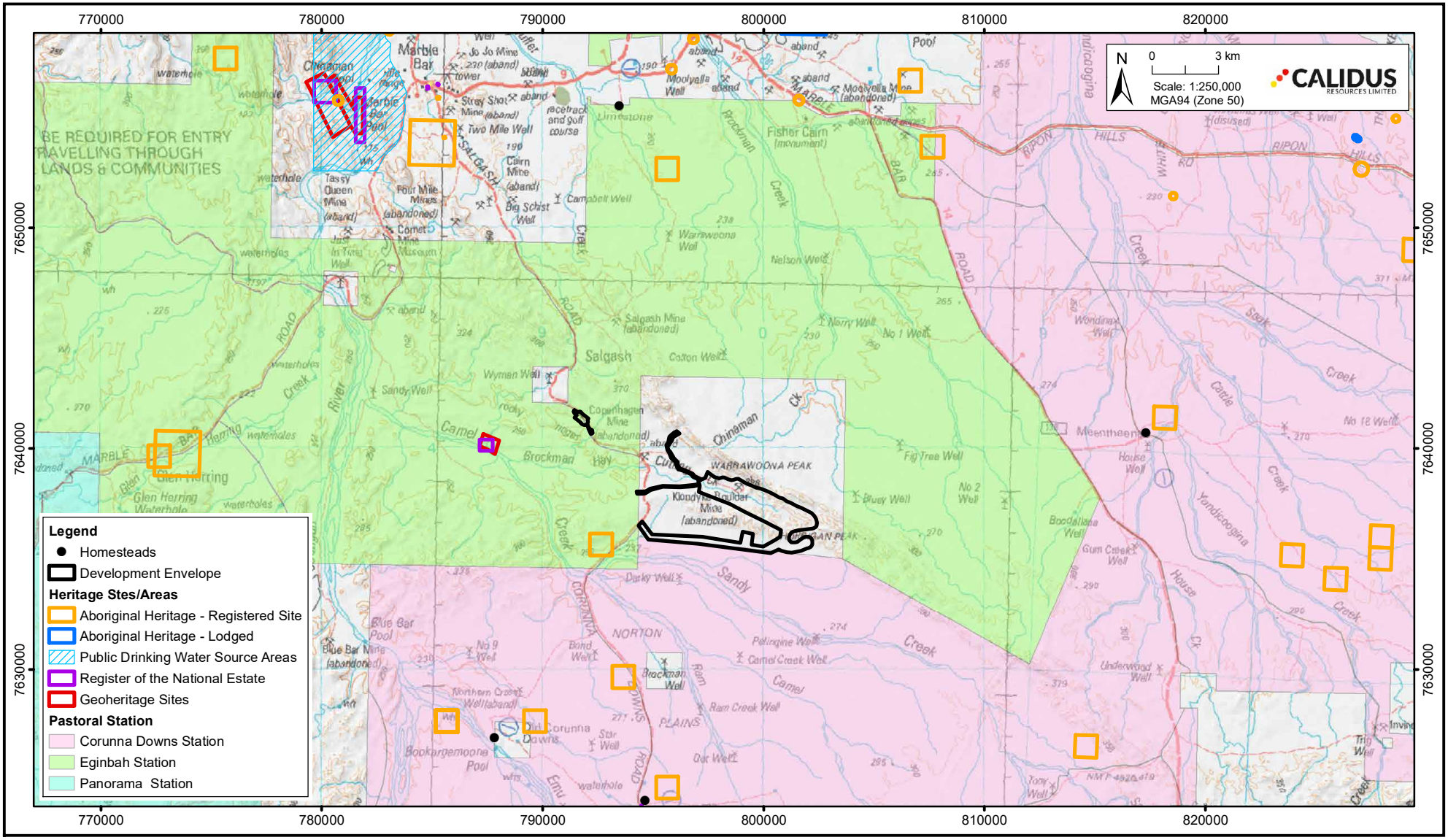
The Warrawoona project is not situated within, or in close proximity to any Nature Reserves, Nationally Important Wetlands, Environmentally Sensitive Areas, or other protected areas.

Figure 14: Regional social values of the Proposal area



Souce: Geoscience Aust. - 1:250k Basemap, Homesteads; DWER - Drinking Water; DPLH - Heritage; DAFWA - Pastoral Stations
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_14, Rev: A

Figure 15: Local social values of the Proposal area



Souce: Geoscience Aust. - 1:250k Basemap, Homesteads; DWER - Drinking Water; DPLH - Heritage; DAFWA - Pastoral Stations
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_15, Rev: A

3 STAKEHOLDER ENGAGEMENT

This section described the status of stakeholder consultation for the Proposal to date, including a list of all relevant stakeholders and topics discussed.

3.1 Key stakeholders

Since acquiring tenements in 2016, Calidus has consulted broadly during the course of ongoing investigation, design and evaluation of the Proposal. Key stakeholders identified and engaged in the last three years are listed below.

- Federal government Agencies
  - Department of the Environment and Energy (Commonwealth, Territories and Assessment Branch) (DoEE).
- State Government Agencies and Branches
  - Department of Mines, Industry Regulation and Safety (DMIRS), Environment
  - DMIRS, Mineral Titles
  - Department of Water and Environment Regulation (DWER), EPA Services
  - DWER, Part V EP Act approvals and licencing
  - DWER, Water Branch
  - Department of Planning, Lands and Heritage (DPLH)
  - Department of Biodiversity Conservation and Attractions (DBCA).
  - Main Roads Western Australia (MRWA).
- Members of parliament and representatives
  - Mr Kevin Michel MLA (Pilbara)
  - Representatives for the Minister for Environment, Disability Services, Electoral Affairs
- Local Government Authority
  - East Pilbara Shire
- Indigenous Groups and representatives.
  - Native Title Claimant Group, Njamal Group
  - Indigenous Youth Arts Programme (sponsorship)
- Mining tenement holders
- Pastoral station owners.
  - Eginbah (Limestone) Station
  - Corunna Downs Station
  - Non-government organisation and Special Interest Groups.
  - Marble Bar Community Resource Centre

3.2 Consultation approach

The method of consultation has varied depending on the forum, subject matter and purpose. The main forms of communication undertaken to date can be categorised as follows:

- Project briefings and presentations;
- Stakeholder meetings and discussions, including those undertaken on Calidus' behalf by consultants (e.g. specific investigations methodologies and approaches);
- Written/Verbal communications (including email and telephone) regarding project updates and process guidance.

Presentations and information sessions have been held to provide stakeholders with an overview of the project as well as information on potential impacts and how they will be managed. These sessions have also provided a mechanism for participant feedback.

3.3 Stakeholder communications

Calidus will continue to actively consult with neighbours, pastoralists, representatives of interested parties and regulatory agencies as the Proposal progresses. The main relevant topics of discussion that have occurred with stakeholders to date are summarised in Table 9.

Table 9 Key Stakeholders for the Proposal

Date	Approach / interest	Outcome
Pastoral Station: Eginbah (Limestone) Station		
2016 - Ongoing	Project overview, conceptual site layout, pastoral access agreement	Draft pastoral access agreement submitted; expression of interest received from Pastoralist for potential contract work at mine site
Pastoral Station: Corunna Downs Station		
2018 - Ongoing	Project overview, Aerodrome Access, pastoral access agreement	Draft pastoral access agreement submitted, three meetings and site visit completed by owners
Mining Tenure Holders: M45/4, M45/656, P45/3033, L45/399		
2017 - Ongoing	Numerous calls, emails and meetings	Provide project overview, discussion on General Purpose Lease and Miscellaneous License that borders tenements. Have moved infrastructure and permit applications to minimise disturbance to nearest neighbor
Indigenous groups and representatives: Native Title Claimants - Njamal		
10/19/2017	Meeting between Njamal MALC and Calidus	Introduce Calidus and discuss heritage clearing/avoidance process
11/6/2017	Meeting Njamal and Calidus	Discussing heritage surveys
Dec 2017 to April 2018	Numerous Emails and meetings	Planning and executing heritage and ethnographic survey
May 2018 - Ongoing	Numerous Emails and meetings	Ongoing dialogue regarding new applications and heritage agreements
Mar-19 – June 19	Numerous Emails and calls	Concluding second and third Heritage Surveys
Aug-19 - ongoing	Meeting and site visits	Meetings and site visits to discuss protocol for negotiating Native Title Agreement

Date	Approach / interest	Outcome
Shires and Local Governments: East Pilbara Shire		
26-Nov-18	Meeting with Calidus in Perth	Introductory meeting, discussion on integration with community with specific reference to roads and airport
11-Dec-18	Email between Calidus and the East Pilbara Shire	No objection of the removal of the old road reserve traversing the old Copenhagen pit
11-Feb-19	Meeting at Shire Chambers in Newman	Update on project, including camp, power (via LNG) and upgrading the road to Marble Bar.
11-Mar-19	Email to DMIRS (Viviana Gorlato)	Advising status of the road reserve, Corunna Downs Rd 8120145. The intent is to formulise the new alignment.
28-Jun-19	Letter to Shire	Requesting closure of Warrawoona Road Reserve. Landgate advised that Shire (via Calidus) instigates process.
May-Oct 19	Emails with Shire CEO	Ongoing dialogue for Marble Bar Aerodrome, organised presentation to Shire Councilors in Newman 25th October post Local Government elections. Shire of East Pilbara proactively working with Calidus on Marble Bar Aerodrome
State Government: Local Members of Parliament / Policy Advisors		
29-Aug-19	Meeting with Local Member	Meeting with Mr Kevin Michel MLA (Pilbara) for introduction and discussion on Warrawoona Project
3-Oct-19	Meeting with Environment Minister Policy Advisors	Calidus met Policy Advisors for the Environment Minister for introduction and discussion on Warrawoona Project
State Government: Department of Mines, Industry Regulation and Safety (Environment)		
27-Jun-18	Meeting at DMIRS Perth.	Introduced the Warrawoona Project. Discussion regarding current exploration practices. DMIRS also provided preference for closure (i.e. backfilled pit, water harvesting TSF and waste rock dumps etc.). DMIRS would refer project to EPA due to the presence of the Pilbara Leaf-nosed Bat and the Ghost Bat.
22-Nov-19	Meeting at DMIRS Perth.	Update to DMIRS on Calidus project. Preliminary discussions regarding TSF and Waste rock design.
7-Mar-19	Meeting at DMIRS Perth.	Outlined TSF valley fill option. Explained the reasoning behind valley fill verses traditional 'paddock style'. Provided an update on the bat roost in KQ and BB and where the TSF sits in the catchment. Discussion regarding the pastoralists requirements that Copenhagen pit be open to stock.
2-Oct-19	Meeting at Calidus Office West Perth	Meeting to provide update on proposed TSF and closure plans. Feedback received from DMIRS for incorporation into Closure Plan and Metalliferous Drainage Management Procedure.
State Government: Department of Mines, Industry Regulation and Safety (Mineral Titles)		
10-Dec-18 12-Mar-19	Email to DMIRS Mineral Titles,	Regarding consent process for the Copenhagen Road Reserve (Section 24 of the Mining Act requirement).
State Government: Department of Water and Environment Regulation (EPA Services)		
12-Jul-18	Pre-Scoping Meeting, DWER Perth.	Environmental factors may be restricted to Fauna. Consult Terrestrial Ecosystems group following baseline investigations.
25-Mar-19	Pre-Scoping Meeting at DWER Joondalup	Defined project description and summary of baseline data to date.
23-Jul-19	Scoping Meeting at Calidus Offices	Provide project update and discussed an accredited process with the Commonwealth.

Date	Approach / interest	Outcome
State Government: Department of Water and Environment Regulation (Department of Water)		
29-Nov-18	Email to initiate discussions	Introducing the Warrawoona Project
State Government: Department of Water and Environment Regulation (Part V EP Act, works approvals and licensing)		
1-Aug-19	Scoping meeting introducing the Warrawoona Project	Provide project overview, discussing surface and hydro issues. Discussions on waste rock, tailings, surface water management at Copenhagen and flow monitoring at Brockman Hay Cutting Creek.
State Government: Department of Biodiversity, Conservation and Attractions		
30-Jan-18	Meeting at DBCA Kensington	Baseline survey meeting, overview of project, review of baseline knowledge to date, overview of planned flora and fauna surveys and discussion around the focus on targeted surveys rather than level 2 surveys.
6-Jun-19	Meeting at DBCA Kensington.	Project and investigations update, overview of project, review of baseline knowledge to date. DBCA discussed TSF and flooding implications, understanding more about humid conditions of the roost. Blasting management procedures to include regular updates with DBCA.
State Government: Main Roads Western Australia		
Ongoing	Phone, emails	Provided project overview.
State Government: Department of Planning, Lands and Heritage (previously Department of Aboriginal Affairs and Department of Lands)		
Identified as key stakeholder. Discussions required to introduce the Proposal discuss heritage surveys and outcomes to date as well as approval strategy. Discussions may also be required regarding the road reserve (to be advised by Mineral Titles).		
Commonwealth Government: Department of the Environment and Energy		
3 April 2019.	Phone Meeting	Project Overview, Biologic provided an overview of Bat work undertaken since 2016 at Warrawoona, including GB genetic studies. Overview of the roosts, population, and foraging (VHF study) (neither species are foraging on the Proposal area). Discussed buffers for mitigation and other MNES species and potential impacts.
6-Aug-19	Email	Accredited process can be initiated at referral. Both State and Commonwealth agencies together determine the appropriate assessment approach
Local and Regional Groups: Marble Bar Community Resource Centre		
11-May-19	Information and BBQ Dinner	Completed Presentation to local residents'
June 2016 - ongoing	Numerous Informal Meetings	Meetings with local residents, pastoral lease owners, business owners, police and school headmaster.
Local Support Initiatives		
June 2017 - ongoing	Sponsorship	Sponsored Indigenous Youth Art Program at Marble Bar and Warralong schools and sponsored Marble Bar Races

Plate 2. Njamal group representatives and David Reeves (Calidus Managing Director) during heritage surveys at the Proposal area.

4 ENVIRONMENTAL PRINCIPLES AND FACTORS

The section describes the way in which Calidus has applied environmental management principles to different aspects of the Proposal, as well as a description of the environmental factors (both 'key' and 'other') that were selected for environmental impact assessment in this document.

4.1 EP Act principles

Table 10 summarises how the EP Act Principals of Environmental Management will be applied to the Proposal.

Table 10 Principles of Environmental Management

Principle	Application
Precautionary Principle Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: ▪ Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and ▪ An assessment of the risk-weighted consequences of various options.	▪ Substantial baseline environmental investigations to identify key factors and potential impacts from the Proposal. ▪ Detailed impact assessment of the key environmental factor (Terrestrial Fauna) to identify, prioritise and mitigate potential impacts. ▪ Outcomes from environmental investigations and impact assessment have informed project design. For example: o the establishment of a mining exclusion zone to protect roosting sites at the Klondyke Queen roost o considered placement of 'flexible' infrastructure such as roads and accommodation footprints. ▪ Where gaps in scientific knowledge exist, management measures were risk adverse when considering the extent of potential impact. For example: o a commitment to less than 30mg/L WAD cyanide discharge at the TSF, which is 40% lower than benchmark levels currently recognised for wildlife protection. o a 200m blasting buffer at the Klondyke Queen roost exceeds the 185m recommended safe buffer required.
Intergenerational Equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	▪ Manage environmental factors within Calidus' control such that future adverse impacts are minimised and that, wherever possible, the quality of the environment is maintained or enhanced. For example: o the establishment of a mining exclusion zone for the protection of the Klondyke Queen roost o opportunist management and control of feral animals during operations o hygiene management to control the introduction and spread of introduced plant and animals. o Implement fire management procedures to reduce the risk of unplanned fires and subsequent changes in current fire regimes ▪ A Mine Closure Plan will be prepared in consultation with regulatory and Traditional Owner stakeholders to ensure that post mining land use is consistent with agreed stakeholder objectives and rehabilitation can be progressively implemented.
Conservation of Biological Diversity and Ecological Integrity Conservation of biological diversity and ecological integration should be a fundamental consideration.	▪ No reduction in biodiversity likely as a result of the Proposal. ▪ Both proposed mine pits will occur within areas of varying degrees of disturbance, with Copenhagen on the footprint of an existing mine pit and Klondyke mine within smaller historic mine workings.

Principle	Application
	▪ Extensive biological surveys over the last 3-4 years have contributed to the knowledge base on conservation significant fauna species and informed project design. For example, the establishment of a mining exclusion zone to protect roosting sites associated with the Klondyke Queen roost. ▪ Planned ongoing ecological research, as detailed in the Significant Species Management Plan (CRL-ENV-PLN-006-19; Appendix 9-1). ▪ Commitment to restore disturbed areas to self-sustaining ecosystems via the Mine Closure Plan.
Improved Valuation, Pricing and Incentive Mechanisms ▪ Environmental factors should be included in the valuation of assets and services. ▪ The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. ▪ The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. ▪ Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.	▪ Project feasibility and design have considered: o Environmental values and constraints in project design o The costs of containment, avoidance and abatement of waste are borne by the proponent and managed under the EP Act and Mining Act. ▪ Participate in the National Greenhouse Emissions Reporting System (NGERS) ▪ All proven, practical and economically viable opportunities and technologies continue to be investigated where possible for improved efficiency.
Waste Minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment. Wastes should be managed in accordance with the following order of preference: ▪ Avoidance. ▪ Re-use. ▪ Recycling. ▪ Recovery. ▪ Treatment. ▪ Containment. ▪ Disposal.	Waste minimisation principles have been considered in project design. This includes: ▪ Minimising the size of the TSF and WRD. ▪ Re-use of topsoil and cleared vegetation in rehabilitation of areas during operations and post-mining. ▪ Disposal of putrescible wastes in a purpose-built onsite landfill within WRD footprints ▪ Reduce landfill by reusing and recycling materials where possible. Minimising packaging wastes associated with reagents by importing in bulk and requiring return of packaging to suppliers.

4.2 Assessment of environmental factors

One ‘key preliminary factor’ is considered most relevant to the Proposal, Terrestrial Fauna. This factor is described in detail in Section 5. Potential impacts and a brief assessment of these impacts is also presented in Table 11.

Six ‘other factors’ are summarised in Section 6, and include: 1) Inland Waters; 2) Terrestrial Environmental Quality; 3) Flora and Vegetation; 4) Social Surroundings (Aboriginal heritage and culture); 5) Subterranean Fauna; 6) Air Quality. These other factors are considered unlikely to be significantly impacted by the Proposal and can be largely managed through secondary environmental approval processes and regulatory mechanisms to achieve an appropriate environmental outcome. These factors are described in detail in Section 6.

Table 11 Summary of Assessment of Environmental Factors relevant to the Proposal

Environmental Factor	Key Environmental Aspects and Potential Impacts	Comments
Key Factors		
Terrestrial fauna	Clearing will remove night refuges and foraging habitats for conservation significant bats. Dewatering may reduce habitat quality/value.	Mining of the Klondyke Pit will not remove any diurnal roosts, but will remove of five old mine workings (KQ488, Cuban, Kopckes Reward and Britannia, St George), which are all considered low value temporary refuge sites and occasionally used by either the Pilbara Leaf-nosed Bat and/or the Ghost Bat. Dewatering the mine pit will affect the nearby bat roost Klondyke Queen, which currently accommodates a colony of Ghost Bats and Pilbara Leaf-nosed Bats.
Other Factors		
Inland waters	A mine pit lake will remain at Klondyke that may alter water quality. Waste contains some harmful materials that require management.	The formation of a pit lake after closure has the potential to affect water quality within the pit lake and surrounding environmental values Surface water runoff around mine infrastructure and storage facilities (such as chemical storage, tailings and waste rock storage facilities) has potential to affect surface water quality, in particular surface water associated with potential exposure metalliferous waste rock material.
Terrestrial environmental quality	Unsuccessful rehabilitation as a result of poor-quality waste material.	Project designed to minimise risk of land and soil contamination and preserve soil quality for rehabilitation. Site procedures already developed, include a Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19 Appendix 9-6) and a TSF and Cyanide Management Procedure (CRL-ENV-PRO-019-19 Appendix 9-5), as well as a comprehensive Mine Closure Plan currently in development, which will manage and mitigate terrestrial environmental quality impacts
Flora and vegetation	Clearing will remove vegetation.	Clearing of up to 398.5ha of vegetation of widespread Pilbara units. Not located within ESAs, Schedule 1 Areas, or within DBCA managed land. No groundwater dependent ecosystems No Threatened Flora, No TECs or PECs. Three Priority flora (P3 and P4s), all very widespread through the survey area and region. Ground disturbance procedures, avoidance measures, weed control and progressive and considered rehabilitation planning will manage and mitigate vegetation and flora impacts.
Social surroundings (Aboriginal heritage and culture)	NA	Site avoidance surveys have recorded archaeological places proximal to the Proposal area, all of which will be avoided. Ground disturbance procedures (CRL-ENV-PRO-002-19) and site avoidance measures will ensure that heritage places are not disturbed.
Subterranean fauna	NA	Potential impacts to subterranean fauna are low, with demonstrated habitat connectivity along the Warrawoona Range ridgeline by key subterranean fauna groups sampled.
Air quality	NA	There are no communities in close proximity to the Proposal. A prospector, on tenements M45/004 and M45/646, is located approximately 2.5km southwest of the proposed plant area. The nearest community is Marble Bar which is approximately 20km north.

5 TERRESTRIAL FAUNA

This section reports on the key environmental factor, Terrestrial Fauna.

Following a brief description of the EPA objective, policy and guidance relevant to terrestrial fauna, a summary is provided of the various relevant studies commissioned by Calidus to date.

This section then describes separately, the three main components of Terrestrial Fauna that are the subject of this impact assessment: 1) Bats; 2) other conservation significant vertebrate fauna; and 3) short range endemic invertebrate fauna (SREs).

For each of these three faunal groups, background information is provided, including preferred habitat and ecological requirements in the region and locally. Following this, investigations commissioned by Calidus into each of these three groups are described in detail, including survey techniques and overall findings.

Based on the outcomes of the investigations, a list of potential impacts is then provided, followed by a detailed assessment of these impacts for each focus species.

Finally, mitigation measures are proposed in accordance with the EPA mitigation hierarchy (avoid, minimise and rehabilitate).

5.1 EPA objective

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

5.2 Policy and guidance

- Statement of Environmental Principles, Factors and Objectives (EPA 2018b).
- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016a).
- Technical Guidance: Terrestrial fauna surveys (EPA 2016b).
- Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016c).
- Technical Guidance - Sampling of short range endemic invertebrate fauna (EPA 2016d).
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2017).
- Survey Guidelines for Australia's Threatened Mammals (DSEWPC 2011).
- Survey Guidelines for Australia’s Threatened Reptiles (DSEWPC 2011).
- DEWHA (2010) Survey Guidelines for Australia’s Threatened Bats (DEWHA 2010).
- Interim guideline for preliminary surveys of Night Parrot, *Pezoporus occidentalis* (Department of Parks and Wildlife 2017).
- National Recovery Plan for the Northern Quoll *Dasyurus hallucatus* (Hill and Ward 2010).

5.3 Supporting studies

Table 12 summarises the terrestrial fauna studies commissioned by Calidus to date, describing the type of assessment and the key outcomes.

Table 12 Summary of terrestrial fauna related investigations

Survey Title	Survey effort/Key outcomes	Season	Reference and Supporting Document
Bat surveys and investigations			
Monitoring bats of conservation significance near Marble Bar, Western Australia: November 2016	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Baseline data on usage and occupancy of mines in the Marble Bar area	Early Dry Season	Specialised Zoological (2017a)
Monitoring bats of conservation significance near Marble Bar, Western Australia: April 2017	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Baseline data on usage and occupancy of mines in the Marble Bar area	Late Wet Season	Specialised Zoological (2017b)
Pilbara Ghost Bat Genetic Project 2017 (Unpublished report prepared for the BHP Billiton Iron Ore Pty Ltd).	Ghost Bat Genetic Project • Genetic and hormone analyses of ghost bat tissue and scats for increasing knowledge of cave use and movement by bats.	Late Wet Season	Biologic (2017b)
Targeted Bat Assessment - September 2017	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses) • Assess underground workings within the Proposal area in terms of providing roosting habitat for Pilbara Leaf-nosed Bat and Ghost Bat	Late Dry Season	Biologic (2018a)
Targeted Bat Assessment – July 2018	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses)	Dry Season	Biologic (2018b)
Targeted Bat Assessment – April 2019	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses)	Late Wet Season	Biologic (2019a) Appendix 1-2
VHF Bat Foraging Studies July 2018	Pilbara Leaf-nosed Bat and Ghost Bat Foraging Study (VHF) • Use VHF tracking to assess foraging habitats and movement patterns	Dry Season	Biologic (2018c)
VHF Bat Foraging Studies April 2019	Pilbara Leaf-nosed Bat and Ghost Bat Foraging Study (VHF) • Use VHF tracking to assess foraging habitats and movement patterns	Late Wet Season	Biologic (2019b) Appendix 1-3

Survey Title	Survey effort/Key outcomes	Season	Reference and Supporting Document
Terrestrial Fauna Surveys			
Level 1 Vertebrate Fauna, and Desktop SRE and Subterranean Assessment - Sept 2017	• Level 1 survey (recorded Northern Quoll; Western Pebble-mound mouse) • 34 motion camera nights (3 sites) • 12 habitat assessments	Late Dry Season	Biologic (2017a) Appendix 1-1
Habitat Assessment and Targeted Vertebrate Fauna Survey - July 2018	Targeted survey (Northern Quoll) • 40 acoustic recording nights (10 sites) • 156 motion camera nights (4 sites) • 12 habitat assessments	Dry Season	Biologic (2019c)
Habitat Assessment and Targeted Vertebrate Fauna Survey - April 2019 (Significant Species Survey and Monitoring)	Targeted survey (Northern Quoll, Pilbara Olive Python, Brush-tailed Mulgara, Night Parrot) • 33 acoustic recording nights (3 sites) • 346 motion camera nights (5 sites) • 40 habitat assessments	Late Wet Season	Biologic (2019d) Appendix 1-4
SRE Invertebrate Studies			
Warrawoona Gold Project SRE Invertebrate Fauna Survey	Short Range Endemic (SRE) invertebrate fauna survey • -determine the presence and distribution of SREs through habitat assessment and field sampling (active foraging and leaf litter searches). (Note: Subterranean fauna are assessed in Section 6.5)	Late Wet Season (Trip 1, May 2018; Trip 3 April 2019) Dry Season (Trip 2 July 2018)	Biologic (2018d) Appendix 2-1
Impact Assessment Studies			
Conservation Significant Bat Species Impact Assessment	Provides a detailed summary of the recent targeted bat survey work completed to date, and assesses the potential impacts from implementation of the proposed development for two conservation significant bat species, the Ghost Bat and the Pilbara Leaf-nosed Bat.		Biologic (2019f) Appendix 3-1
Conservation Significant Vertebrate Fauna Impact Assessment.	Provides a detailed summary of terrestrial vertebrate fauna investigations to date, and assesses the potential impacts from implementation of the proposed development for the two conservation significant Bat species.		Biologic (2019g) Appendix 3-2

Survey Title	Survey effort/Key outcomes	Season	Reference and Supporting Document
Assessment of Blasting on the Klondyke Queen. A roost site for Pilbara-Leaf-nosed Bat and Ghost Bat.	Assess the effects of blasting on the structure in which the PLNB and GB roost. Model a set of blast parameters for potential blast vibration, airblast overpressure and flyrock to determine a safe set of blast parameters to commence drill and blast activities at the Klondyke Mine.		Blast It Global (2018) Appendix 3-3
Klondyke Deposit Geotechnical Review of Blasting Report	Technical review of Blast it Global (2018). The review endorsed the outcomes of the investigation and its recommendations		Peter O'Bryan and Associates (2019) Appendix 3-4
Environmental Noise Assessment: Warrawoona Gold Project, Marble Bar	Model the noise emissions from the site proposed process plant and associated power plant, and night-time mining operations at the Klondyke pit. Assess the noise impact from the site at nearby receivers, including known roost sites for two bat species		Lloyd George Acoustics (2019) Appendix 3-5
Warrawoona Gold Project – Assessment of Dust Emissions.	Desktop dust assessment found that with conventional dust management measures, in conjunction with the adopted exclusion zone and setback to sensitive roost locations, airborne dust emissions are expected to be maintained within acceptable levels at sensitive receptor locations.		Environmental Technologies and Analytics (2019) Appendix 3-6

5.4 Existing environment

Following a summary desktop assessment of terrestrial fauna values within the region, this section will then separately describe three terrestrial faunal groups known from the local area: 1) conservation significant bats; 2) other conservation significant vertebrate fauna; and 3) short range endemics (SREs). Subterranean fauna is discussed separately in Section 6.5.

5.4.1 Desktop assessment

Literature review and database searches have identified 316 species of vertebrate fauna with the potential to occur in the Proposal area. These comprise 37 native mammals, nine non-native mammals, 154 birds, 102 reptiles, ten amphibians and four fish (note, some species identified are unlikely to occur, preferring habitats not found within Proposal area).

Of the 319 vertebrate fauna identified above, 29 species are of conservation significance. Within the suite of conservation species, six species have been confirmed within the Proposal area; three species were considered likely to occur and a further three species were considered possible. Table 13 summarises the 12 species of conservation significance known to, or with potential to, occur in the Proposal area. The full results are presented in (Biologic 2018e, 2019d, 2019c) (Appendix 1-1; Appendix 3-1; Appendix 3-2).

Table 13 Conservation significant fauna confirmed or likely to occur on the Proposal area

Species	Status	Habitats in Proposal area	Comment	Likelihood of occurrence
Conservation Significant Bats, described in Section 5.4.2				
Ghost Bat	Vulnerable (EPBC and BC Act)	Roosting within historical underground workings. Foraging habitat may include the Medium and Minor Drainage Line, Rounded Hills, Rocky Breakaway, and to a lesser significance Hillcrest/hillslope, and plain habitat (Stony Plain, Sandy Plain).	Multiple roosting and refuge sites throughout the Proposal area and in surrounding landscape. Colony at the Klondyke Queen roost, which will eventually be a minimum of 200m from the adjacent the Klondyke pit (at its closest point).	Confirmed
Pilbara Leaf-nosed Bat	Vulnerable (EPBC and BC Act)	Roosting within historical underground workings. Foraging habitat may include the Medium and Minor Drainage Line, Rounded Hills, Rocky Breakaway, and to a lesser significance Hillcrest/hillslope, and plain habitat (Stony Plain, Sandy Plain).	Multiple roosting and refuge sites throughout the Proposal area and in surrounding landscape. Large colony (600 - 1,000 individuals) present at the nearby Bow Bells South, approximately 4km northwest of the Klondyke pit (at its closest point).	Confirmed
Other Conservation Significant Fauna, described in Section 5.4.3				
Northern Quoll	Endangered (EPBC and BC Act)	Rocky Breakaways (core denning habitat), Medium/Minor Drainage Line, Hillcrest/Hillslope, Rounded Hills (medium quality NQ habitat with some opportunity for denning)	2 individuals 2018; 5-6 individuals 2018; 3-4 individuals 2019.	Confirmed
Pilbara Olive Python	Vulnerable (EPBC Act and BC Act)	Rocky Breakaways, Medium/Minor Drainage Line	Associated with drainage systems, including areas with localised drainage and watercourses. In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation. One individual Pilbara Olive Python was recorded on camera, in the Klondyke Queen mine workings.	Confirmed

Species	Status	Habitats in Proposal area	Comment	Likelihood of occurrence
Brush-tailed Mulgara	Priority 4 (BC Act)	Sand Plain Habitat	Prefers spinifex (*Triodia* spp.) grasslands on sand plains and the swales between low dunes (Woolley 2006; Pavey *et al*. 2012). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.* 2007). Brush-tailed Mulgara were captured during on motion camera over multiple nights in Sandplain.	Confirmed
Western Pebble-mound Mouse	Priority 4 (BC Act)	Stony Plains, Hillcrest/hillslope	Five mounds (one active, four inactive) have been opportunistically recorded in the Proposal area.	Confirmed
Spectacled Hare-wallaby	Priority 3 (BC Act)	Stony Plain and Sandplain Habitat	Sparsely distributed and generally uncommon across northern Australia, distributed from northern Queensland in the east, to the Pilbara where the species is considered relatively rare (Van Dyck and Strahan 2008a).	Likely
Greater Bilby	Vulnerable (EPBC) and BC	Sand Plain Habitat	The nearest record is 15km to the east of the Proposal area boundary. However, the record location dates back to 1967, 2001, and 2004.	Likely
Peregrine Falcon	Other specially protected fauna (BC Act)	Rocky Breakaways, Medium/Minor Drainage Line	In arid areas, it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone and Storr 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25m and 50m high (Olsen and Olsen 1986).	Likely
Northern Brush-tail Possum	Priority 4 (BC Act)	May include Medium/Minor Drainage Line	Patchily distributed. The nearest DBCA record is located approximately 40km south-east	Possible
Long-tailed Dunnart	Priority 4 (BC Act)	Rocky Breakaway	Typically occurs on plateaus near breakaways and scree slopes, and on rugged boulder-strewn scree slopes (Gibson and McKenzie 2009). Once considered rare, now shown to be relatively common and widespread in rocky habitats (Burbidge *et al*. 2008).	Possible
Night Parrot	Endangered (EPBC Act), Critically Endangered (EP Act)	Sandplain and Stony Plain habitat.	There are only two contemporary records of the species within Western Australia. The nearest record of Night Parrot is located ~55km north-east of the Proposal area from 1980 (DBCA 2017b). There is suitable habitat within the Proposal area, and the species is known to travel up to 100km per night for foraging.	Possible

5.4.2 Bats

5.4.2.1 Background and description

This section describes the two species of conservation significant bat within the Proposal area (Ghost Bat and Pilbara Leaf-nosed Bat), providing background information on range and regional records. Habitats and records of these species within the Proposal area are discussed in Section 5.6.2.3 (investigations findings and outcomes) and Section 5.6.1 (Impact assessment).

Ghost Bat, *Macroderma gigas*

Conservation Status: Vulnerable under the EPBC Act and BC Act
Likelihood of occurrence: Confirmed in Proposal area

The Ghost bat is restricted to the Pilbara, the Kimberley, the northern part of the Northern Territory, coastal and near coastal Queensland from Cape York to near Rockhampton (Churchill 2008), and Western Queensland (Threatened Species Scientific Committee 2016a) (Figure 16).

The Ghost Bat occurs, and has been recorded, widely across the entire Pilbara IBRA region (Figure 16).

The Pilbara population is estimated to be between 1,300 and 2,000 individuals (Threatened Species Scientific Committee 2016a). The largest population occurs within the Chichester subregion (estimated at approximately 1,500 individuals) where known populations are largely restricted to disused mines.

The distribution of Ghost Bats in the Pilbara is determined by the presence of suitable roosting sites, either natural caves or historic mines and adits. Natural roosts comprise deep, complex caves beneath bluffs or low rounded hills of Marra Mamba or Brockman Iron Formation (Armstrong and Anstee 2000).

Roosts used by the species can be classified into four types: night roosts, night/occasional diurnal roosts, diurnal roosts with regular small groups present/possible maternity roosts, and permanent roosts with large populations/maternity roosts.

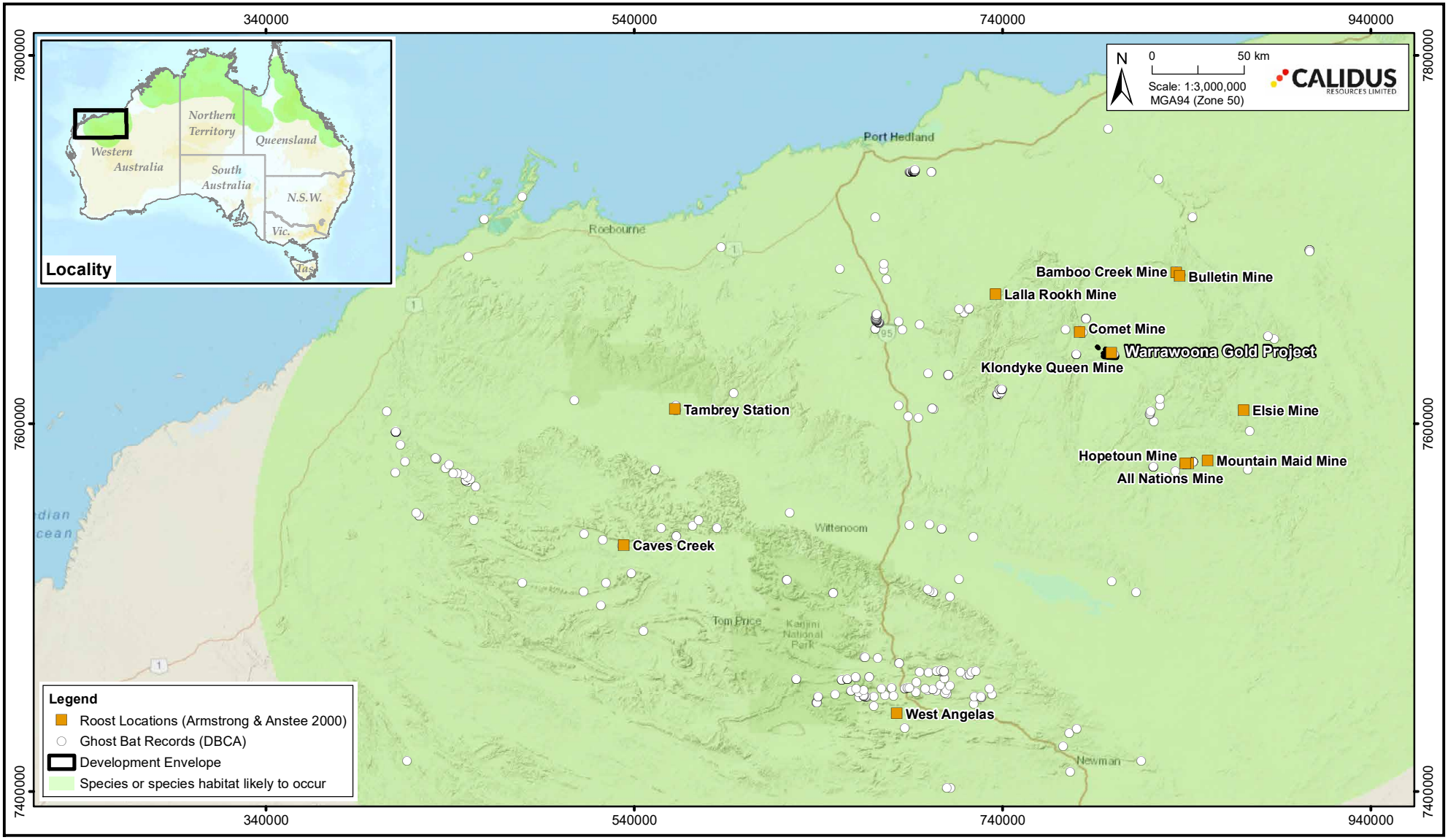
Armstrong and Anstee (2000) reported high relative humidity (82 - 84 %) at two known maternity roosts in the Hamersley Ranges, with the remaining caves recording relative humidity readings of between 14 - 31 %. R. Bullen (Bat Call WA, pers. comm. May 2019) has also recorded Ghost Bats roosting and reproducing in caves with low humidity levels.

Centralised breeding sites in the Pilbara have largely been recorded at abandoned mines in the Chichester Ranges (Armstrong and Anstee 2000), with few known maternity roosts in natural caves in the Pilbara. Based on available data, breeding has been documented in natural caves at Mining Area C, Mt Brockman and West Angelas in the Hamersley sub-region, and at Callawa and Tambrey Station in the Chichester sub-region (Armstrong and Anstee 2000).

Pilbara Ghost Bats regularly move between a number of caves as dictated by weather conditions, and require a range of cave sites (Hutson *et al.* 2001). Outside of the breeding season, male bats are known to disperse widely, most likely during the wet season when conditions allow bats to use caves otherwise not suitable. Genetic studies indicate that females are likely to stay close to the maternity roosts (Worthington-Wilmer *et al.* 1994).

While there are currently no studies detailing the home range of Ghost Bats in the Pilbara region, a study in the Northern Territory recorded an average foraging area of 61ha (Tidemann *et al.* 1985). Tidemann *et al.* (1985) demonstrated that foraging areas were usually located 1.9km from a diurnal roost, with individuals generally returning to the same foraging areas each night (note: there are likely differences in the ecology and foraging behaviour of Ghost Bats in the Pilbara and the tropics).

Figure 16: Distribution of the Ghost Bat in the region of the Proposal (Source: Biologic 2019a; Appendix 1-2)



Souce: ESRI - Basemap, Homesteads; DBCA - Ghost Bat Records
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_16, Rev: A

Ghost Bats need an "apartment block" of roosting opportunities, comprising at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal feeding and refuge opportunities, a local productive set of gullies and gorges, a productive foraging area within 5-10km radius, usually including a good quality riparian line or ephemeral fresh water lake bed (R. Bullen, Bat Call WA, pers. comm. May 2019).

When Ghost Bats are flushed in daylight they almost immediately go to an alternative site before returning to the diurnal roost cave.

Ghost Bats in the Pilbara are believed to mate in July and August, with the females giving birth in late October or November (Richards *et al.* 2008).

Ghost Bats commence hunting approximately 1 to 1.5 hours after sunset and will hunt for about two hours (Boles 1999). This is followed by periods of inactivity interspersed by periods of hunting, with a resumption of feeding activity just prior to sunrise (Boles 1999). Ghost Bats have a 'sit and inspect' foraging strategy; they hang on a perch where they visually inspect their surroundings for movement. Once their prey is detected it may be captured in the air, gleaned (taken from the surface of a substrate by a flying bat) from the ground or vegetation, or dropped on from a perch (Boles 1999).

Proposal area and surrounds

Outside the Proposal area, the closest known diurnal roosts are found at Comet Mine (approximately 20km northwest), Marble Bar Copper (approximately 16km north west), Lalla Rookh (approximately 75km west, Atlas Iron 2014) and multiple sites at Corunna Downs.

Closer to the Proposal area, the species has been recorded at various disused mines including Bow Bells approximately 4km northwest) and Trump mines (7.5km west) (Armstrong and Anstee 2000; Hall *et al.* 1997) (Figure 17).

Within the Proposal area, Ghost Bats have been recorded at Klondyke Queen complex, Klondyke Boulder, Dawson City, Mullens adit, Klondyke No 1 East and Klondyke No 1 West (Figure 18).

Together with other large colonies such as Lalla Rookh, the subregion is known to support a population of approximately 1,500 individuals (Threatened Species Scientific Committee 2016a).

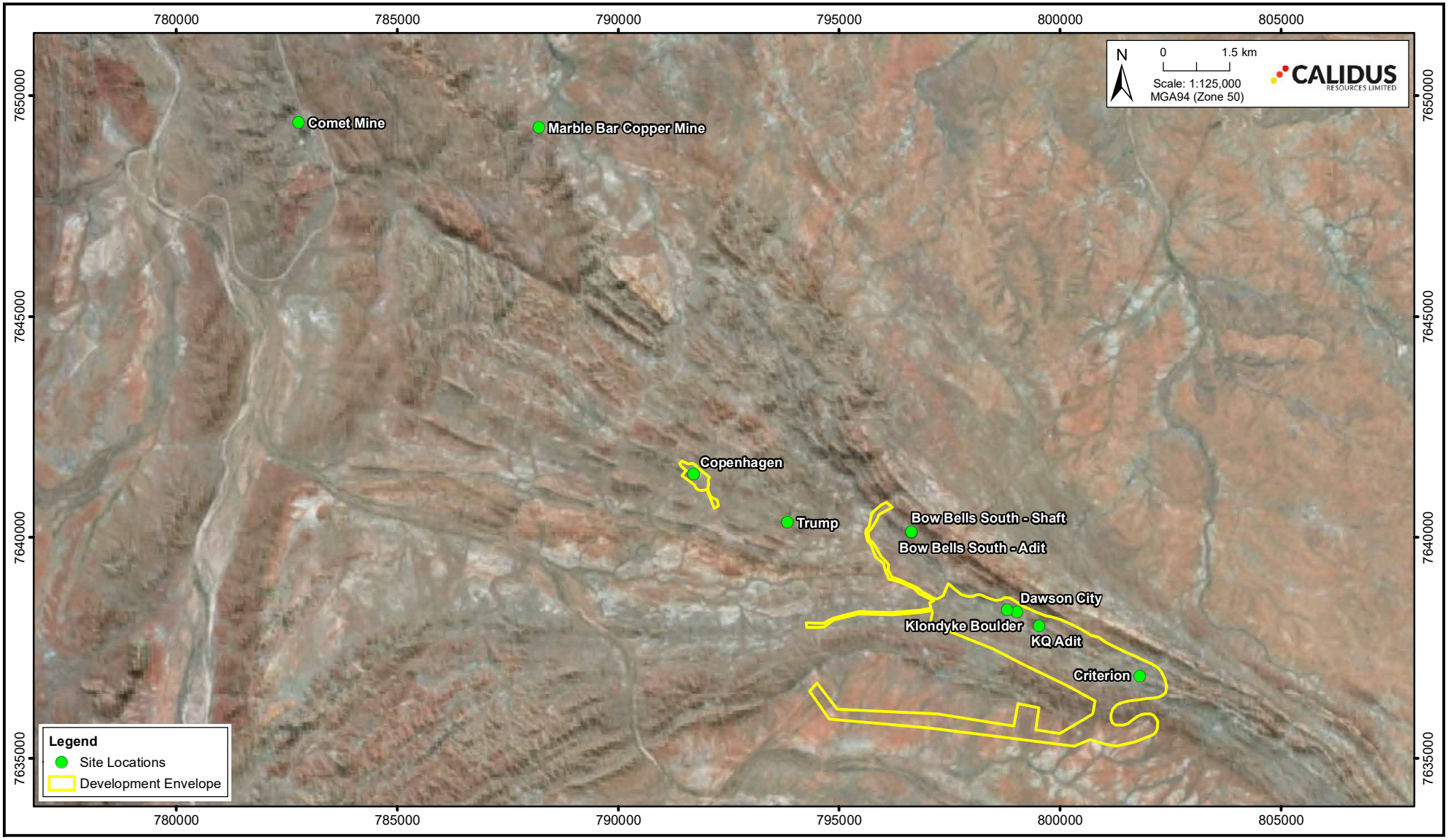
Klondyke Queen roost

The Klondyke Queen roost is located within a disused mine, approximately 200m west of the proposed Klondyke open pit edge (at its closest point).

The Ghost Bat was first confirmed at Klondyke Queen in 1957, approximately twelve years after the cessation of mining in the area. Since this time the species has been confirmed consistently, via visual observations. Refer to Appendix 3-1 (Biologic 2019f) for a complete list of previous Ghost Bats records at Klondyke Queen.

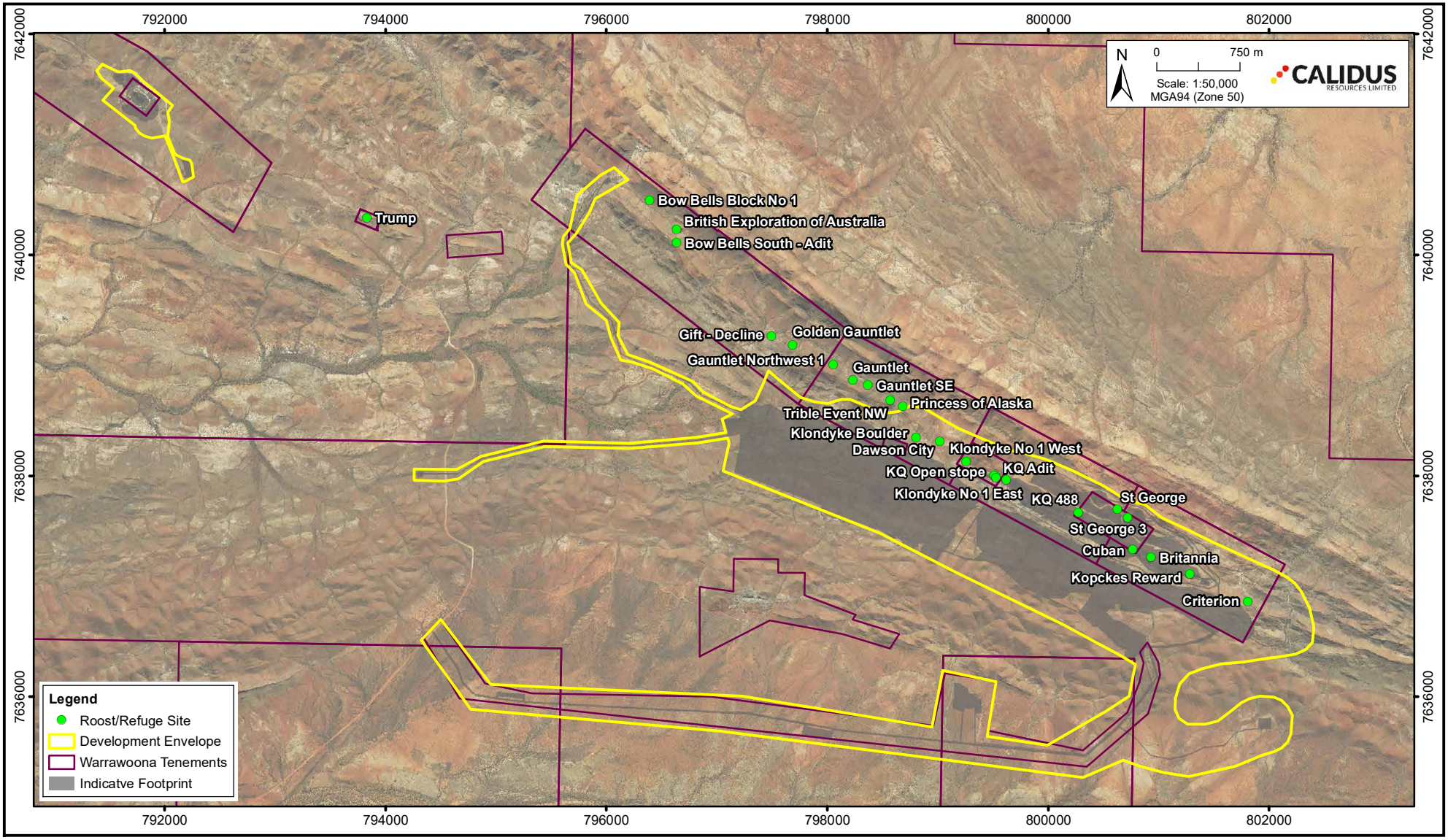
Breeding activity of the species was confirmed at Klondyke Queen during the early 1990's (Hall *et al.* 1997), with several gravid and lactating females recorded. The consistent presence of the species in relatively high densities indicates that the roost is likely to be a permanent maternity site and possibly one of the largest colonies in the Pilbara (R. Bullen, Bat Call WA, pers. comm. May 2019).

Figure 17: Local roosting areas across the Proposal area and surrounds (Source Biologic 2019a, Appendix 1-2)



Source: Biologic - Roosts, ESRI/DigitalGlobe - Imagery
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_17, Rev: A

Figure 18: Known roosting in the Proposal area adjacent the proposed Klondyke mine



Source: DMIRS - Tenements, Biologic - Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_18, Rev: A

Plate 3. Ghost Bat recorded from the Proposal area (Source: R. Bullen, Bat Call WA)

Plate 4. Pilbara Leaf-nosed Bat from the Proposal area (Source: R. Bullen, Bat Call WA)

Pilbara Leaf-nosed Bat, *Rhinonicteris aurantia*

Conservation Status: Vulnerable under the EPBC Act and BC Act
Likelihood of occurrence: Confirmed in Proposal area

The Pilbara Leaf-nosed Bat is a small (10 g) insectivore, geographically isolated form of the tropical populations of Orange Leaf-nosed Bat (Armstrong 2001) and known from the Pilbara, Ashburton and Little Sandy Desert bioregions. Pilbara Leaf-nosed Bat roosts are found in disused mines and gorge systems in the eastern Pilbara and Little Sandy Desert, Hamersley Ranges, and the Barlee Nature Reserve (Threatened Species Scientific Committee 2016b) (Figure 19).

The Pilbara Leaf-nosed Bat occurs, and has been recorded, widely across the entire Pilbara IBRA region (Figure 19).

The Pilbara Leaf-nosed Bat roosts may range from a few individuals to a few hundred (Threatened Species Scientific Committee 2016; Bullen 2013).

Across northern Australia the Pilbara Leaf-nosed Bat is reliant on roost sites in caves or mine adits with stable, very hot (28 – 32 ^{o}C) and very humid (96 – 100%) microclimates (Churchill 2008). This is a result of their limited ability to conserve heat and water (Armstrong 2001; Churchill 1991). Caves and abandoned mines deep enough to create this environment are relatively uncommon in the Pilbara (Van Dyck and Strahan 2008b), which limits the availability of diurnal roosts for this species.

Foraging habitat for the Pilbara Leaf-nosed Bat is diverse. The species generally hunts through riparian vegetation in gorges, and over hummock grassland and sparse tree and shrub savannah (Churchill 1994). In the Pilbara, it has been observed in Triodia hummock grasslands covering low rolling hills and shallow gullies, with scattered *Eucalyptus camaldulensis* along the creeks (Threatened Species Scientific Committee 2016c).

The species begin to depart for, and cease, their nightly flying activity at diurnal roosts at specific times following a seasonal pattern. On average, colonies depart their roost 5 minutes before civil twilight (R. Bullen unpub. data).

The Pilbara Leaf-nosed Bat is an acrobatic, high-energy flyer foraging for prey along the gorges and ridgelines around its roost. It is most often observed in flight over waterholes or flying along road easements 1 - 2m from the ground (Churchill 2008).

Proposal area and surrounds

The species has been recorded roosting at two disused mines in the region, Bamboo Creek and Comet (Armstrong 2001; Threatened Species Scientific Committee 2016), with ten diurnal roosts confirmed in the Pilbara region and a further 21 were inferred (Threatened Species Scientific Committee 2016) (Figure 17).

Further afield, the Pilbara Leaf-nosed Bat has been recorded at a number of diurnal roosting sites, including two located at Corunna Downs (approximately 20km west), Copper Hills (approximately 40km south, Armstrong 2001), multiple sites at Mt Webber (approximately 50km south-west, MWH 2016), and multiple sites near Lalla Rookh and North Star (approximately 75km west, Atlas Iron 2014; Bat Call 2013). The presence of these roosts within the vicinity of the Proposal area, as well as the potential for undiscovered roosts, demonstrates that the species is not rare within the local region.

Figure 19: Distribution of the Pilbara Leaf-nosed Bat in the region of the Proposal (Source: Biologic (2019a); Appendix 1-2)

Souce: ESRI - Basemap, Homesteads; DoEE - Roost Records
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_19, Rev: A

Klondyke Queen roost

In 1981, a colony of Pilbara Leaf-nosed Bats was first discovered in the old workings of the Klondyke Queen mine (Churchill *et al.* 1988). The adit was previously trapped by Douglas (1967) with no Pilbara Leaf-nosed Bats recorded, suggesting that the adit was colonised subsequent to this.

Trapping and entrance counts conducted over recent decades has shown that the colony has varied in size. Armstrong (2001) reported "a gradual decline in numbers" following mining activity, which included an excavation of an adit beneath the Klondyke Queen and a drilling program in 1994. Armstrong (2001) reported the workings to be in a poor state of repair, with evidence of several collapses near the entrance and underground. It was suggested that individuals had subsequently moved their roosting location sporadically between Klondyke Queen, Comet Mine and Bamboo Creek mine (Armstrong 2001).

Diurnal roosting, as opposed to strictly nightly visitation, has been suspected although not confirmed at Klondyke Queen consistently since 1981. Refer to Appendix 3-1 (Biologic 2019f) for a complete list of previous counts of Pilbara Leaf-nosed Bat recorded at Klondyke Queen.

The nearby roost at Bow Bells South (approximately 4km northwest) also supports a large colony and is considered to be of regional significance for the Pilbara Leaf-nosed Bat (Biologic 2019f).

5.4.2.2 Proposal area investigations

Eight surveys over five survey events, targeting the two conservation significant bat species have been undertaken in the Proposal area since 2016. The investigations have included the following:

- Habitat Suitability: 68 sites were visited and visually assessed for their suitability to provide habitat for bat species of conservation significance.
- Population Monitoring: 31 sites were initially targeted utilising ultrasonic recordings of bat calls, population censuses via video recordings and/or visual counts to determine baseline data on usage and monitor occupancy of potential and known roosts within the Proposal area. Ongoing population monitoring has primarily focused on 9-10 sampling sites across key roosting areas at Klondyke Queen and Bow Bells.
- Ghost Bat genetic study: Genetic sampling at 74 caves or adits across seven survey events within the Pilbara looking at cave usage and bat movement (Biologic 2017a), including individuals captured at Klondyke Queen and Comet.
- Foraging habitat monitoring: Two VHF tracking studies at the Proposal area (2018, 2019) (Biologic 2018c, 2019b), involving digitally encoded VHF transmitters attached to Pilbara Leaf-nosed Bats and Ghost Bats, and detecting an automated VHF tracking system designed to record movement.

For further details, refer to Appendix 1-2, Appendix 1-3, and to Appendix 3-1.

5.4.2.3 Findings and outcomes

Information in this section is based on results and findings from supporting studies commissioned by Calidus, as summarised in Section 5.3 (Table 12).

Ghost Bat population

Ghost Bats were detected at 23 of the 31 sites surveyed in the Proposal area and more broadly. A summary of the Ghost Bat activity across the Proposal area and surrounds is presented in Table 14 (Figure 17 and Figure 18). Within the Proposal area, diurnal roosting was recorded at Klondyke Queen and more broadly at Bow Bells South, with lower numbers of individuals recorded at Dawson City, Criterion and Klondyke Boulder. Klondyke Queen regularly recorded the maximum number of individuals exiting, including at least 450 individuals over both the 2018 and 2019 survey events.

Off site, Ghost bats were also recorded exiting Comet mine, with 269 recorded in 2019.

Pilbara Leaf-nosed Bat population

The Pilbara Leaf-nosed Bat was detected at 30 of the 31 sites surveyed. A summary of the Pilbara Leaf-nosed Bat activity across the Proposal area and surrounds is presented in Table 14.

Within the Proposal area, consistently high levels of activity were recorded at Klondyke Queen (with between 1,500 and 3,300 calls per night) and at Bow Bells South, which recorded approximately 4,000 call per night in 2017 at the adit and in excess of 4,200 calls per night in 2018 at the shaft entry (Table 14). High activity levels were also recorded each night at Dawson City and Klondyke Boulder. Low activity was recorded for Pilbara Leaf-nosed Bats at the remaining sites, including sites further afield (Table 14).

For more information on the sites within the Proposal area and surrounds, including photographs of each root, refer to the Significant Species Management Plan (CRL-ENV-PLN-006-19, Appendix 9-1)

Plate 5. Rob Bullen, bat specialist, with a Ghost Bat during monitoring at the Proposal area.

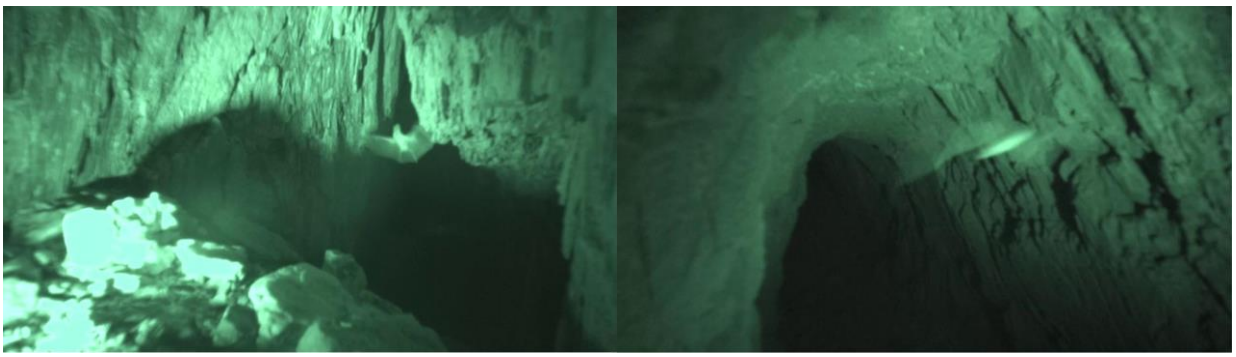


Plate 6. IR-lit video showing (a) Ghost Bat existing from the Klondyke Queen inner adit; (b) Pilbara Leaf-nosed Bat at high speed in the Bow Bells South adit (Source: Biologic 2019a; Appendix 2-1).

Roosting significance

Table 14 also presents the roost and other habitat types identified at the regularly sampled sites visited at the Proposal area and surrounds. Based on the previous surveys, the most significant sites identified to date across the Proposal area and surrounds include: 1) Bow Bells South; 2) Klondyke Queen and 3) Comet.

Bow Bells South (approximately 4km northwest of the proposed Klondyke pit at its closest point, Figure 17 and Figure 18)

- Pilbara Leaf-nosed Bat: Pilbara Leaf-nosed Bats were recorded roosting at Bow Bells South on multiple nights over a number of seasons and years. Based on the number of calls, it is likely that the colony consists of 600 - 1,000 individuals. The repeated roosting presence of species indicates that it is a permanent diurnal roost of regional significance.
- Ghost Bat: Although unlikely that the Ghost Bat use Bow Bells South as a permanent diurnal roost, the species has been recorded roosting and foraging there on several occasions. Its internal structure with multiple horizontal drives is conducive to roosting by the species, offering an occasional diurnal roost, and therefore representing an important site for the species.

Klondyke Queen (200m west of the proposed Klondyke pit and outside of the Proposal area, Figure 17 and Figure 18)

- Ghost Bat: Klondyke Queen is a confirmed diurnal roosting site for the Ghost Bat. Given the continuity of presence across multiple years and seasons, and records of pregnant individuals, Klondyke Queen is also a confirmed maternity roost for the species. Ghost Bats disperse widely when not breeding but concentrate in a few roost sites when breeding, thus making maternity caves of increased significance. Monitoring results to date suggest that the population roosting within the Klondyke Queen is largest during the mid to late dry season. The population of Ghost Bat broadly across the Warrawoona study area is estimated to be 500 individuals (R. Bullen, Bat Call WA, pers. comm. 3 October 2019 in Biologic 2019f).
- Pilbara Leaf-nosed Bat: The Klondyke Queen contains a permanent diurnal roost (Biologic 2019a), with a small number of diurnally roosting Pilbara Leaf-nosed Bats occurring within the complex (adit, hilltop and open cut sites are interconnected). The number of Pilbara Leaf-nosed Bats at Klondyke has fluctuated substantially since the colony was discovered (Biologic 2019f). The population of the Pilbara Leaf-nosed Bat across the broader Warrawoona study area is estimated at approximately 1500-2000 individuals, with counts fluctuating between the Klondyke Queen complex and the Bow Bells South site depending on which roost the individuals are utilising at the time of monitoring (R. Bullen, Bat Call WA, pers. comm. 3 October 2019 in Biologic 2019f). Pilbara Leaf-nosed Bats have been consistently confirmed roosting within the adit based on large numbers of echolocation calls and observations.

Given that the Klondyke Queen is a maternity roost for the Ghost Bat and a permanent diurnal roost for the Pilbara Leaf-nosed Bat, the site is considered of regional significance.

Although it is difficult to confirm as the workings are not safe to enter, historic mine plans for the site suggest that the roost is located 70m from the adit opening, and approximately 10m below surface. The adit dimensions are approximately 2m x 2m with multiple openings to the surface prior to the roost location. The openings to surface are old mined-out areas and are approximately 1m wide.

Comet (20km northwest of proposed Klondyke pit, Figure 17)

- Ghost Bat: Comet is a confirmed permanent maternity roost for the Ghost Bat. Comet has consistently recorded the presence of the Ghost Bat across multiple years and seasons indicating that Comet accommodates a large colony.

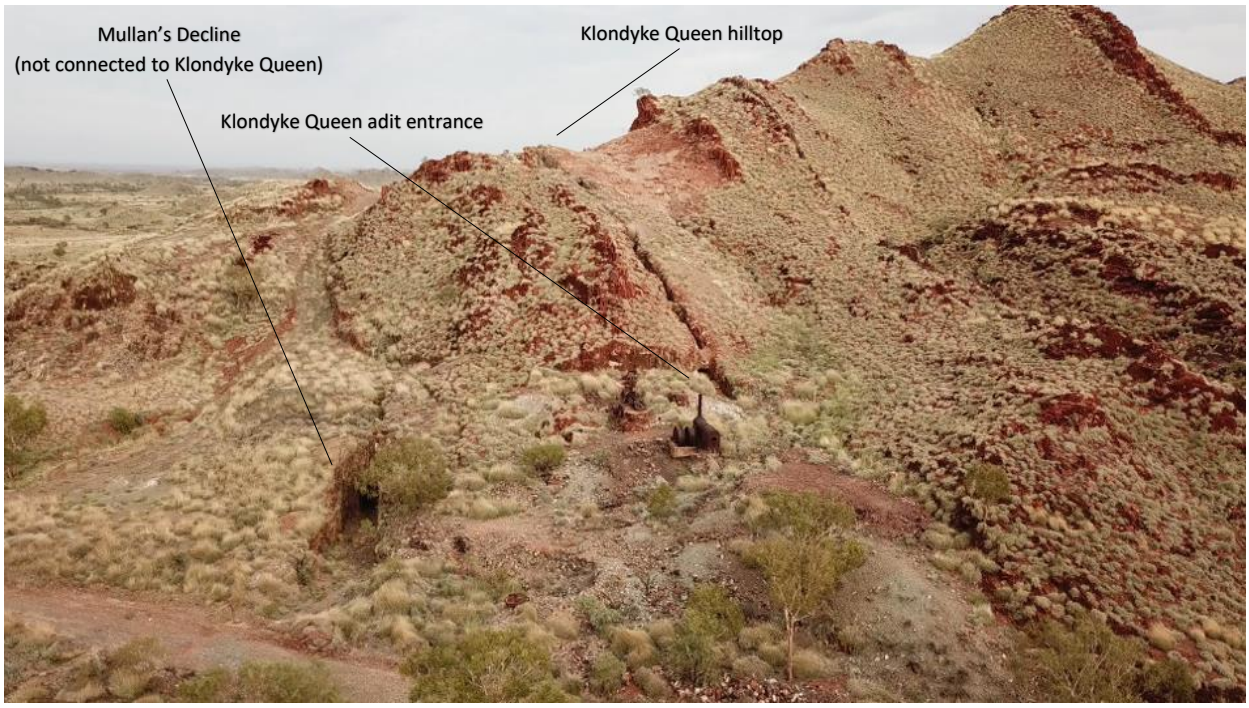


Plate 7. Klondyke Queen Complex (adit, hilltop, and open stopes/cut)

Table 14 Roost classification of mine workings within the Proposal area and surrounds, with annual activity levels

Site	Roost significance#		Pilbara Leaf-nosed Bat activity levels*				Ghost Bat activity levels*			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018	2017	2016	2019	2018	2017	2016
Bow Bells Block 1	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	58 (av calls per night) (Biologic 2017d)	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
^^Bow Bells South - adit	Permanent Diurnal Roost	Occasional Diurnal Roost	>1,750 (av calls per night)	> 2800 calls (548 individuals recorded exiting)	>4000 (Biologic 2017d)	3-25 calls	11 recorded via video. >35 ultrasonic calls recorded per night.	Av 15 calls per night at adit	1 recorded via video-camera (Biologic 2017d)	Present (no quantification of numbers)
^^Bow Bells South - Shaft	Permanent Diurnal Roost	Occasional Diurnal Roost	Not sampled	>4,200 av calls per night	>1,100 av calls per night (Biologic 2017d)	Not sampled	Not sampled	~10 calls per night ultrasonic and social	~150 calls (Biologic 2017d)	Not sampled
+Britannia	Nocturnal Refuge	-	Not sampled	Not sampled	10 (av calls per night)	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
British Exploration of Australia	Nocturnal Refuge	-	Not sampled	Not sampled	9 calls av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call	Not sampled
Comet	Nocturnal Refuge	Permanent Maternity Roost	2 (av calls per night)	~25 calls per night	5 calls (Biologic 2017d)	No calls recorded	269 recorded visually	~130 calls (67 via visual counts)	105 recorded visually (Biologic 2017d)	Present (>43)
Copenhagen Open Cut	Foraging site	Foraging site	23 (Range 20 - 26 calls per night)	Av 43 calls over 5 nights (range 27-68)	177 calls (Biologic 2017d)	83 – 392 calls	No calls recorded	No calls recorded	No calls recorded	No calls recorded
Criterion	Nocturnal Refuge	Possible occasional Diurnal Roost	15 (av calls per night)	Not sampled	25 (Biologic 2017d)	Not sampled	25 calls recorded	Not sampled	No calls recorded	Not sampled
+Cuban	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	-	Not sampled	Not sampled	Not sampled	10 calls	Not sampled

Site	Roost significance#		Pilbara Leaf-nosed Bat activity levels*				Ghost Bat activity levels*			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018	2017	2016	2019	2018	2017	2016
Dawson City	Nocturnal refuge	Occasional diurnal roost	126 (Range 107 - 152 calls per night)	610 calls/night	>1000 calls per night (av 727) (Biologic 2017d)	Not sampled	~10 calls p.n.	<5 calls on two nights, 1 individual recorded exiting	10 calls (Biologic 2017d)	Not sampled
Gauntlet	Nocturnal refuge	Night roost	Not sampled	Not sampled	7 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic 2017d)	Not sampled
Gauntlet SE	Nocturnal refuge	Night roost	Not sampled	Not sampled	24 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic 2017d)	Not sampled
Gift – Decline	Nocturnal refuge	-	Not sampled	Not sampled	25 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic 2017d)	Not sampled
Gift – Shaft	Nocturnal refuge	-	Not sampled	Not sampled	132 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Golden Gauntlet	Nocturnal refuge	-	Not sampled	Not sampled	16 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Klondyke 1 East	Nocturnal refuge	Night roost	Not sampled	Not sampled	7 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	8 calls	Not sampled
Klondyke 1 west	Nocturnal refuge	Night roost	Not sampled	Not sampled	7 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	4 calls (Biologic 2017d)	Not sampled
Klondyke Boulder	Nocturnal refuge	Possible occasional diurnal roost	79 (Range 65 - 93 calls per night)	1,070 av calls/night	1070 calls per night (Biologic 2017d)	Not sampled	~3 calls p.n.	<5 calls	5 calls (Biologic 2017d)	Not sampled
^Klondyke Queen - adit	Permanent diurnal roost	Permanent maternity roost	~1,500 recorded exiting by IR-lit video	July 2018: >4800 calls and bats sighted	April 2017: Between 23 – 98 calls from the adit and 72 – 457 calls from the roof over four nights May 2017: Individuals recorded Sep 2017: >3000 calls and bats sighted	Nov 2016: 152, 96, and 73 calls over three nights (Specialised Zoological 2017b)	~475 recorded exiting by IR-lit video	July 2018: 450 visual count of bats exiting	April 2017: 24 and 28 recorded May 2017: 200 recorded on camera, five individuals captured Sept 2017: 265 visual count of bats exiting	Nov 2016: 366 and 80 individuals observed over two nights

Site	Roost significance#		Pilbara Leaf-nosed Bat activity levels*				Ghost Bat activity levels*			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018	2017	2016	2019	2018	2017	2016
^Klondyke Queen – Hill Top	Permanent diurnal roost	Permanent maternity roost	Not sampled	Not sampled	255 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	~ 10 recorded visually (Biologic 2017d)	Not sampled
^Klondyke Queen – Open Cut	Permanent diurnal roost	Permanent maternity roost	Not sampled	Not sampled	>3,000 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	~ 5 recorded visually (Biologic 2017d)	Not sampled
+Klondyke Queen 488	Nocturnal refuge	Night roost	Not sampled	Not sampled	58 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	4 calls (Biologic 2017d)	Not sampled
+Kopckes Reward	Nocturnal refuge	-	Not sampled	Not sampled	5 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Marble Bar Copper	Nocturnal refuge	Foraging site	Not sampled	53 av calls per night (Biologic 2018)	12 av calls per night (Biologic 2017d)	Present (no quantification of numbers) (Specialised Zoological 2017a, 2017b)	Not sampled	1 call (Biologic 2018)	No calls recorded	Present (no quantification of numbers) (Specialised Zoological 2017a)
Mullan's	Nocturnal Refuge		Not sampled	Not sampled	113 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	13 calls (Biologic 2017d)	Not sampled
St George	Nocturnal refuge	Night roost	Not sampled	Not sampled	6 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	2 calls (Biologic 2017d)	Not sampled
+St George 3	Nocturnal refuge	-	Not sampled	Not sampled	2 av calls/night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Trible Event NW	Nocturnal refuge	Night roost	Not sampled	Not sampled	25 av calls per night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic 2017d)	Not sampled

Site	Roost significance#		Pilbara Leaf-nosed Bat activity levels*				Ghost Bat activity levels*			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018	2017	2016	2019	2018	2017	2016
Trump	Nocturnal refuge	Foraging site	25 (av calls per night)	270 (av calls per night)	2 (Biologic 2017d)	Technical error	~15 calls per night	1-3 calls per night	< 5 calls per night	Technical error (no calls recorded)
Wheel of Fortune East	Nocturnal refuge	Night roost	Not sampled	Not sampled	5 av calls/night (Biologic 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic 2017d)	Not sampled

***2016 surveys** = Specialised Zoological 2017a); **2017 surveys** = Biologic 2017a, 2018b, 2018b, Specialised Zoological 2017b**; 2018 surveys** = Biologic 2018c; **2019 surveys** = Biologic 2019a)
+ proposed to be removed as part of the Proposal (5 sites)
^ workings are connected (3 sites); ^^ workings are connected (2 sites)

Categories and definition for underground refuges used by the **Pilbara Leaf-nosed Bat** (Threatened Species Scientific Committee 2016b):

- Permanent diurnal roosts (Priority 1)—occupied year-round and likely the focus for some part of the 9-month breeding cycle; considered as critical habitat that is essential for the daily survival of the PLNB.
- Non-permanent breeding roosts (Priority 2)—evidence of usage during some part of the 9-month breeding cycle (July–March), but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the PLNB.
- Transitory diurnal roosts (Priority 3)—occupied for part of the year only, outside the breeding season (i.e. April–June), and which could facilitate long distance dispersal in the region; considered as critical habitat that is essential for both the daily and long-term survival of the PLNB.
- Nocturnal refuge (Priority 4)—occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Excludes overhangs. Not considered critical habitat, but are important for persistence in a local area.

Categories and definition for underground refuges, based on Threatened Species Scientific Committee (2016b) and adapted for **Ghost Bats** (R. Bullen, pers. comm. October 2019):

- Permanent diurnal roosts (Priority 1) -occupied year-round by large colonies of over 50 bats and are proven maternity sites; considered as critical habitat that is essential for the daily and long-term survival of the Ghost Bat
- Non-permanent breeding roosts (Priority 2) -evidence of regular usage during some part of the 9-month breeding cycle (July-March) by small numbers of Ghost bats, but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the Ghost Bat.
- Transitory diurnal roosts (Priority 3) -occupied occasionally by small numbers of Ghost bats (typically less than 5) within, or continuously for part of the year only outside, the breeding season (i.e. April-June), and which could facilitate long distance dispersal in the region; considered as non-critical habitat that supports the Ghost bats persistence in a local area
- Night roost (nocturnal refuge) (Priority 4) -occupied or entered at night for resting, feeding or other purposes. Not considered critical habitat but supports the Ghost bats persistence in a local area.

Foraging significance

VHF foraging habitat studies have revealed that the Proposal area is not a significant foraging ground for either bat species sampled, with the preferred foraging grounds for both species outside the Proposal area:

- Ghost Bats tended to leave the Proposal area upon emergence from their diurnal roost, using flight paths outside the Proposal area along the northern edge of the Warrawoona Ranges.
- Pilbara Leaf-nosed Bats also leave the Proposal area, preferring to forage in the region northwest, towards Bow Bells.

It was also noted that the existing pit lake at Copenhagen did not represent a crucial foraging ground or water source for either species.

Summary of key findings

Based on an intensive sampling effort across the Proposal area and surrounds since 2016, the key outcomes of the Bat studies are:

- confirmed regional significance of the Klondyke Queen, Bow Bells South and Comet roosts:
  - Bow Bells South – permanent diurnal roost for Pilbara Leaf-nosed Bat with large colony (possible maternity roost), and occasional diurnal roost for Ghost Bat.
  - Klondyke Queen – a colony for both species, with a permanent diurnal roost for Pilbara Leaf-nosed Bat, and a permanent maternity roost for the Ghost Bat;
  - Comet – a large colony and permanent maternity roost for the Ghost Bat.
- preferred foraging grounds for both species is outside the Proposal area, north of the Warrawoona Range.

5.4.3 Other terrestrial vertebrate fauna

5.4.3.1 Background and description

This section described the species of conservation significance and provides background information on range and regional records. Habitats and records of conservation significant species within the Proposal area are discussed in Section 5.4.3.3 (investigation findings and outcomes) and Section 5.6.2 (impact assessment).

Northern Quoll, *Dasyurus hallucatus*

Conservation Status: Endangered under the EPBC Act and BC Act
Likelihood of occurrence: Confirmed in Proposal area

Once widely distributed across northern Australia, the Northern Quoll is now restricted to populations in the Pilbara, the Kimberley and Northern Territory, Queensland, as well as a number of islands on the north coast (DoE 2016).

The Northern Quoll is both arboreal and terrestrial, inhabiting ironstone and sandstone ridges, scree slopes, granite boulders and outcrops, drainage lines, riverine habitats (Braithwaite and Griffiths 1994; Oakwood 2002), dissected rocky escarpments, open forest of lowland savannah and woodland (Oakwood 2002; Woinarski *et al.* 2008). Rocky habitats tend to support higher densities, as they offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite and Griffiths, 1994; Oakwood 2000). Other microhabitat features important to the species include: rock

cover; proximity to permanent water and time-since last fire (Woinarski *et al.* 2008). Dens occur in a wide range of situations including rock overhangs, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings/infrastructure, where individuals usually den alone (Oakwood 2002; Woinarski *et al.* 2008).

The Proposal area is located within the species range, within an area mapped as 'species known/likely to occur' by Department of the Environment (2016 in Biologic 2019g). Prior to targeted surveys within the Proposal area, the nearest Northern Quoll records were from four locations; < 28km south-west during surveys conducted during 2014 at Corunna Downs and Roy Hill; < 37km south-east from surveys conducted from 2012 – 2014 (21 records); ~12 records, 28 - 48km north of the Proposal area, ranging in time from 1958 – 2016 from surveys conducted from Marble Bar, Muccan Station, and Yarrie Station (DBCA 2019 in Biologic 2019g).

Pilbara Olive Python, *Liasis olivaceus barroni*

Conservation Status: Vulnerable under the EPBC Act and BC Act
Likelihood of occurrence: Confirmed in Proposal area

The Pilbara Olive Python is endemic to the Pilbara region, distributed from Burrup Peninsula, Ord Ranges and Meentheena south to Nanutarra and Newman (Bush and Maryan 2011).

The species commonly inhabits moist areas such as gorges, rivers, pools and surrounding hills, but can be found in a range of habitats (Burbidge 2004; Department of Sustainability, Environment, Water, Population and Communities 2011). In the inland Pilbara, the Pilbara Olive Python is most often encountered in the vicinity of permanent waterholes in rocky ranges or among riverine vegetation (Department of Sustainability, Environment, Water, Population and Communities 2011; Pearson 1993). The species is not reliant on, or restricted to, areas near permanent water; but they do offer and abundance of suitably-sized prey (Pearson 2003).

Brush-tailed Mulgara, *Dasycercus blythi*

Conservation Status: DBCA listed Priority 4 species
Likelihood of occurrence: Confirmed in Proposal area

The Brush-tailed Mulgara is a small carnivorous marsupial occurring from southwestern Queensland across the Simpson, Tanami, and Great Sandy Deserts and central Western Australia, including parts of the Pilbara (Woinarski *et al.* 2014). The species is found in sand ridge habitat, *Triodia* sand plain and gibber plain (Pavey *et al.* 2012), and on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Start *et al.* 2000). Mulgara are renowned for using multiple burrow systems within a home-range and changing these frequently (Thompson and Thompson 2007). A study in Kata Tjuta National Park found that on average burrows were used for only 3.2 days by one individual over a 55-day period, and numerous burrows were used by a single individual, indicating little burrow fidelity (Körtner *et al.* 2007).

Western Pebble-mound Mouse, *Pseudomys chapmani*

Conservation Status: DBCA listed Priority 4 species
Likelihood of occurrence: Confirmed in Proposal area

The Western Pebble-mound Mouse has experienced a significant decline in their range through the Gascoyne and Murchison and is now considered endemic to the Pilbara (Start *et al.* 2000). This species almost exclusively occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee and Armstrong 2001).

The nearest regional record to the Proposal area is approximately 16km north-east from 1957 (Biologic 2019g). The most recent records from the vicinity include three records from 2014, one of which was ~22km south-west and two ~45km south-east of the Proposal area, with a further 14 records within 45km (Biologic 2019g). Within the Proposal area, suitable habitat is extensive, and includes the Hillcrest/ Hillslope and Stony Plain habitat.

Greater Bilby, *Macrotis lagotis*

Conservation Status: Vulnerable under the EPBC Act and BC Act
Likelihood of occurrence: Likely to occur in Proposal area

The Greater Bilby is an arid zone ground dwelling marsupial mammal species at risk of predation by introduced foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) (Johnson and Isaac 2009). Greater Bilbies are semi-fossorial and nocturnal, remaining in their burrows during the day and intermittently during the night for rest and refuge. Greater Bilby populations naturally occur as scattered solitary individuals or small groups (Southgate 1990). They are recorded as having low site fidelity and high mobility (Southgate *et al.* 2007); males regularly move three to five kilometres between burrows on consecutive days; and have been recorded moving up to 15km in a few weeks (Southgate and Possingham 1995). This high mobility, together with low population density, ensures that the area of occupancy is often far less than the extent of occurrence. As Greater Bilby's are solitary in nature, lack territoriality and have large home ranges, it is likely that males adopt a roving strategy to find receptive females; consistent with an overlapping promiscuous mating system (Dziminski and Carpenter 2017; Southgate *et al.* 2007).

Greater Bilbies occupy three major vegetation types - open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (Southgate 1990). Laterite and rock feature substrates are an important part of Greater Bilby habitat as they support shrub species, such as *Acacia kempeana, A. hilliana* and *A. rhodophylla*, which have root-dwelling larvae prone to supporting a constant food source (Dziminski and Carpenter 2017;). These habitats also contain spinifex hummocks, which are quite uniform and discrete, providing runways between hummocks and enabling easier movement and foraging (Southgate *et al.* 2007). Minimal ground cover is a common feature in Greater Bilby habitats, as it allows easy foraging (Dawson 2018). Habitat within the Pilbara bioregion seems to consist mostly of spinifex sand plain associated with major drainage line sandy terraces. In general, the distribution of Greater Bilbies can be limited by the availability of suitable burrowing habitat, such as dunes where burrow excavation is easier (Moseby and O'Donnell 2003 in Biologic 2019g) and are not found in predominantly rocky areas or mountains, where they would be unable to dig suitable burrow systems or dig for food.

The Proposal area falls within the current distribution of the Greater Bilby, located within the Chichester sub-region in the Pilbara (Southgate, 1990a). Although there are numerous Greater Bilby records in the broader region of the Proposal area, there is a lack of contemporary records in the near vicinity. The nearest records are: Meentheena Reserve in 2004 (15km to the east of the Proposal area); Corunna Station in 1984 (12km south of the Proposal area); and Eginbah (Limestone) Station in 1984 (15km north of the Proposal area from 1984) (DBCA 2019, in Biologic 2019c). From aerial imagery, these nearby records all appear to be within Sandplain habitat. Other records from the vicinity of the Proposal area date back to 1962 near Marble Bar (DBCA 2019 in Biologic 2019c).

Spectacled Hare wallaby, *Lagorchestes conspicillatus leichardti*

Conservation Status: DBCA listed Priority 3 species
Likelihood of occurrence: Likely to occur in Proposal area

The Spectacled Hare-wallaby is sparsely distributed and generally uncommon across northern Australia, distributed from northern Queensland in the east, to the Pilbara where the species is considered

relatively rare (Van Dyck and Strahan 2008a). The species shelters within grass tussocks and spinifex hummocks and low shrubs (Ingleby and Westoby 1992).

The nearest record of this species is 1.1km north-east of the Proposal area from an unknown date (DBCA 2017c, in Biologic 2019c). One further record has been documented 29km south-west of the Proposal area in 2014 (DBCA 2017b, in Biologic 2019c). The species is patchily distributed throughout the Pilbara region with few records of the species. The Sandplain and Stony Plain habitat which comprises expanses of *Triodia* hummock grasslands provides suitable habitat for the species. Based on the availability of suitable habitat in the Proposal area, nearby records, and the location of the Proposal area within the species distribution, Spectacled Hare-Wallaby are considered likely to occur.

Peregrine Falcon, *Falco peregrinus*

Conservation Status: Other Specially Protected Fauna (OS) under the BC Act
Likelihood of occurrence: Likely to occur in Proposal area

In arid areas, the Peregrine Falcon is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone and Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25m and 50m high (Biologic 2019c)(Olsen and Olsen, 1989). It also appears to prefer nesting on large ledges a reasonable distance (average of 13 m) from the top of the cliff (Olsen and Olsen, 1989), possibly to avoid ground dwelling predators.

The Peregrine Falcon was recorded in 2001 approximately 10km west of the Proposal area (DBCA 2017c, in Biologic 2019c). Potential nesting habitat may be present within Rocky Breakaway and Medium Drainage Line habitats, which are likely to provide suitable foraging habitat for the species.

Night Parrot, *Pezoporus occidentalis*

Conservation Status: Endangered under the EPBC Act; Critically Endangered under the BC Act
Likelihood of occurrence: Possible in Proposal area

The distribution of the Night Parrot is very poorly understood and was thought to be extinct until 2013 when it was discovered in Queensland (Pullen Pullen Reserve; DoEE 2018, in Biologic 2019c). Subsequently, the species has been found in Goneaway National Park and Diamantina National Park in Queensland (Palaszczuk and Miles 2017) and the Great Sandy Desert and Murchison regions of Western Australia (Jackett *et al.* 2017).

The Night Parrot is a small, elusive, ground dwelling parrot endemic to Australia (DoEE 2018 in Biologic 2019d). This highly cryptic and nocturnal parrot inhabits arid and semi-arid areas that comprise dense, low vegetation. Based on accepted records, the habitat of the Night Parrot consists of *Triodia* grasslands in stony or sandy environments, samphire and chenopod shrublands (including genera such as *Atriplex*, *Bassia* and *Maireana)*, on floodplains and claypans, and on the margins of salt lakes, creeks or other sources of water (North 1898, Whitlock 1924, McGilp 1931, Wilson 1937).

The current interim guidelines for preliminary surveys of Night Parrot in Western Australia suggest this species requires old-growth (often more than 50 years unburnt) spinifex (*Triodia*) for roosting and nesting (DPaW 2017). Foraging habitat is not necessarily within or adjacent to roosting habitat, as the Night Parrot has been known to fly from 40km (Murphy, Austin, *et al.* 2017, Murphy, Silcock, *et al.* 2017) up to 100km (Night Parrot Recovery Team 2017) in a single night to forage; however, foraging habitat is likely to be more important if it is adjacent to or within about 10km of suitable roosting habitat (DPaW 2017). *Triodia* is likely to provide a good food resource at least in times of mass flowering and seeding. The succulent *Sclerolaena* has been shown to be a source of food and moisture; other succulent chenopods are also likely to be significant (DPaW 2017).

The distribution of the Night Parrot is very poorly understood in Western Australia; however, the Proposal area falls within the distribution as currently understood (DPaW 2017). There are only two contemporary records of the species within Western Australia, one located approximately 70km west of the Proposal area at Minga Qwirriawirie Well, south of the Cloudbreak mine site (Davis and Metcalf 2008) and the other from an unnamed location in the East Murchison in early 2017 (Jackett *et al.* 2017; Night Parrot Recovery Team 2017). The nearest record of Night Parrot is located approximately 55km north-east of the Proposal area from 1980 (DBCA 2019 in Biologic 2019d).

Northern Brush-tail possum, *Trichosurus vulpecula arnhemensis*

Conservation Status: Vulnerable under the BC Act
Likelihood of occurrence: Possible in Proposal area

The Northern Brush-tail Possum occurs from the north-west Pilbara, through the Kimberley into the Northern Territory (van Dyck and Strahan 2008). Little ecological information is known about the Pilbara population, although it is most often recorded from Medium drainage lines that contain large hollow-bearing Eucalypts (DBCA 2017b). Within the Northern Territory, the species is omnivorous but often feeding on flowers and insects (Cruz *et al.* 2012).

The nearest record of the species is located approximately 26km south-west of the Proposal area from 2014 (DBCA 2017b in Biologic 2019d). Medium Drainage Line habitat provides potential denning habitat for the Northern Brush-tail Possum, although the species is somewhat patchily distributed through the region.

Long tailed Dunart, *Sminthopsis longicauda*

Conservation Status: DBCA listed Priority 4 species
Likelihood of occurrence: Possible in Proposal area

The Long-tailed Dunart is a nocturnal and agile species that is distributed through the Pilbara, north eastern goldfields and Gibson desert, south to the Nullarbor Plain, to central Northern Territory and western South Australia (van Dyck and Strahan 2008). Its core habitat includes rocky scree slopes with hummock grass and shrubs, and tall open *Acacia* shrubland and woodlands (McKenzie *et al.* 2008).

The nearest DBCA (2017c in Biologic 2019d) record of this species is located approximately 17km south-east of the Proposal area from 2003. Owing to the occurrence of suitable habitats on Rocky Breakaway along the north-eastern border of the Proposal area, it is possible the species occurs within the Proposal area.

5.4.3.2 Proposal area investigations

Habitat assessment

Habitat assessments across the Proposal area were undertaken using methodology and terminology modified from the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009), and the extent and continuity of habitat extending beyond the habitat assessments was assessed with the aid of a remotely piloted aircraft.

Fauna habitats were assessed for the likelihood that they may support conservation significant fauna. All major fauna habitats present within the Proposal area were rated (High, Moderate or Low) per the criteria in Table 15.

Table 15 Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)
High	Fauna listed as threatened (EPBC Act or BC Act) recorded within the habitat.
	Suitable core habitat for EPBC Act listed species with records within 50 km.
	Regionally uncommon habitat, considered critical for DBCA listed Priority fauna. For example, if the habitat for a Priority species is limited in the region and the extent within the Proposal area forms a large proportion of the known habitat, it would be scored 'high'.
	Habitat that only occurs in small, isolated geographic areas.
Moderate	Habitat is known to support DBCA listed Priority fauna that do not occur in any of the other habitat types.
	Habitat that supports EPBC Act listed Migratory fauna. Habitat may be used by EPBC Act listed fauna but it is not their core habitat (i.e. may be used periodically/ seasonally or for dispersal).
	Habitat supports a particularly diverse and uncommon faunal assemblage. Habitat that occurs throughout region, and does not occur in small or isolated areas, is excluded.
Low	Habitat is widespread, common, and does not solely support any significant fauna.

Baseline Surveys

A Level 1 fauna survey was conducted across the Proposal area (Biologic 2018a). Vertebrate fauna of the Proposal area was sampled via motion cameras, targeted transects and opportunistic sampling.

Baseline surveys (via cameras) confirmed the presence of the Northern Quoll, Pilbara Olive Python and the Brush-tailed Mulgara at the Proposal area, with evidence of the Western Pebble-mound Mouse recorded opportunistically during these surveys (Biologic 2019a, 2019b, 2019c and 2019d) (refer to Section 5.4.3.3 for details on findings).

Target Surveys

Targeted monitoring surveys across the Proposal area in September 2018 and April 2019 (Biologic 2019a, 2019b, 2019c, and 2019d) focussed on species considered to be matters of national environmental significance, in particular the Northern Quoll, Night Parrot, and Greater Bilby. The primary survey methods included motion detection cameras in core habitat, acoustic recorders and opportunistic sightings or evidence.

Despite multiple targeted surveys, no Night Parrots or Greater Bilby's were recorded.

5.4.3.3 Findings and outcomes

Information in this section is based on results and findings from supporting studies commissioned by Calidus, as summarised in Section 5.3 (Table 12).

Habitat types

Habitat mapping across the Proposal area recorded seven fauna habitat types (Figure 20), comprising:

- Rocky Breakaway
- Sandplain
- Medium Drainage Line
- Rounded Hills
- Hillcrest/ Hillslope
- Minor Drainage Line
- Stony Plain
- Claypan

The Rocky Breakaway was deemed to be of high significance as it provides high density denning and foraging habitat for the Northern Quoll, and foraging habitat for the Pilbara Olive Python, Ghost Bat, and Pilbara Leaf-nosed Bat. The Sandplain habitat type in the southern portion of the Proposal area is also considered of high significance as it supports Brush-tailed Mulgara, and potentially Night Parrot and Greater Bilby (Table 16).

Five of the habitats recorded are considered to be of moderate significance

- The Medium and Minor Drainage Lines provide dispersal and foraging habitat for the Northern Quoll, Pilbara Olive Python, Ghost Bat, and Pilbara Leaf-nosed Bat.
- Stony Plain habitat provides potential habitat for the Spectacled Hare-Wallaby and Western Pebble-mound Mouse and contains some suitable areas of potential habitat for the Night Parrot.
- The Hillcrest/ Hillslope and Rounded Hills habitat contains small rocky breakaways that provide additional denning habitat of the Northern Quoll, although such features are small in extent and sparsely distributed.

The remaining habitat (Claypan) was deemed to have a low significance as it either does not support species of high conservation value and/ or such species are not dependent on the habitats at the broad scale. The values and reasons for significance for each of these habitats are summarized in Table 16 below.

Table 16 The extent and significance of fauna habitats within the Proposal area and their significance (Source: Biologic 2019g)

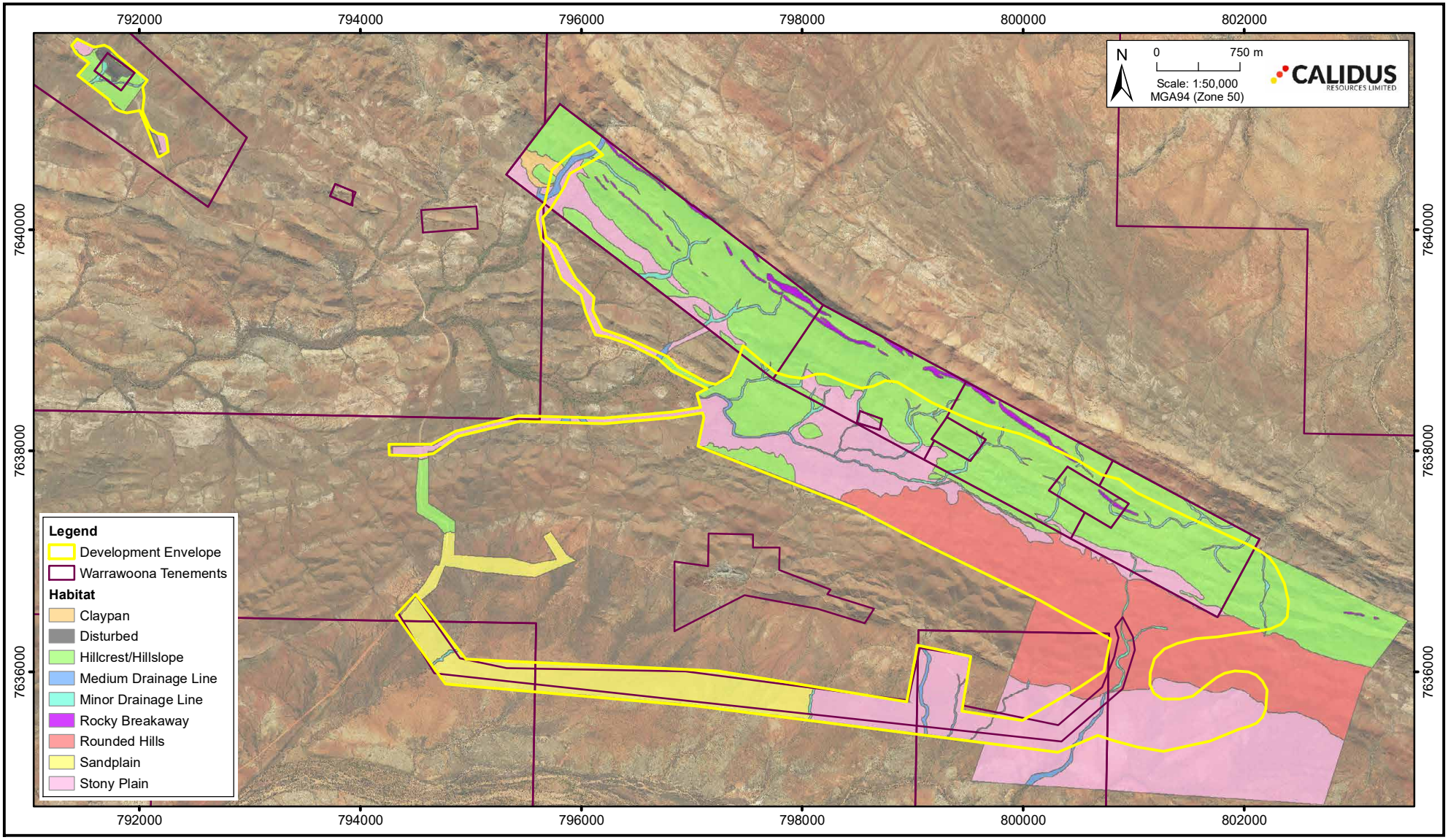
Habitat	Distinguishing habitat characteristics	Extent of the habitat	Conservation Significant Species	Photo
Hillcrest/ Hillslope 718ha 39.4% Moderate Significance	This habitat comprises hills and undulating plains on the tops of ranges, supporting hard spinifex with a mantle of gravel and pebbles. Vegetation was dominated by a *Triodia* hummock grassland with scattered *Eucalyptus leucophloia* trees and mallee and Acacia and *Grevillea* shrubs. The primary microhabitat is the spinifex hummocks. This habitat was differentiated from the remaining habitat by the lack of rocky outcropping and lack of vegetation diversity.	This habitat was the most widespread and dominant habitat of the Proposal area. The Hillcrests and Slopes habitat is a characteristic habitat type of the Pilbara region. The flora and fauna which comprise this habitat are most like Stony Plains that occur at lower altitudes and are common throughout the region. As such the fauna which occupy this habitat type are generally common, widespread at a regional level and are well represented within the region's conservation estate.	Suitable for: • Northern Quoll • Western Pebble-mound Mouse	
Stony Plain 548ha 30.1% Moderate Significance	Scattered Acacia and small shrubs over dense spinifex hummock grasslands on red stony clay soil with some exposed outcrops. These are erosional surfaces of gently undulating plains, ridges and associated footslopes. Supporting little to no vegetation besides some scattered trees, with a mantle of gravel and pebbles.	The Stony Plain habitat spans along the western margins of the Proposal area. The habitat lies adjacent to the Hillcrest/ Hillslopes in the north and east and intersected by the Minor Drainage Line and Medium Drainage Line habitats. The Stony Plain is one of the most common and widespread habitat types within the Pilbara region. Much of this habitat type is contained within conservation estate both at a subregion and regional level.	Suitable for: • Western Pebble-mound Mouse • Spectacled Hare-wallaby • Black-lined Ctenotus • Night Parrot	

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Conservation Significant Species	Photo
Rounded Hills 339ha 18.6% Moderate Significance	This habitat type comprised a series of undulating rounded hills and gentle to steep slopes rising occasionally to isolated areas of Rocky outcrop, as well as shallow/ open gullies leading to drainage foci in the valleys	This habitat type comprised a large area in the central zone of the Study Area between the main Hillcrest/hillslope and Stony Plain habitat, intersected by Medium Drainage Lines. Rounded Hills as a habitat type are not noted as particularly common in the region; however, it may often be continuous with Hillcrest/ hillslope habitat.	Suitable for: • Northern Quoll • Western Pebble-mound Mouse	
Sandplain 137ha 7.5% High Significance	Sand Plain habitat is characterised by relatively deep sandy soils supporting dense spinifex grasslands and sparse low shrubs. This habitat transitions into patches of Mulga in places. This habitat often occurs as terraces along Medium Drainage Lines and extensive plains.	This habitat type forms an almost continuous band across the southern section of the Study Area and extends south of the Study Area boundary to cover a significant area of the local vicinity. Sandplain is a reasonably common habitat type in the Chichester subregion.	Suitable for: • Greater Bilby • Night Parrot • Brush-tailed Mulgara • Spectacled Hare-Wallaby	

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Conservation Significant Species	Photo
Minor Drainage Line 31ha 1.7% Moderate Significance	The vegetation of this habitat comprised dense stands of shrubs, often *Acacia* sp. and *Petalostylis* sp. The understorey generally comprised tussock grasses including Buffel Grass. The substrate can be sandy in places but generally consists of a skeletal loam gravel or stone.	The Minor Drainage Line habitat is located throughout the Study Area and represents the small drainage channels within the Stony Plain and Hillcrest/ Hillslope habitat. One of these smaller channel's feeds into the Medium Drainage Line in the north-western portion of the Study Area. The Minor Drainage Line habitat is common throughout the Pilbara bioregion particularly within the Chichester and Hamersley subregions where it is associated with the stony habitats. As a drainage-type habitat it is well connected through the landscape	Suitable for: • Northern Quoll • Pilbara Olive Python • Peregrine Falcon • Northern Brush-tail Possum • Grey Falcon • Ghost Bat • Pilbara Leaf-nosed Bat	
Rocky Breakaway 18.6ha 1.0% High Significance	This habitat type comprised all the rocky landforms within the Study Area. This habitat was defined by the presence of extensive outcropping. Due to the high amount of rocky material, this habitat often contains a high number of cracks and crevices which provide shelter sites for various species. The vegetation of the habitat is somewhat variable but usually dominated by a hummock or tussock grassland, with scattered shrubs.	The Rocky Breakaway habitat is isolated to the higher elevation areas on the Study Area, which consists of the Warrawoona range running north-west to south-east within the Study Area. The Rocky Breakaways represent the upper limits of these ranges. This habitat is relatively common throughout the Pilbara and represents a habitat that is relatively unique to the region. While the broad habitat is well-represented outside of the Study Area, throughout the region and in conservation estate. This includes rocky gullies and ranges containing considerable amounts of cracks and crevices for saxicolous species such as the Northern Quoll.	Suitable for: • Northern Quoll • Peregrine Falcon • Long-tailed Dunnart • Pilbara Olive Python	

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Conservation Significant Species	Photo
Medium Drainage Line 18.5ha 1.0% Moderate Significance	The Medium Drainage Line habitat was defined by large drainage channels lined with large *Eucalyptus* trees. The main drainage channel is often devoid of vegetation or dense Buffel Grasslands. The major feature influencing species composition is the extensive number of large hollows as well as the high vegetation cover, woody debris and leaf litter.	This habitat was only located in the north-western section of the Study Area. The Medium Drainage Line was associated with drainage from the Hillcrest/ Hillslopes and ranges throughout the Study Area. Medium Drainage Lines are common throughout the Pilbara region and well represented within conservation estate. Medium Drainage Lines within the Pilbara are somewhat unique to system found in surrounding regions, attributed mainly to the amount and frequency of water that they are exposed to and the habitats in which they intersect. As with most drainage systems, this habitat is well connected within the landscape.	Suitable for: • Northern Quoll • Pilbara Olive Python • Peregrine Falcon • Northern Brush-tail Possum • Grey Falcon • Ghost Bat and Pilbara Leaf-nosed Bat	
Claypan 6ha 0.3% Low Significance	Low lying areas on heavy alluvial soils, sometimes cracking clay. Prone to ponding following significant rainfall events and almost completely devoid of any vegetation. Small low shrubs are present in the ecotone between the claypan and surrounding habitat types	This habitat type is only located in the north-western section of the Study Area adjacent to the Medium Drainage Line. Claypans are relatively uncommon within the Chichester subregion although there are numerous within the neighboring Fortescue subregion.	Provides temporary habitat for: • Sharp-tailed Sandpiper • Common Greenshank • Woodsandpiper	

Figure 20: Habitat mapping in the Proposal area



Source: DMIRS - Tenements, Biologic - Habitats
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_20, Rev: A

Fauna assemblages

A total of 35 species were recorded during field surveys across the Proposal area, either directly or via secondary evidence, comprising of 12 mammals, 19 birds and 4 reptiles. For further details, refer to Appendix 1-1, Appendix 1-4, and Appendix 3-2. Of the 35 species recorded within the Proposal area, six species are conservation significant (Biologic 2019d). Apart from the two conservation significant bat species already discussed (Section 5.4.2 - Ghost Bat and Pilbara Leaf-nosed Bat), four further species of conservation significance were also recorded in the Proposal area:

- Northern Quoll: 10-12 individuals from motion cameras, over 3 sampling events within Hillcrest/Hillslope and Minor Drainage Line habitats (Table 17)
- Western Pebble-mound Mouse: Five mounds (two recently active), opportunistically recorded from Hillcrest/Hill slope habitat
- Pilbara Olive Python: One individual from camera, in the Klondyke Queen mine workings
- Brush-tailed Mulgara: One individual from motion camera over multiple nights in Sandplain habitat.

No evidence was found of the Night Parrot, Greater Bilby or other conservation significant species considered likely or possibly occurring within the Proposal area - despite multiple targeted surveys in preferred habitats.

Table 17 Northern Quoll survey summary

Survey year	Survey Timing	Life stage for species	Capture rate	Number individuals recorded	Habitat of record	Estimated population size
2017	Sept 2017	End of breeding season, into male die-off	WAR_NQ01: 22.2 % WAR_NQ04: 100 %	2	Hillcrest/ Hillslope	4
2018	July 2018	Breeding season	WAR_NQ01: 20 % WAR_NQ02: 5.1 % WAR_NQ03: 7.5 %	5-6	Hillcrest/ Hillslope, Minor Drainage Line	6
2019	April 2019	Prior to breeding season, post weaning	WAR_NQ03: 12.5 % WAR_NQ05: 55 %	3-4	Hillcrest/ Hillslope, Stony Plain	7

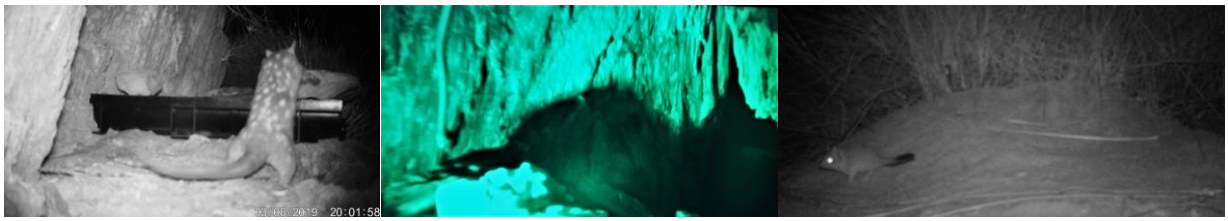


Plate 8. Conservation significant fauna captured on motion cameras in the Proposal area (left, Northern Quoll; centre, Pilbara Olive Python; right, Brush-tailed Mulgara) (Source: Biologic).

Introduced Fauna

Feral cats have been recorded within the Proposal area via motion camera (Biologic 2019d). Other invasive predators (Red foxes *Vulpes vulpes*) and grazers (e.g. camel *Camelus dromedarius*) have been recorded multiple times in the vicinity of the Proposal area (Bamford Consulting 2009; ecologia Environment 2012; How *et al.* 1991 in Biologic 2019d) and by their nature are likely to be present. European cattle *Bos taurus* have also been previously recorded in the Proposal area (Biologic 2017c).

5.4.4 SRE

5.4.4.1 Background and description

Short range endemic (SRE) fauna are groups of invertebrates with naturally small distributions and with often poor dispersal capabilities, confining them to disjunct habitats (Biologic 2018d). Harvey (2002) proposed a range criterion for terrestrial SRE species at less than 10,000 km^2, which has been adopted by regulatory authorities in Western Australia (EPA 2016d). Short- range endemism in a species is determined by several factors including life history, physiology, dispersal capabilities and opportunities as well as the tendency for differentiation and speciation.

Taxonomic groups that show high levels of short-range endemism:

- Trapdoor spider (*Mygalomorphae*)
- Crab spiders (*Selenopidae*)
- Millipedes (*Diplopoda*)
- Land snails (*Pulmonata*); and
- Pseudoscorpions (*Pseudoscorpionida*)

5.4.4.2 Proposal area investigations

Habitat assessment

The habitat assessments were aimed at determining the significance of each site as potential SRE habitat, and hence the likelihood that each site may contain SRE invertebrate fauna. The habitat assessment was based on three major factors influencing the significance of habitats for SRE species; isolation, protection and habitat complexity:

- Isolation: based on the level of connectivity between sites, which share similar habitat characteristics.
- Protection: this primarily covers protection from exposure.
- Habitat complexity: this factor drives species richness and often abundance at a site, i.e. the more complex a site is, the more species and individuals it is likely to contain.

For more details on the habitat assessment process, refer to Appendix 2-1.

Field survey

Habitats considered suitable for SRE terrestrial invertebrates in the Pilbara were targeted for the survey, including gorges/ deep gullies, shallow/ open gullies, ridges/ breakaways and drainage foci. In total, 60 sites were targeted over three sampling events across the Proposal area. Sampling was undertaken at each sampling site for 1.5 person hours and involved active foraging and leaf little searching.

5.4.4.3 Findings and outcomes

Information in this section is based on results and findings from supporting studies commissioned by Calidus, as summarised in Section 5.3 (Table 12).

Habitats

SRE habitat preferences/suitability was based on the seven habitat types mapped during broader habitat assessment investigations (Table 16).

No habitat type within the Proposal area was regarded to be of high suitability for SRE fauna with all habitat types considered as moderate to low suitability (Table 18). Despite the presence of some gorge/ gully habitats within the Rocky Crests and Slopes habitat zone, none of these were regarded as significant enough to warrant a moderate/high or high suitability. All the gorges/ gullies were relatively shallow and lacked the high degree of protection that major gorges and gullies provide (Biologic 2018d).

Table 18 SRE suitability across habitat types

Habitat	SRE Suitability
Sandplain	Low
Stony Plain	Low
Minor Drainage Line	Low/Moderate
Rounded Hills	Low/Moderate
Hillcrest/ Hillslope	Low/Moderate
Claypan	Moderate
Medium Drainage Line	Moderate
Rocky Breakaway	Moderate/High

SRE Invertebrate Fauna

No specimens collected in the Proposal area were considered 'Confirmed' SRE invertebrate fauna. Four groups of taxa that could be considered Potential SRE based on generic identification included *Araneomorphae*, *Pseudoscorpiones*, *Gastropoda* and Isopoda. The study concluded that it was highly unlikely that any SRE invertebrate species would be restricted to the Proposal area with the habitats appearing to be of lower complexity than those found in areas to the southwest, such as the Corunna Downs area (Biologic 2018d).

5.5 Potential Impacts

Environmental impacts that may result from activities associated with the project that could potentially harm or threaten terrestrial fauna, are described in the following section.

5.5.1 Direct loss of fauna habitat

The most direct impact from the Proposal is a loss of habitat, including roosting habitat, due to land clearing and ore/waste removal for mine construction and operation. The removal of key habitat will result in a reduction in the localised abundance and distribution of fauna and a reduction in localised habitat availability.

Establishment of mine infrastructure (such as the TSF and waste dumps) directly over existing habitat, including foraging habitat, will also negate the habitat value of the area.

5.5.2 Habitat fragmentation

Land clearing for infrastructure such as roads, as well as pipelines, power lines and other utilities, has the potential to fragment habitat and disrupt localised fauna linkages for native fauna. This can result in restricted movements of animals and has the potential to impact a fauna community more broadly than just the area cleared.

5.5.3 Habitat modification and reduced habitat quality

Mine pit dewatering has the potential to reduce habitat quality for fauna if groundwater regimes are required to maintain suitable habitat conditions, such as humidity levels.

Noise and vibration emissions as a result of mining activities (i.e. blasting and ore removal) also have the potential to decrease the habitat value of nearby roosting habitats and displace local populations.

Poor water quality has the potential to harm local populations, through the following sources:

- mine pit lake water quality concentrations (post closure);
- TSF decant (WAD cyanide discharge less than 30mg/L); or
- metalliferous drainage from waste dumps.

A final aspect of the Proposal that reduces habitat quality, but will not require detailed impact assessment as it is easily avoided/mitigated, is increased vehicles within the Proposal area that have the potential to introduce soil and vegetative material that may contain weeds and seeds from other environments. An increase in weeds into the area will reduce habitat quality by degrading the condition and resilience of local vegetation.

5.5.4 Increased predation and competition from introduced species

The Proposal has the potential to attract feral and other introduced animals due to introduction of workforce and vehicles, establishment of new roads and corridors, inappropriate waste collection and storage practices, and inadequate rehabilitation of disturbed land, resulting in native terrestrial fauna mortality (through increased predation rates) and/or competition for resources.

5.5.5 Death or injury to individuals

Fauna injuries and mortalities also have the potential to occur during operations as a result of interactions with vehicles, infrastructure, machinery and the workforce.

5.5.6 Altered behaviour of populations and/or individuals

Increased emissions in noise, vibration, artificial light and dust have to potential to influence the behaviour of local fauna populations. Behavioural changes may include factors such as migration, breeding or foraging.

Behaviour change can also occur with the introduction of water storage facilities, including water that is discharged to the TSF or stored for used during processing.

Another aspect of the Proposal that may alter the behaviour of fauna, but will not require detailed impact assessment as it is easily avoided/mitigated, is changes to foraging patterns as a result of increased waste generated at camp. Availability of food and other waste can result in a dependency or reliance on this food as well as an increase in interactions between fauna and the workforce, which in turn may lead to other negative consequences.

5.5.7 Altered fire regimes

Changes in fire regimes (e.g. increased frequency, intensity, extent) through uncontrolled or unintentional fires as a result of increased human activity in the area, has the potential to modify, degrade or remove fauna habitat or individuals.

5.6 Assessment of Impacts

5.6.1 Bats

5.6.1.1 Direct habitat removal

Roosting habitat

The Proposal will directly impact five roosting sites within the indicative disturbance footprint. These sites include four within the Klondyke Pit and one within the St George East Pit. Note, no sites associated with the Klondyke Queen roost are within the disturbance footprint. Table 19 presents a summary of the characteristics of each site to be removed.

Table 19 Sites within the indicative disturbance footprint

Site	Easting	Northing	Site Description	PLNB use	Ghost Bat use
Klondyke Main Pit					
Britannia	800932	7637260	Two deep shafts of unknown depth	Nocturnal refuge	-
Cuban	800767	7637335	4 vertical shafts of unknown depth, but not very deep	Nocturnal refuge	Night roost
KQ 488	800270	7637670	Deep cut with shaft. Good potential habitat	Nocturnal refuge	Night roost
Kopckes Reward	801282	7637115	Shallow shaft (~2.5m deep)	Nocturnal refuge	-
St George East Pit					
St George 3	800719	7637619	Shaft of unknown depth, though fairly deep, perhaps 10-30m	Nocturnal refuge	-
Total night roosts/refuges to be removed				**5**	**2**

All sites proposed for removal are historic mine workings (shafts of various depths), and not natural cave systems.

With the exception of KQ 488, activity levels recorded at these sites has been very low (1-10 calls per night) (Table 14, Section 5.4.2.3). KQ488 recorded moderate activity for Pilbara Leaf-nose Bats (56 calls per night), but much lower activity levels compared to other sites at the nearby Klondyke Queen roost.

Two of the five sites to be removed have been used by Ghost Bats as a night roost, while all five sites have been used by the Pilbara Leaf-nosed Bat as a nocturnal refuge (Table 14, Section 5.4.2.3). The Threatened Species Scientific Committee (2016b), in providing conservation advice on the Pilbara Leaf-nosed Bat, defines a nocturnal refuge as "*occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Not considered critical habitat, but are important for persistence in a local area.*"

The sites proposed for removal are not considered critical habitat for the daily and/or long-term survival of the Pilbara Leaf-nose Bat or Ghost Bat.

There are multiple night roost and nocturnal refuge sites recorded in the immediate surrounds that are not being removed (Table 14, Section 5.4.2.3). Eight sites outside the disturbance footprint have been recorded as Ghost Bat night roosts and 16 sites outside the disturbance footprint have been recorded as nocturnal refuge sites for the Pilbara Leaf-nosed Bat.

Foraging habitat

Foraging habitat categories, as defined by Threatened Species Scientific Committee (2016b) for the Pilbara Leaf-nosed Bat, have been used to calculate potential impacts on foraging habitat. Table 20 describes five categories of foraging habitat based on their importance to the Pilbara Leaf-nosed Bat. The Table also presents the total area surveyed for each foraging habitat category as well as the area of proposed disturbance for each foraging habitat category. Figure 21 and Figure 22 present the foraging habitat preferences for the Ghost Bat and Pilbara Leaf-nosed Bat respectively.

The total area surveyed across the Proposal area represents approximately 1,822ha.

The Proposal area does not contain any Priority 1 (Gorges with pools) or Priority 2 (Gullies) foraging habitats.

Priority 3 foraging habitat (Rocky outcrops) accounts for 18.6ha of the area surveyed, of which only 0.8ha (4.6%) is within the proposed disturbance footprint. Priority 4 foraging habitat (watercourses) represents 55.5ha of the area surveyed, with 14.3ha (25.8%) of this surveyed habitat type in the disturbance footprint. The area surveyed also contains approximately 1,742ha of open grassland foraging habitat (Priority 5), of which approximately 380ha (21.8%) is within the disturbance footprint.

The total disturbance footprint accounts for approximately 22% of the surveyed foraging habitat within the Proposal area. The majority of the surveyed foraging habitat represents open grasslands and woodlands (Priority 5 foraging habitat), and is widely distributed more broadly throughout the Pilbara IBRA region.

Despite the proposal area containing potential foraging habitat across the Proposal area, VHF tracking studies (Biologic 2019b) concluded that the preferred foraging grounds for both the Pilbara Leaf-nosed Bat and the Ghost Bat extended outside the area surveyed, particularly northwest towards the Bow Bells roost and to the plains north of the Warrawoona Range.

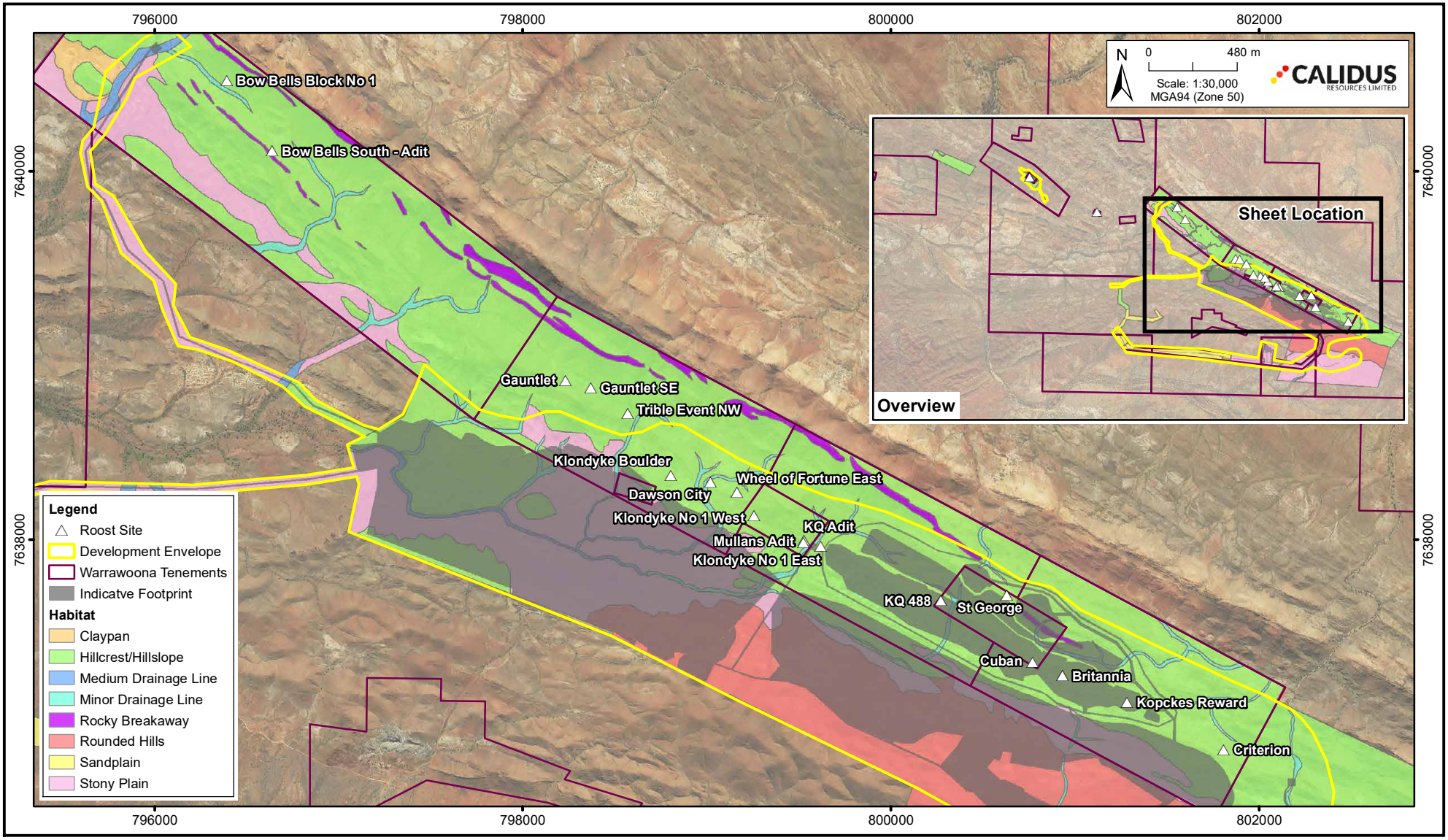
Biologic (2019b) also determined that the proposed Klondyke pit, TSF and WRD were not significant foraging grounds for either species, however some areas of the Proposal were used as a flight path to other foraging sites. Equally, the existing pit lake at Copenhagen did not represent a crucial foraging ground or water source for either species. Monitoring bat activity at Copenhagen is ongoing.

Table 20 Classification of habitat types within the Proposal area with priority foraging habitats of Pilbara Leaf-nosed Bat, as defined by Threatened Species Scientific Committee (2016b). Source Biologic2019f

Foraging habitat type category	Priority	Description	Area (ha)	Proposed disturbance
Gorges with pools	Priority 1 (sites of relatively large biomass production, sometimes containing caves)	Watercourses through upland areas bounded by sheer rock walls for parts of their length, often containing pools that remain for weeks or months;	0	
Gullies	Priority 2 (less biomass production than Priority 1 gorge habitat)	Primary drainage with limited riparian development in upland rocky habitats, sometimes containing small pools that may last for weeks	0	
Rocky Outcrop	Priority 3 (P3)	Areas of exposed rock at the top of rocky outcrop and mesa hills that contain caves and overhangs, and boulder piles in the granite terrains	18.6ha	0.8ha (4.6% of surveyed P3 habitat)
Major watercourses	Priority 4 (P4) (generally supports higher productivity of biomass than the surrounding habitats)	Riparian vegetation on flat land plus the main gravelly or sandy channel of the river bed, sometimes containing pools that persist for weeks or months	55.5ha	14.3ha (25.8% of surveyed P4 habitat)
Open grassland (and woodland)	Priority 5 (P5)	Dominated by Triodia, on lowland plains, colluvial slopes and hilltops.	1742.5ha	380.0ha (21.8% of surveyed P5 habitat)
Total			**1816.1ha***	**398.5ha (21.9% of surveyed foraging habitat)**

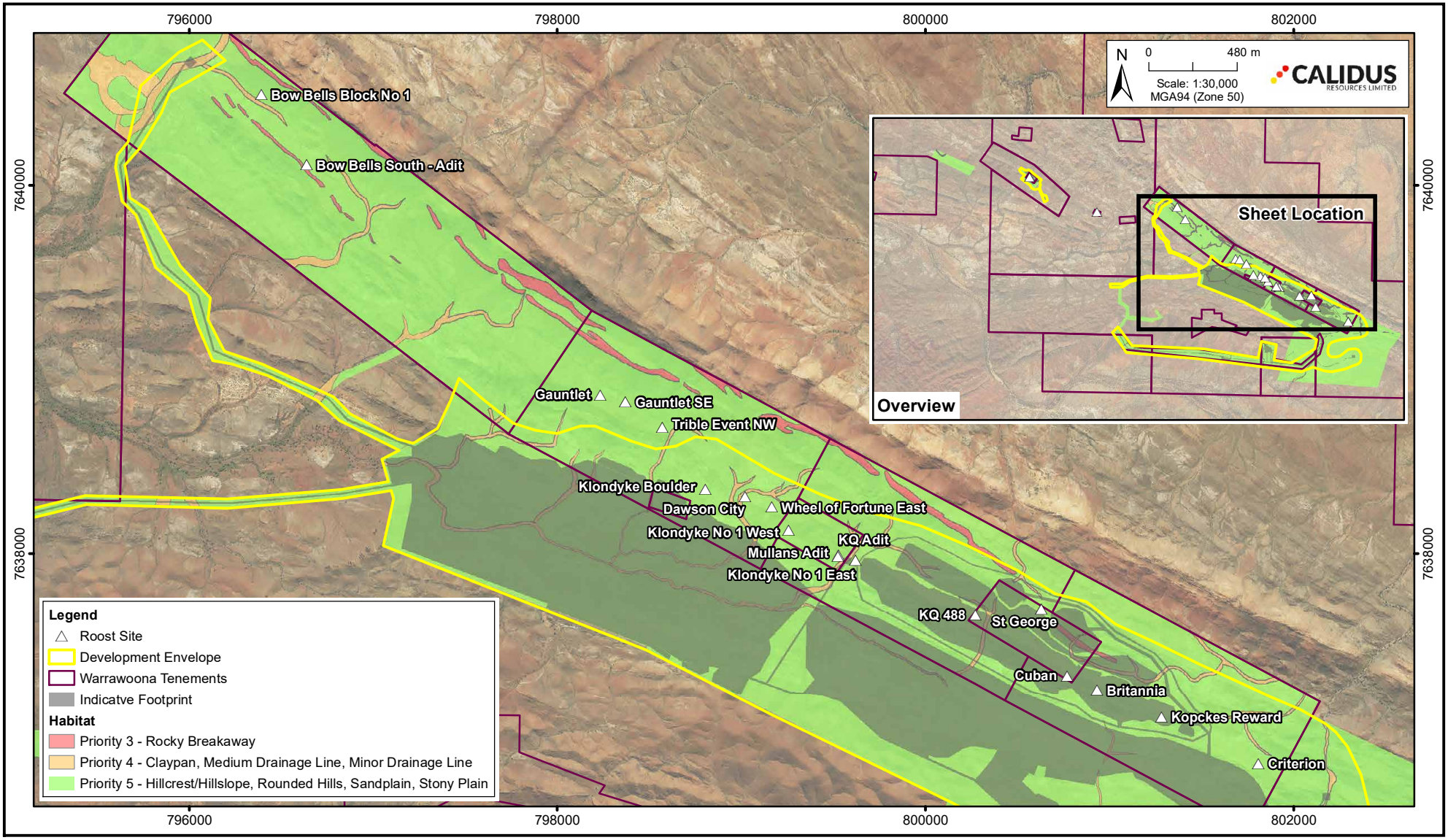
*excludes ~6ha of disturbed/cleared areas

Figure 21: Known Ghost Bat roost sites within the Proposal area and potential foraging habitat (Source Biologic 2019f; Appendix 3-1)



Source: DMIRS - Tenements, Biologic - Habitats
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_21, Rev: A

Figure 22: Known Pilbara Leaf-nosed Bat roost sites within the Proposal area and potential foraging habitat (Source Biologic 2019f; Appendix 3-1)



Source: DMIRS - Tenements, Biologic - Habitats
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_22, Rev: A

5.6.1.2 Death or injury from vehicle strike

The Proposal will establish a network of roads, as well as haulage and maintenance tracks. It is estimated that the access and road network will cover 31km throughout the Proposal area. The main road into the mine area is approximately 7.9km long, with the smaller internal roads and tracks covering the remaining 23km. Table 21 presents a summary of the proposal road network across habitat types.

The main access road into the mine area will carry the majority of traffic. The majority of the main road into the mine will cut through Sand Plain and Stony Plain habitat types, which are associated with the open grassland and woodland foraging habitat (Priority 5 foraging habitat, see above). Stony Plan habitat also represent a large majority of the internal tracks, and maintenance roads.

Table 21 Road and track network and length across the Proposal Area

Type of Road	Length of Rd (km)	TOTAL (km)
Main access road		
Minor Drainage Line	0.2	
Rounded Hills	0.8	
Sandplain	4.0	
Stony Plain	2.8	
Medium Drainage Line	0.1	**7.9**
Internal tracks, haulage and mine access roads		
Disturbed	0.4	
Hillcrest/Hillslope	5.7	
Medium Drainage Line	0.5	
Minor Drainage Line	0.8	
Rounded Hills	6.3	
Stony Plain	9.4	**23.1**
Total		**31.0**

The likelihood of a Ghost Bat experiencing a vehicle strike is increased during the night given the nocturnal foraging behaviour close to the ground (Churchill 2008). Vehicle movements at night will be significantly less than during the day and generally limited to in-pit operations. It is unlikely that there will be a significant increase to the strike of Ghost Bats in the local area and region.

Pilbara Leaf-nosed Bats are known to be susceptible to strikes from vehicles (Threatened Species Scientific Committee 2016b). Five records of species recorded in the Pilbara are from road kills (Fortescue Roadhouse, 1990; near Tom Price, 1995; near Yarrie 2005), or specimens found in carparks, presumably after falling off the vehicle (Millstream, no date; Karratha, 1985) (Armstrong 2001). They tend to fly relatively low and display a curiosity for light sources, which increase the chance of mortality along roads (DoE 2015). Local decline of the species may occur if a busy haul or access road is to be located close to a known roost or foraging site. However, vehicle movements at night (when Pilbara Leaf-nosed Bats are active) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations.

At a regional level, the sporadic occurrences of roadkill are unlikely to have a significant regional impact on the population size (DoE 2015).

5.6.1.3 Wildlife toxicity

Tailings Storage Facility (TSF)

As discussed in Section 2.3.4, a series of potentially hazardous reagents will be used during processing, including Sodium cyanide.

Exposure to cyanide in solution through consumption of surface water is the main exposure route for most animals affected by cyanide poisoning, but concurrent exposure through inhalation and skin absorption may also occur. In addition, animals may consume cyanide inadvertently in tailings slurry or sediments during foraging, when consuming carcasses or preening feathers (Australian Government 2008).

Poisonings most frequently affect birds, but records indicate a wide range of wild and domestic animal species have been poisoned by cyanide. Mammals (including bats), frogs, reptiles (such as snakes, lizards, tortoises) and insects are also susceptible to cyanide (Australian Government 2008).

At 'no discharge' mine facilities, 50mg/L WAD cyanide for cyanide solutions accessible to wildlife is widely recognised by the mining industry as a water quality benchmark for the protection of wildlife (Donato *et al.* 2007). This level is derived from observations in both the USA and Australia that bird mortalities tend to occur when the WAD cyanide concentration increases above 50mg/L (Donato *et al.* 2007).

The impact on wildlife is demonstrated to be low if tailings ponds contain WAD cyanide at levels less than 50mg/L, access to the ponded area is restricted and releases of water to the environment are avoided. Bird monitoring data supports the assertion that WAD cyanide 50mg/L level is a safe level (Australian Government 2008; Donato 1999).

Using a precautionary approach, and in recognition of limited data on acceptable cyanide levels for the Ghost Bat and Pilbara Leaf-nosed Bat, Calidus has committed to a concentration of WAD cyanide discharge less than 30mg/L. Following volatilization of cyanide post discharge, it is further expected that WAD cyanide in the supernatant will be lower.

It is also not expected that bats will rely on the TSF as a water source, given their current propensity to forage away from the Proposal area towards the plains north of the Warrawoona Ranges and the region north-west of Bow Bells. The existing pit lake at Copenhagen also does not represent a crucial foraging ground or water source for either bat species (Biologic 2019f).

The processing plant will be designed such that process water containing cyanide is recycled and kept within the area encompassed by the processing plant run-off collection drain and storage. In the event of spillages, all solutions will be contained within the process plant bunding, and the appropriate spill response procedure will be initiated. Portable pumps will be provided within the processing area for the pumping of spills within the bunded areas back to the storage tanks or emergency holding tanks (TSF and Cyanide Monitoring Procedure, CRL-ENV-PRO-019-10; Appendix 9-5).

The tailings delivery and return water lines will be contained within bunded pipeline corridors. The tailings slurry will be pumped to the TSF. Daily inspections of the tailings delivery and water return pipelines will be undertaken for physical integrity and to identify any minor leaks. In addition, an automatic, pressure activated shut-down mechanism will be provided on the tailings discharge pipeline to enable the early detection and stoppage of significant leaks or failures. The tailings pipeline will be fitted with a low flow alarm linked to the central control room with automatic shutdown capability. Further information on cyanide management at the proposal area, refer to the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5).

The following management measures will be in place to protect fauna from interactions with the TSF:

- Minimising the area of supernatant water in the TSF (decant);
- Monitoring usage of the TSF decant by fauna;
- Development of Procedures for the rescue of fauna;
- Beach Management via spigots placement to avoid ponding of supernatant water in areas other than the decant

Fauna monitoring at the TSF will occur twice a day to observe and record fauna usage. One patrol will be conducted after dawn and the other in late afternoon. The monitoring results will be utilised to determine the requirement for modification to the mechanisms being implemented to keep fauna away from the TSF.

Further information on management of the TSF is provided in Section 5.7.3.3

Mine Pit Lakes

Following mine closure, a pit lake will remain at the Klondyke pit, forming a hydraulic (groundwater) sink. From year 3 to 100 years post closure, the pit lake level is predicted to fluctuate between 178mRL and 204mRL; with an overall average base level across the 100-year period predicted to fluctuate between 178mRL and 183mRL (Groundwater Resource Management 2019b). Current elevation at the proposed Klondyke pit area and edge (based on the elevation recorded across ten groundwater investigation bores) ranges between 278.1mRL and 304.8mRL (Groundwater Resource Management 2019b). The risk of pit overflow, even under extreme rainfall events, is therefore negligible.

The current groundwater quality at the proposed Klondyke deposit is fresh to slightly brackish and slightly alkaline. Concentrations of dissolved metals in the groundwater are generally low, apart from arsenic and iron. Arsenic is above the Australian Drinking Water Guideline (ANZECC,2000) for human consumption (0.01mg/L) in most of the bores, but below the guideline value of 0.5mg/L for livestock watering in all samples analysed (Groundwater Resource Management 2019b, Appendix 4-2). The presence of arsenic at low levels in the local groundwater is considered to be naturally occurring (Groundwater Resource Management 2019b, Appendix 4-2).

Mine voids that form groundwater sinks tend to become progressively more saline overtime (Johnson and Wright 2003). Bat species are known to avoid saline waterbodies, with R. Bullen (Bat Call WA, pers. comm. 2019) noting that some bats tend to avoid waterbodies with a conductivity of greater than 3,200mg/L. Modelling suggests the Klondyke pit lake will reach a salinity of between 3,000 and 4,000mg/L TDS within 3 to 4 years of mine closure (Groundwater Resource Management 2019b), which will reduce the long-term risk of bats being impacted by the water quality in the Klondyke pit lake at closure.

In the 3 to 4 years post closure, prior to salinity levels in the pit lake reaching the 3,200mg/L bat avoidance level/threshold, arsenic toxicity at the mine pit lake is not expected to occur due to the amount of arsenic a bat would be required to consume to experience acute poisoning. For mammals, the lethal dose varies from approximately 15mg/kg taken orally to a low of 0.6 mg/kg/day of inorganic arsenic. Arsenic measured from the Copenhagen pit lake in March 2019 ranged from 560 to 580ppb. Accordingly, for acute poisoning to occur based on the lowest (most sensitive) poisoning thresholds, a Ghost Bat would have to drink approximately 75ug of arsenic each day, which would require it consuming its approximate body weight (130 g) in pit lake water from Copenhagen each day. It is considered highly unlikely that Ghost Bats would drink that amount of water from an open pool during their nightly foraging activities (R. Bullen, Bat Call WA, pers. comm. 7 October 2019).

The Copenhagen pit was flooded in the late 1980s and both Ghost Bats and Pilbara Leaf-nosed Bats have been continuously recorded across the Proposal area and surrounds during this 30-year period, suggesting that pit lake quality has not influenced their persistence in the local area.

Bat activity at the existing Copenhagen pit lake may also be an indicator of predicted activity levels at the Klondyke pit lake post closure. Investigations to date have showing that Copenhagen is not a preferred drinking source. Foraging studies have also revealed that Copenhagen is not frequently visited, with bats preferring to forage (and drink) outside the Proposal area (Biologic 2019f). Monitoring bat activity at, and utilisation of, the existing Copenhagen pit lake is ongoing.

A freshwater dam, to be maintained during operations within the mine exclusion zone, will further provide bats and other fauna with an alternative water source. Once established, bat activity at the freshwater dam will also be monitored to determine if Ghost Bats and/or Pilbara Leaf-nosed Bats use this water source as an alternative to pit lakes (e.g. Copenhagen), or the tailings decant.

5.6.1.4 Modified bat habitat from mine pit dewatering

A groundwater flow model was developed by Groundwater Resource Management (2019b) to estimate the expected range of dewatering rates and the extent of drawdown from mine pit dewatering at the Klondyke Pit.

The model found that following closure, the Klondyke pit will form a hydraulic sink, with the pit lake level predicted to remain below 204mRL for up to 100 years post closure (standing water levels recorded in recent groundwater investigation bores at Klondyke ranged between 254.3mRL and 271.5mRL) (Groundwater Resource Management 2019b).

The model found that by the end of mine (Year 6) the drawdown could extend up to approximately 3-3.5km to the northwest and southeast along the strike of the Warrawoona Range, and to approximately 2-2.5km laterally to the northeast and southwest from Klondyke (Figure 23 and Figure 24). Groundwater Resource Management (2019d) noted that given the frequency of large seasonal recharge events (such as thunderstorms and tropical cyclones crossing the Pilbara coast), it is likely the final drawdown impact will be smaller than that predicted.

Groundwater modelling indicated that levels in the vicinity of Klondyke Queen, Dawson City and Criterion sites will reduce (Table 22 and Figure 24), which may affect humidity levels at these bat roosts. Groundwater drawdown is expected to influence the Bow Bells underground workings, which will retain a significant saturated thickness (Groundwater Resource Management 2019b).

Table 22 Roost sites and groundwater drawdown

Roost Sites	Estimated drawdown (m) from current levels*
Comet Mine, Marble Bar Copper Mine, Trump	No change
Bow Bells Block No 1; Bow Bells South adit; Bow Bells South Shaft, British Exploration of Australia	<5m
Gift – Shaft; Gift – Decline; Golden Gauntlet	10-15m
Gauntlet Northwest 1; Gauntlet; Gauntlet SE; Trible Event NW; Princess of Alaska Trible Event	20-50m
Klondyke Boulder; Criterion; Dawson City	60-100m
Wheel of Fortune East, Kopckes Reward, St George, Klondyke No 1 West, Britannia, KQ 488, St George 3, Cuban, Klondyke No 1 East, Mullans adit, KQ adit, KQ Open stope	100+m

*Based on preliminary flow model developed by Groundwater Resource Management (2019b): Drawdown at month 72 (end of project mining).

Ghost bats

Dewatering of the proposed Klondyke Pit is not expected to significantly impact the Klondyke Queen roost or local colony of Ghost Bats. The often-perceived reliance on high humidity for roosting may not be a significant influence for Ghost Bat populations in the Pilbara, as roosting and reproducing in caves has recorded low humidity conditions (R. Bullen, Bat Call WA, pers. comm. 2019). Armstrong and Anstee (2000) have also reported roosting caves with humidity readings of between 14 - 31 %.

It is also considered that surface water recharge (rainwater percolating through the rock above) and the presence of the bats themselves is a strong contributor to roosting conditions for Ghost Bats (R. Bullen, Bat Call WA, pers. comm. 2019).

The Klondyke Queen roost (and the nearby Comet roost, old mine workings outside of the Proposal area) have recorded large numbers of Ghost bats roosting in chambers well above and not directly connected to the water table, and with close to ambient conditions noted (Biologic 2019f).

Pilbara Leaf-nose Bat

Pilbara Leaf-nosed Bats are more sensitive to changes in the conditions within the roosts, preferring stable, very hot (28 – 32 °C) and very humid (96 – 100 %) microclimates (Churchill 2008). This is a result of their limited ability to conserve heat and water (Armstrong 2001; Churchill, 1991).

It is expected that the population of Pilbara Leaf-nose Bats, which currently use both Klondyke Queen and Bow Bells, will begin to preference the Bow Bells South roost. The Bow Bells South roost is the main maternity roost in the area and is on the edge of the dewatering cone of depression. It should be noted that given the frequency of large seasonal recharge events (such as thunderstorms and tropical cyclones crossing the Pilbara coast), it is likely the final drawdown impact will be smaller than that predicted (Groundwater Resource Management 2019b). It is also expected that the Bows Bells South roost will maintain a significant saturated thickness (Groundwater Resource Management 2019b, Appendix 4-2).

5.6.1.5 Modified bat habitat from flooding

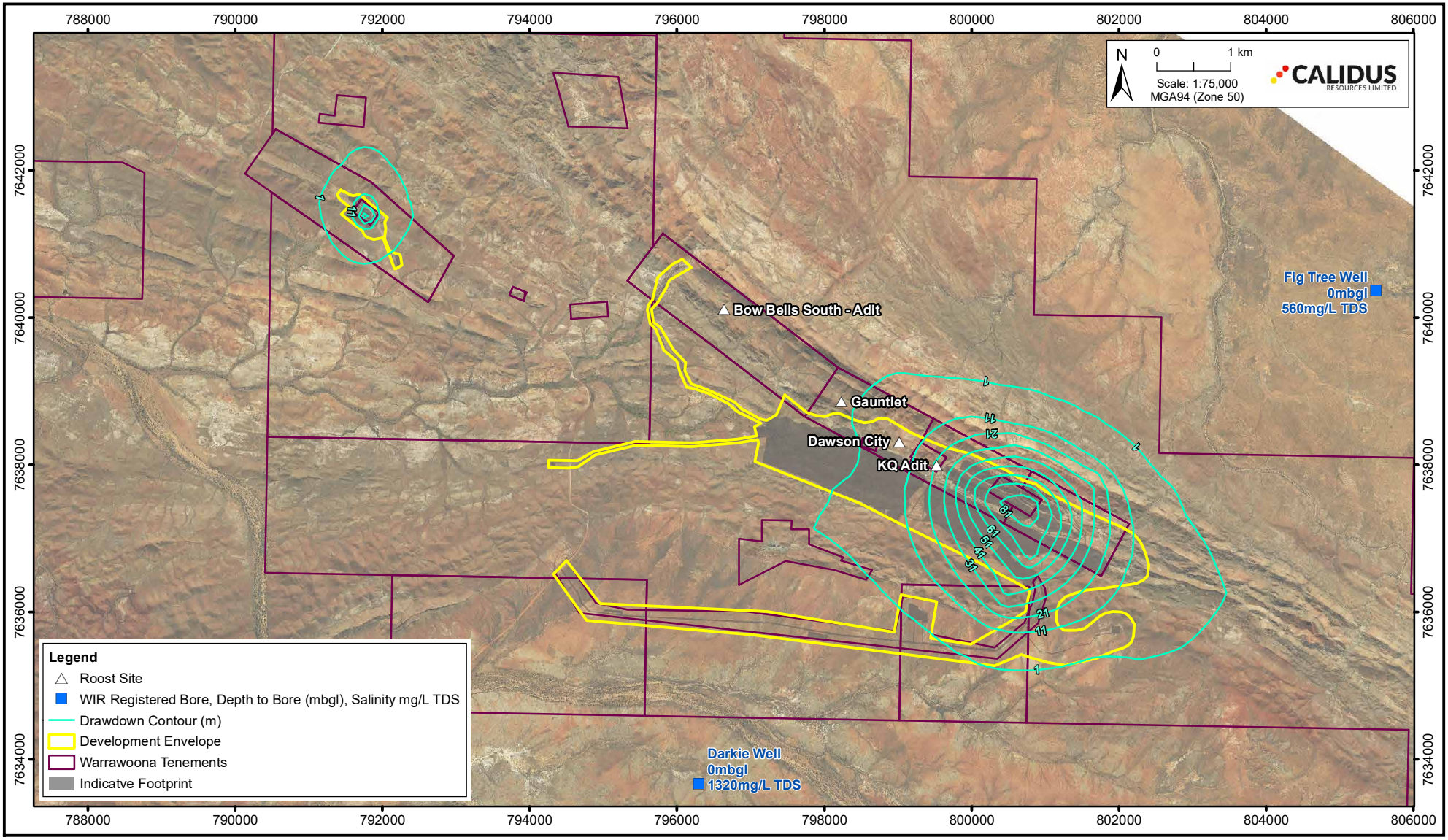
A flood risk assessment was undertaken of bat roosts in the Brockman Hay Cutting Catchment, which is the proposed location for the ~145ha 'valley fill' TSF (Groundwater Resource Management 2019a).

Thirteen historical mine workings closest to the proposed Klondyke Pit, WRD and TSF are summarised in Table 23, along with their approximate height above the proposed ultimate tailings beach where relevant. Inspection of these heights indicates the following:

- Eight underground workings adjacent to the proposed TSF are situated between 5 and 19m approximately above the ultimate tailings beach elevation; and,
- Five of the underground workings (Gauntlet, Gauntlet Northwest 1, Golden Gauntlet, Gift Decline and Criterion), are located outside of the proposed TSF upstream catchment area.

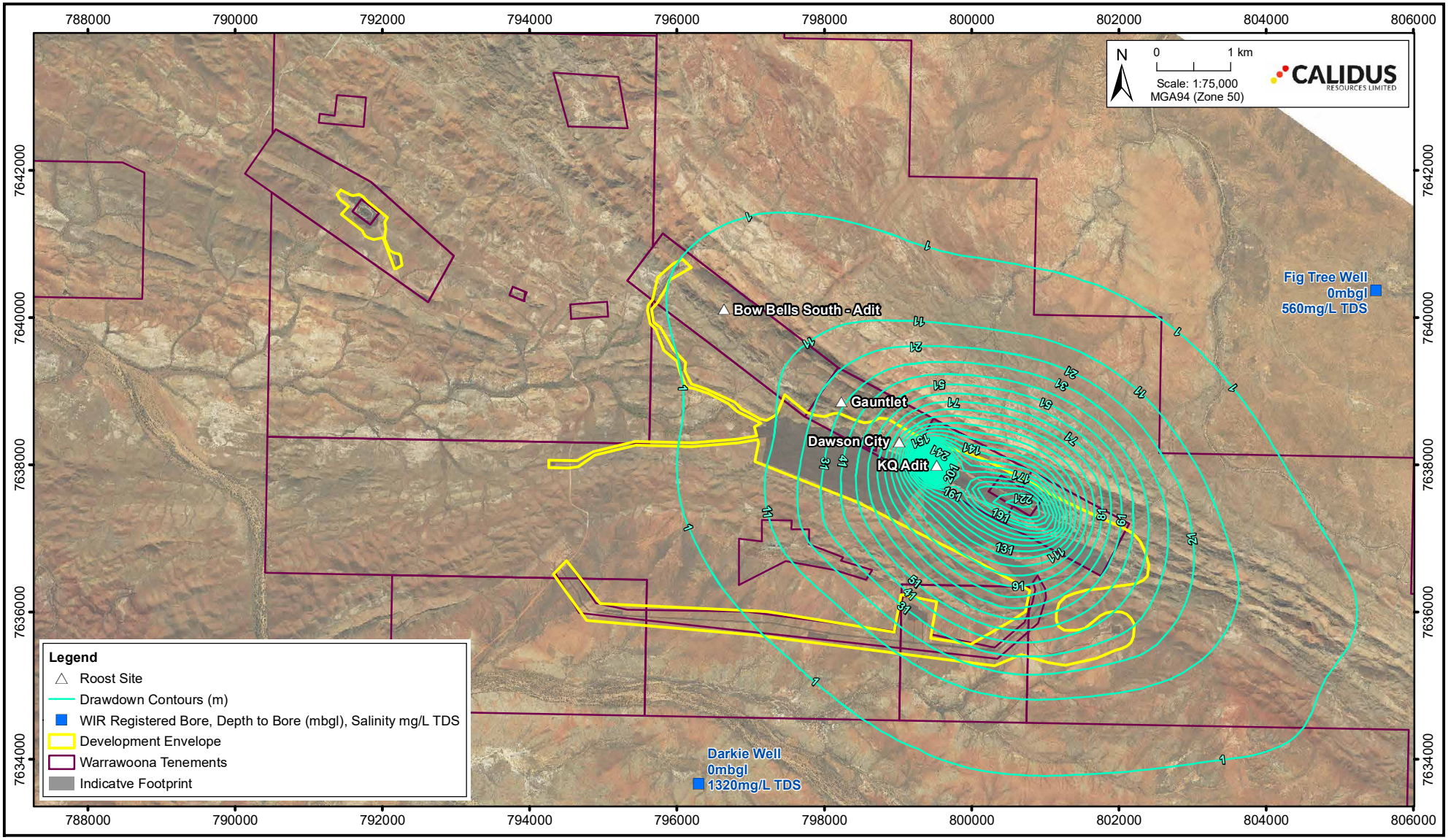
The entrance to the Klondyke Queen underground workings at elevation 281.0mAHD is also situated ~8m above the 273.0mAHD invert elevation of the ephemeral watercourse immediately to the southeast of the roost and ~2m above the lowest crest elevation of 279.0mAHD at the western end of the Klondyke pit. It is concluded that no sites are at risk from flooding (Groundwater Resource Management 2019a).

Figure 23: Drawdown extent, end of Copenhagen mining (Source: Groundwater Resource Management 2019b; Appendix 4-2)



Source: DMIRS - Tenements, Groundwater Res. Cons. - Contours
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_23, Rev: A

Figure 24: Drawdown extent, end of Klondyke mining (Source: Groundwater Resource Management 2019b; Appendix 4-2)



Source: DMIRS - Tenements, Groundwater Res. Cons. - Contours
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_24, Rev: A

Table 23 Roosting sites in the Brockman Hay Cutting Creek catchment and their height above the proposed ultimate tailings beach

Roost name	Existing Elevation (mAHD)	TSF Ultimate Beach Elevation (mAHD)	Roost Height above TSF Ultimate Beach (m)
Klondyke Queen - adit	281	269	12
Klondyke No 1 West	277.4	268.5	8.9
Wheel of Fortune East	284.1	268.5	15.6
Dawson City	273	268	5
Klondyke Boulder	275.8	268	7.8
Trible Event	284.3	265	19.3
Trible Event NW	279.5	265	14.5
Gauntlet SE	283.4	265	18.4
Gauntlet	292.4	N/A	Roosts located outside TSF upstream catchment area
Gauntlet Northwest 1	275.7	N/A	
Golden Gauntlet	269	N/A	
Gift - Decline	259	N/A	
Criterion	287.7	N/A	

5.6.1.6 Reduced bat habitat quality from noise and vibration

Noise

The Proposal will generate noise from blasting, heavy machinery and ore removal as well as processing and power generation. Potential impacts caused by noise range from interruptions in feeding and resting behaviour, to complete abandonment of an area (Newport *et al*. 2014). Constant levels of noise may also interfere with species communication, via acoustic interference (Parris and Scheider 2009). Species that may be especially at risk of disturbed communication are those that use calls to communicate or navigate.

Noise impacts will be largely associated with blasting, which will be restricted to daytime operations. Habitat most likely to be at risk are systems that support diurnal roosting, such as Klondyke Queen.

The Pilbara Leaf-nosed Bat and Ghost Bat are both known to be susceptible to noise (R. Bullen, Bat Call WA, pers. comm. 2019; Martin 2012; K. N. Armstrong unpub obs; Armstrong 2001), however Bullen and Cresse (2014) did note a tolerance of nearby noise from drilling activities by Ghost Bats.

Predicted noise emissions generated by mine operations (process plant, power plants and the general mining operations) at Klondyke pit has been modelled for each nearby roost site (Lloyd George Acoustics 2019, Appendix 3-5).

As *Environmental Protection (Noise) Regulations 1997* do not apply to fauna, Lloyd George Acoustics (2019) selected noise level restrictions (for determination of compliance) based on levels for sites classified as 'sensitive with no building', which assigns 60 dB LA10 at all hours. Based on this stringent noise level restriction, with the exception of the Klondyke Queen roost, all other roost sites complied with these limits (Table 24, Figure 25). Klondyke Queen, with 71 dB LA10, could further be reduced to 69 dB LA10 with noise controls to the drill rigs and haul trucks. It is also expected that the topographical separation of a hill and creekline between the Klondyke pit and the Klondyke Queen roost (and many other roost sites further north) will further act to shield/minimise noise and vibration impacts (from haulage, drilling and blasting activities) from reaching the workings (Figure 6, Section 2.3.2.3).

Even with the predicted worst-case scenario of 69-71 dB(A), this level is not expected to adversely impact on the local bat population, with a study by Bullen and Cresse (2014) indicating that noise levels up to 70 dB(A) from drilling activities did not appear to disturb bats roosting at the time.

Furthermore, as the predicted noise level modelled at the Klondyke Queen roost is based on a point 1.5m above the ground surface, and the Klondyke Queen roost is located approximately 10m below ground and well away from the adit's entrance, the noise levels within the cave are expected to be lower than the surface prediction of 69-71 dB(A) (Lloyd George Acoustics 2019).

In a follow up study, Lloyd George Acoustics (2019) developed a model of the Klondyke Queen adit in Sound Plan in order to more accurately predict the noise impacts within adit using the characteristics of the roost (depth below the surface, length of shaft/adit into roost, reverberating nature of the walls etc.). The model was based on a 70m long adit, with an average cross-section of $4m^2$, which was assumed to be relatively reverberant (i.e. solid rock with minimal soft ground/vegetation within). This follow-up 'Sound Plan' model determined that noise levels within the roost were predicted to be below 55 dB(A) using the VDI 3760 algorithms (Lloyd George Acoustics 2019, Appendix 3-5).

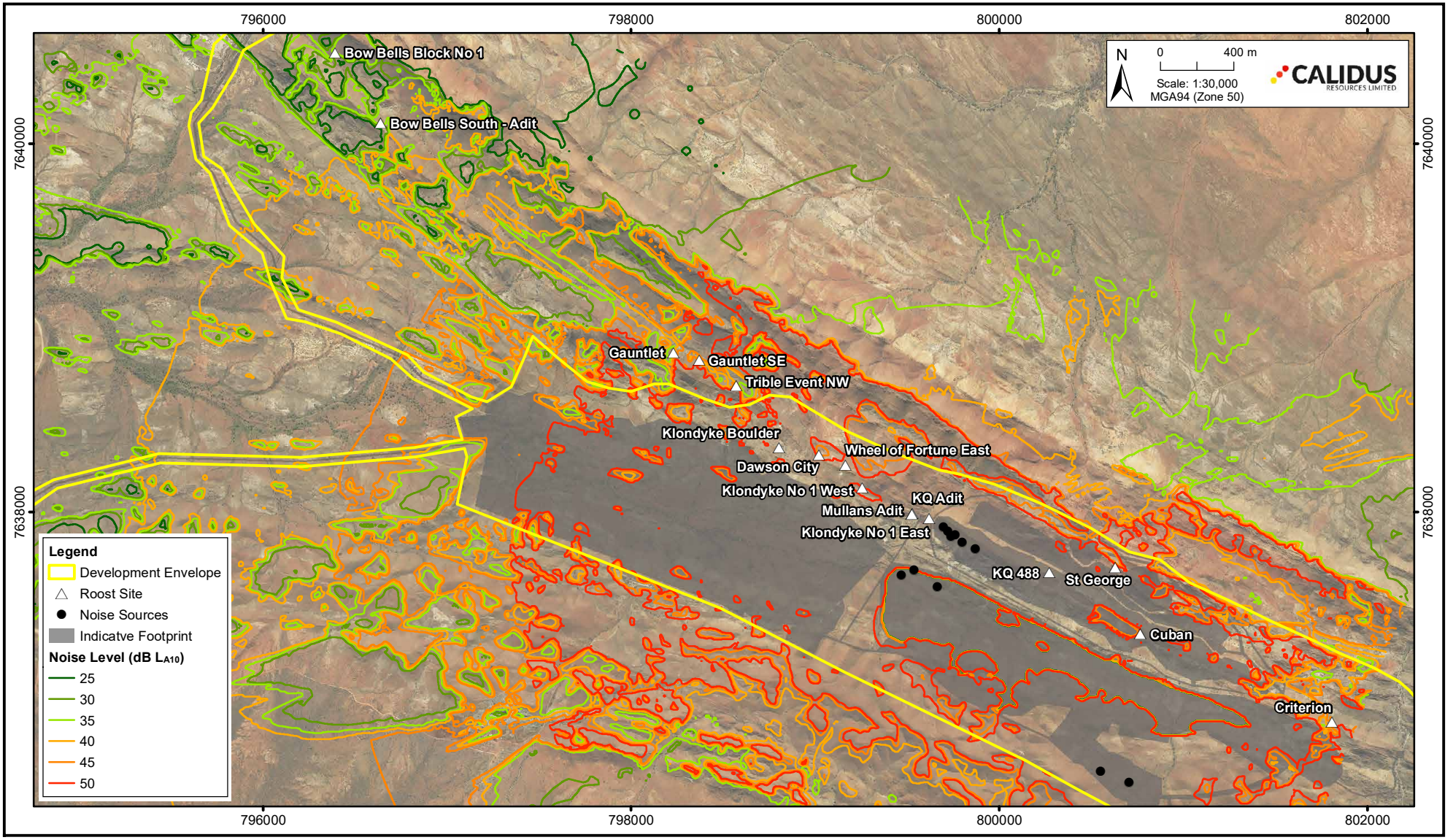
Based on the predicted noise levels of 69-71 dB(A) at the surface and 55 dB(A) within the roost, it is considered that noise emissions from the Proposal will not adversely impact on the local bat population (Lloyd George Acoustics 2019).

It is also noted that the 'A' frequency weighting is used to imitate the frequency response of the human ear, and attenuates low frequency signals (i.e. below 250 Hz) more than higher frequency sounds. Given that predicted noise levels from the Proposal will be dominated by low frequency sounds, combined with the large separation distance between the roost and the pit, it is therefore also considered unlikely that noise emissions will interfere with bat call signals (which are understood to be near 2 kHz and above) (Lloyd George Acoustics 2019).

Table 24 Predicted Noise Levels (Night, Worst-case Weather Conditions)

Receiver (Roost) (based on record 1.5m above ground surface)	Predicted Noise Levels, dB L_{A10}		
	Process Power Plant	Mine Operations	Overall
Bow Bells Block No 1	25	36	37
Bow Bells South (adit)	24	37	38
British Exploration of Australia	23	33	33
Dawson City	27	44	44
Gauntlet	19	35	35
Gauntlet Northwest 1	17	41	41
Gauntlet SE	31	44	45
Gift - Decline	14	28	28
Golden Gauntlet	14	29	29
Klondyke Boulder	37	58	58
Klondyke No 1 West	29	50	50
Klondyke Queen (adit)	44	71	71
Trible Event	28	41	41
Trible Event NW	31	47	47
Trump	20	30	30
Wheel of Fortune East	41	58	58

Figure 25: Noise contour model and Bat roosts (Source: Lloyd George Acoustics 2019; Appendix 3-5)



Source: DMIRS - Tenements, Lloyd George Acoustics - Noise
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_25, Rev: A

Blasting

Both bat species appear heavily reliant on unstable disused underground mines, which is a significant threat contributing to the conservation status of both species (Threatened Species Scientific Committee 2016a and 2016b), with important sites such as Klondyke Queen experiencing several historical collapses (Threatened Species Scientific Committee 2016a). It is also possible that the artificial nature of these structures, causes less-stable microclimates potentially explaining the temporary abandonment of Klondyke Queen as indicated from previous studies (R. Bullen and N. McKenzie pers. obs. quoted in Cramer *et al*. 2016) and nearby mine sites, (i.e. Comet, J. Dunlop unpub. data quoted in Armstrong 2001).

Blast It Global (2018) assessed the effects of blasting on the structure at the Klondyke Queen roost. A set of blast parameters were modelled to determine the most appropriate blast parameters to minimise impacts to the Klondyke Queen roost from drill and blast activities at the nearby Klondyke pit.

The modelling determined that in order to comply with less than 10mm/s vibration levels at the Klondyke Queen roost (which is the same value applied to other sensitive sites including heritage sites), 102mm and 115mm blast holes on a 5m bench height can be successfully used up to 185m of the Klondyke Queen roost without impact (Blast It Global 2018). This outcome has been further validated through a peer/technical review process (Peter O'Bryan and Associates 2019).

As a precautionary approach, Calidus has applied a setback/buffer of 200m between blasting activities at the Klondyke pit and the Klondyke Queen roost. All blasts with 1,000m will be monitored via a permanent blast monitor within 10m of the Klondyke Queen and located between the Klondyke Queen and the pit.

A follow-up study by Blast It Global (2018) (Appendix 3-3 addendum) also considered blast vibrations from the underground mining component of the Proposal (see Section 2.3.2.2 for further information on underground mining). This study found that compliant vibration levels of less than 10mm/s (on a 95% confidence interval basis) can be achieved up to 200m from the base of the old workings through the use of 64mm diameter blast holes. As such, Calidus has also applied the recommended 200m buffer in a vertical extent below the Klondyke Queen workings. Figure 5 (Section 2.3.2.2) shows the proposed underground workings below Klondyke Queen (western portion of the underground mine component).

Overall, blasting can be managed to avoid structural consequences for Klondyke Queen (Blast it Global 2018) and it is not expected that increases to noise and vibration from mining activities (such as blasting) will detrimentally impact local Ghost Bat and Pilbara Leaf-nosed Bat colonies.

5.6.1.7 Altered fire regime

Consideration of fire frequency is relevant to the maintenance of suitable foraging habitat for bats, especially when females are lactating and might require greater food resources (Threatened Species Scientific Committee 2016b). Although the proposed development may increase the frequency of fire, it is not expected to have a significant impact on the species.

On a regional scale, extensive burning of the preferred foraging zone in the plains north of the Proposal area in May 2018 (Landgate 2019) did not deter the local colony of Ghost Bats or Pilbara Leaf-nosed Bats from using the area during 2018 and 2019 VHF surveys (Biologic 2019f).

5.6.1.8 Introduced species

The Pilbara Leaf-nosed Bat and Ghost Bat have been exposed to the degradation and modification of natural habitats caused by introduced species such as invasive weeds, domestic herbivores and other larger feral ungulates since the arrival of Europeans (Threatened Species Scientific Committee 2016b; Biologic 2018a)

There is recent evidence that Ghost Bats predate on Cane Toads and are susceptible to their toxicity (Purtill 2014). If Cane Toads expand into the Pilbara, the presence of artificial water sources may attract these introduced species.

Invasive species are unlikely to have a significant effect in comparison to other key threats. It is anticipated that numbers of feral predators, such as feral cats and foxes, and introduced grazers, will not significantly increase, given Calidus' commitment of monitoring and management of these issues. Feral cats have been recorded in the Proposal area (Biologic 2019d and 2019f).

Proposed roads to be established cover relatively small distances for the Pilbara and are unlikely to result in a significant increase in feral species, given also the presence of roads, tracks and other disturbance in the local area as a result of historic mining and prospecting since the 1800's.

The threat of increased species is therefore not expected to escalate at a local or regional level due to the proposed development.

5.6.1.9 Altered behaviour from increased light and dust emissions

Light spill

Ghost Bats are known to be susceptible to light spill, with strong light sources potentially causing confusion or temporary blindness during foraging (R. Bullen, Bat Call WA, pers. comm. 2019; Martin 2012).

The Pilbara Leaf-nosed Bat also displays a curiosity for light sources (Threatened Species Scientific Committee 2016b), and foraging Pilbara Leaf-nosed Bats have been recorded as attracted to artificial lights (car headlights, head torches and mine site lights) (Cramer *et al*. 2016b), which may make it more susceptible to vehicle strike or predation.

Localised increases to light from mining activities are not expected to impact the local bat colonies, as bats within the Proposal area tend to forage further outside the proposed development envelope. However, ongoing monitoring will continue to build a strong baseline dataset prior to development so that any changes detected at key development stages of the Proposal (construction, operations etc.) can be managed.

Dust

Ghost bats have excellent vision and it is possible that high dust levels could irritate the eyes or reduce vision and affect their ability to capture prey (Threatened Species Scientific Committee 2016a). Habitat most likely to be at risk are those in proximity to the proposed Klondyke Pit. Airborne dust will be highest during daylight hours when activities generating dust (including blasting) occur and bats are not active. Given this, the likelihood that the Ghost Bat colony will be affected by dust emissions is low due to no night-time blasting and the underground protection of the roost.

An air emissions desktop assessment was undertaken across the Proposal area, which characterised the local climate and meteorology and the potential atmospheric emissions for the Proposal (Environmental Technologies and Analytics 2019) (Appendix 3-6).

Environmental Technologies and Analytics (2019) concluded that with conventional dust management measures in conjunction with the adopted exclusion zone and setback to sensitive roost locations of 200m from the pit edge, airborne dust emissions are expected to be maintained within acceptable levels at sensitive receptor locations. Environmental Technologies and Analytics (2019) also noted that because the mining exclusion zone is on a separate hill and on the opposite side of a gully to the proposed Klondyke pit, this natural topography is also expected to provide a natural shield to exposure.

5.6.2 Other terrestrial vertebrate fauna

5.6.2.1 Direct habitat removal

The Proposal area contains eight habitat types (excluding cleared areas), seven of which are within the disturbance footprint. The disturbance footprint represents approximately 22% of the total area surveyed. The values of each habitat type and the extent of their impact is summarised in Table 25.

Two habitat types of the Proposal area are considered 'High' significance habitat types (Biologic 2019f, Table 25) and disturbance to these habitat types has been avoided where possible. It is proposed to clear less that 12ha of these 'High' value habitat types, which represents just 3% of the total disturbance footprint. The two 'High' value habitat types of the Proposal area include:

- The Rocky Breakaway habitat type, which provides high density denning and foraging habitat for the Northern Quoll, and foraging habitat for the Pilbara Olive Python, Ghost Bat, and Pilbara Leaf-nosed Bat. The Proposal will disturb 0.8ha of this habitat type, which represents just 4.6% of the Rocky Breakaway habitat type recorded across the Proposal area, and only 0.2% of the total disturbance footprint. This habitat type is well represented outside the Proposal area, across the Warrawoona Range and throughout other ranges of the Pilbara IBRA region more broadly.
- The Sandplain habitat type in the southern portion of the Proposal area supports Brush-tailed Mulgara, and potentially the Night Parrot and Greater Bilby. The Proposal will disturb 11.1ha of this high value habitat type, which represents 8.1% of the recorded Sandplain habitat type in the Proposal area, and only 2.8% of the total disturbance footprint. This habitat type is well represented outside the Proposal area, across the plains north and south of the Warrawoona Range and throughout the plains of the Pilbara IBRA region more broadly.

The other five habitat types within the disturbance footprint are of 'Moderate' significance and account for 383.2ha, 96.2% of the disturbance footprint. These 'Moderate' significance habitat types include:

- The Medium/Minor Drainage Lines provide dispersal and foraging habitat for the Northern Quoll, Pilbara Olive Python, as well as the previously discussed Ghost Bat and Pilbara Leaf-nosed Bat. The Proposal will disturb 14.3ha of Medium and Minor drainage lines, which represents 28.9% of the recorded drainage line habitat types of the Proposal area, which is just 3.6% of the total disturbance footprint. These drainage line habitat types are widespread throughout the Pilbara IBRA region.
- The Stony Plain habitat type provides potential habitat for the Spectacled Hare-Wallaby and Western Pebble-mound Mouse and some suitable areas of potential habitat for the Night Parrot. The Proposal will disturb 141.7ha of this 'Moderate' value habitat type, which is approximately 26% of the recorded Stony Plain habitat in the Proposal area, and approximately 35% of the total disturbance footprint. The Stony Plain habitat is a very widely distributed habitat type, representing 550ha across the Proposal area and a significant portion of the Pilbara IBRA region more broadly.
- The Hillcrest/ Hillslope and Rounded Hills habitat types both contain small rocky breakaways that provide additional denning habitat for the Northern Quoll as well as habitat and resources for the Western Pebble-mound Mouse. The Proposal will disturb 138.1ha of Hillcrest/Hillslope and 89.2ha of Rounded Hills, which represents 19.2% and 26.3% of their recorded habitat types in the Proposal area respectively. Combined, these two widely distributed habitat types of the Pilbara make up 57% of the total disturbance footprint.

The remaining Claypan habitat type was considered a 'Low' significance habitat type, as it either does not support species of high conservation value and/or such species are not dependent on the habitats at the broad scale. No disturbance will occur on the Claypan habitat type.

Existing disturbance and cleared landscapes were mapped across almost 6ha of the Proposal area.

Table 25 The value and extent of disturbance of each habitat type within the Proposal area.

Habitat	Habitat Value Score*	Reason for significance	Survey area	Habitat within disturbance footprint (proportion of the total disturbance footprint) *	Proportion of habitat surveyed to be disturbed
Rocky Breakaway	High	• Northern Quoll - Provides core denning and foraging habitat • Pilbara Olive Python – provides core foraging habitat	18.6ha	0.8ha (0.2% of total disturbance footprint)	4.6%
Sandplain	High	• Greater Bilby and Brush-tailed Mulgara – provides core burrowing and foraging habitat • Spectacled Hare-Wallaby – core foraging habitat and shelter • Night Parrot – potential foraging and nesting habitat	137ha	11.1ha (2.8% of total disturbance footprint)	8.1%
Medium Drainage Line	Moderate	• Northern Quoll and Pilbara Olive Python - Provides dispersal and foraging habitat	18.5ha	5.8ha (1.5% of total disturbance footprint)	31.3%
Minor Drainage Line	Moderate	• Northern Quoll and Pilbara Olive Python - Provides dispersal and foraging habitat	31ha	8.5ha (2.1% of total disturbance footprint)	27.5%
Stony Plain	Moderate	• Western Pebble-Mound Mouse – provides core habitat • Spectacled Hare-Wallaby – core foraging habitat and shelter • Night Parrot – potential habitat	548ha	141.7ha (35.6% of total disturbance footprint)	25.9%
Hillcrest/ Hillslope	Moderate	• Northern Quoll - Provides dispersal and foraging habitat • Western Pebble-Mound Mouse – provides core habitat	718ha	138.1ha (34.6% of total disturbance footprint)	19.2%
Rounded Hills	Moderate	• Northern Quoll - Provides dispersal and foraging habitat	339ha	89.2ha (22.4% of total disturbance footprint)	26.3%
Claypan	Low	No conservation significant species occurring or likely to occur are solely dependent on this habitat type within the Proposal area or vicinity. It may be used by migratory birds when inundated.	6ha	0ha	0%
Disturbed			5.9ha	3.4 (0.9% of total disturbance footprint)	57.7%
Total			**1,822**	**398.5**	

*indicative disturbance footprint

Northern Quoll

The Northern Quoll population within the Proposal area is most likely permanent and considered a high-density population, important for the long-term survival of the species. Although their semelparous nature (death of the males after reproduction as part of an overall strategy maximize reproduction success at the expense of future life) may make them susceptible to local extinction, the species does have good dispersal ability (Oakwood 2000; Spencer 2013; Woolley 2015). Core habitat for the Northern Quoll, Rocky Breakaways, will have very minimal disturbance (~0.8ha) (Figure 26).

Pilbara Olive Python

The Pilbara Olive Python is confirmed from the Proposal area, and core foraging and dispersal habitat is likely to be partially removed. Destruction of habitat is an identified threat to the species (Threatened Species Scientific Committee 2008b). They may cross roads but drains and pits will represent barriers to movement. Core habitat for the Pilbara Olive Python, Rocky Breakaways, will have very minimal disturbance (~0.8ha) (Figure 27).

In addition, retention of the Klondyke Queen workings and other workings within the mining exclusion zones will provide habitat for the Pilbara Olive Python.

Brush-tailed Mulgara

There is only one habitat type considered highly suitable to support the species within the Proposal area (Sandplain) and disturbance to this habitat is low (~11ha, 8% of the habitats surveyed area). Although disturbance or fragmentation (i.e. the proposed access track) within this habitat type is likely to have a local impact, studies have suggested that the species can tolerate a moderate local reduction in cover (up to 15%) of its preferred habitat (Masters *et al.* 2003) (Figure 28).

Greater Bilby

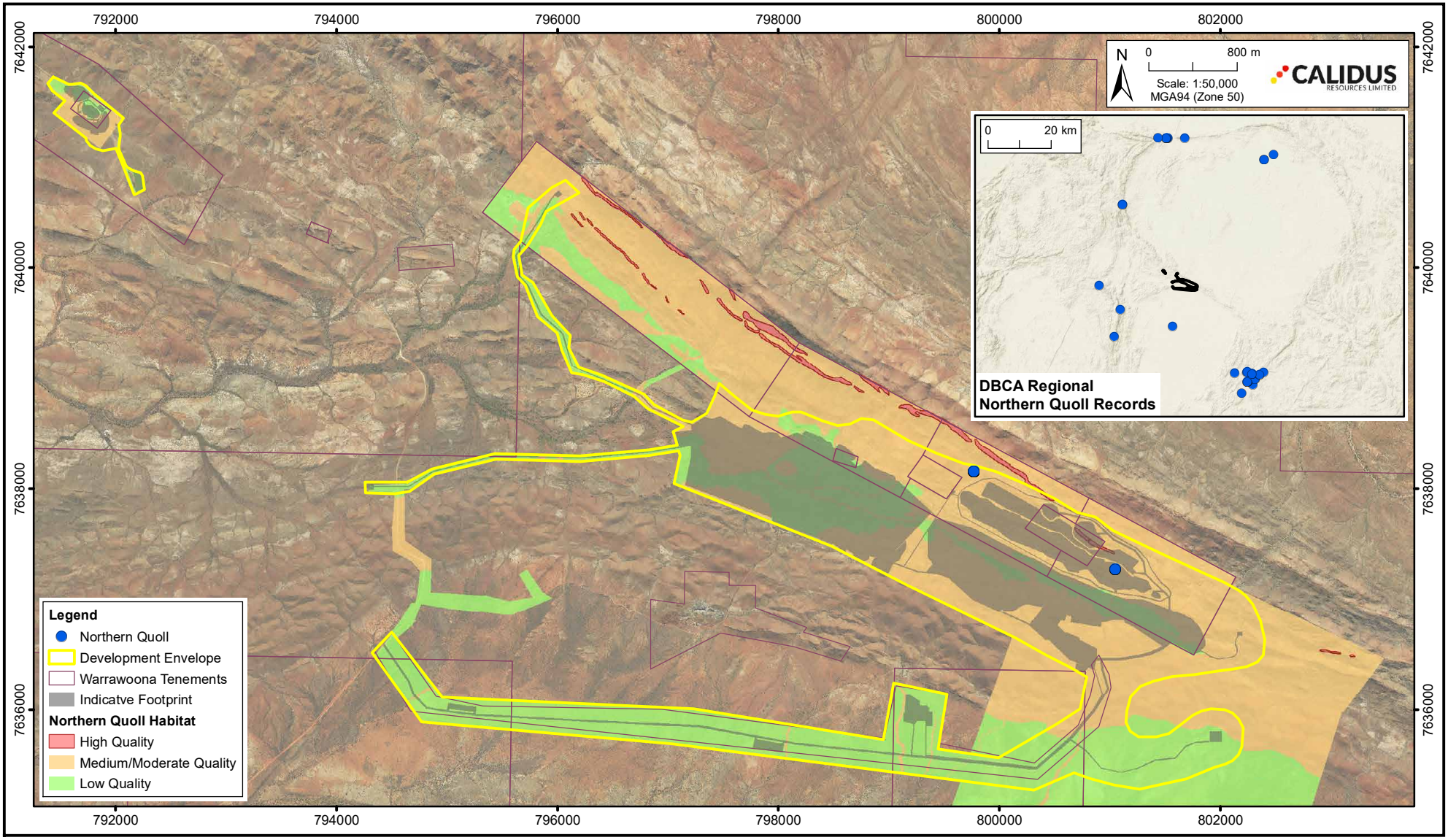
The Greater Bilby species is a habitat specialist in Sandplain (and potentially Stony Plain). They occur naturally as scattered solitary individuals or small groups (Smythe and Philpott, 1968; Southgate, 1990), and the loss or modification of core habitat may have a potential impact on the ability of the Proposal area to support a population. The effects of linear land clearing for tracks, road and rail on bilby numbers is uncertain (Bradley 2015). A very small area of their core Sandplain habitat is within the disturbance footprint (~11ha, 8% of the habitats surveyed area) (Figure 29). Despite targeted surveys, the species has not been recorded in the Proposal area or its surrounds.

Western Pebble-mound Mouse

Core habitat types for the Western Pebble-mound Mouse include Hillcrest/hillslope and Stony Plain, which are the largest habitat extents within the Proposal area and will experience the largest disturbance footprints of all habitat types (~138.1ha and 141.7ha disturbance respectively). Given the species is a habitat specialist to these areas, the individuals within the Proposal area may negatively impact individuals at a local level.

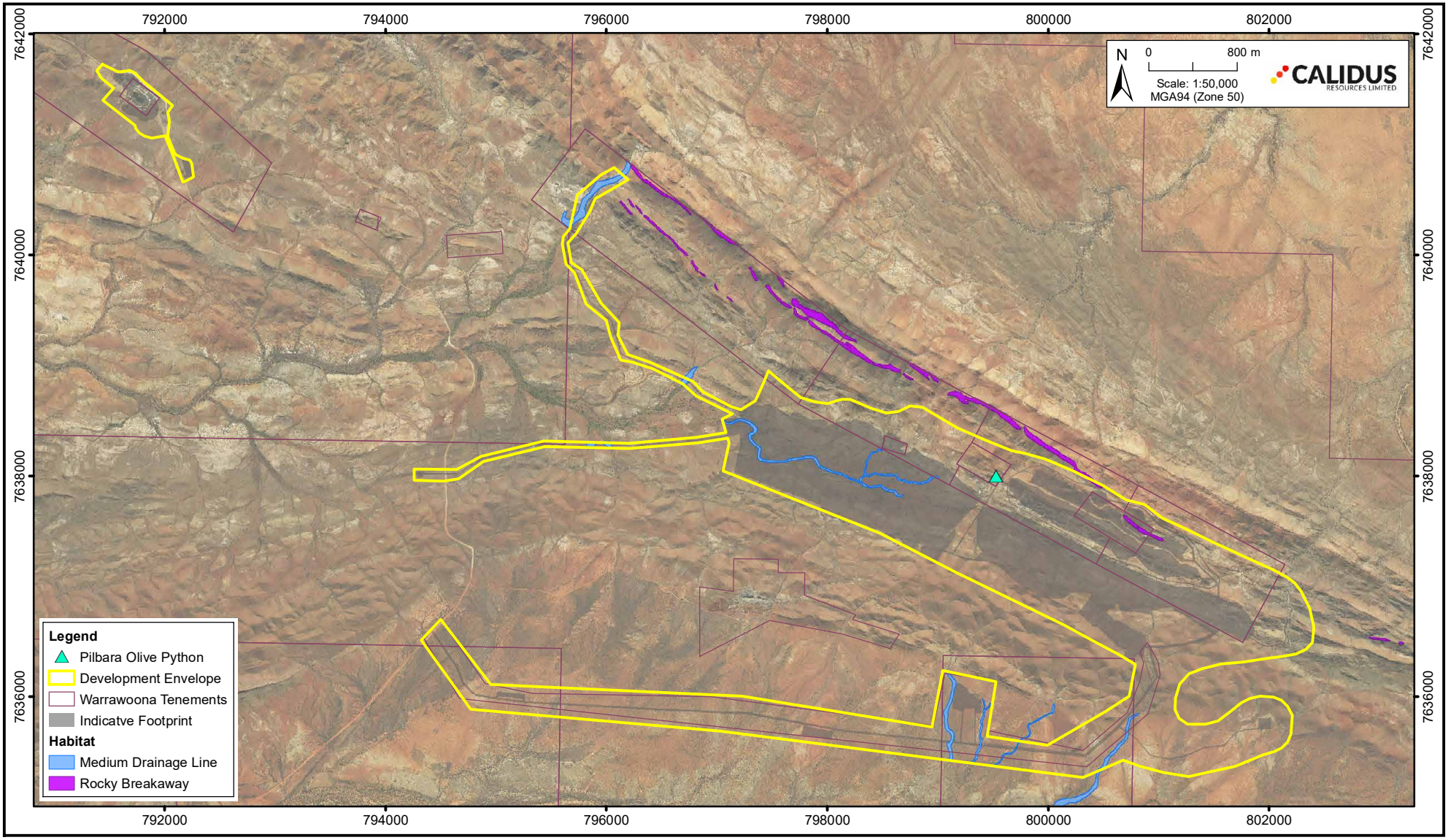
Although the total disturbance area for the Western Pebble-mound Mouse's preferred habitat, Hillcrest/hillslope and Stony Plain, is almost 280ha, the total area surveyed for both habitats was 1,266ha, with only 22% of this habitat to be disturbed, providing for a large area within which the local populations can redistribute. Clearing for roads is unlikely to cause a barrier to movement between local populations, as small rodents are known to readily cross roads and use culverts (Queensland Department of Main Roads 2000, in Biologic 2019g).

Figure 26: Potential Northern Quoll habitat within proposal area (Source: Biologic 2019g; Appendix 3-2)



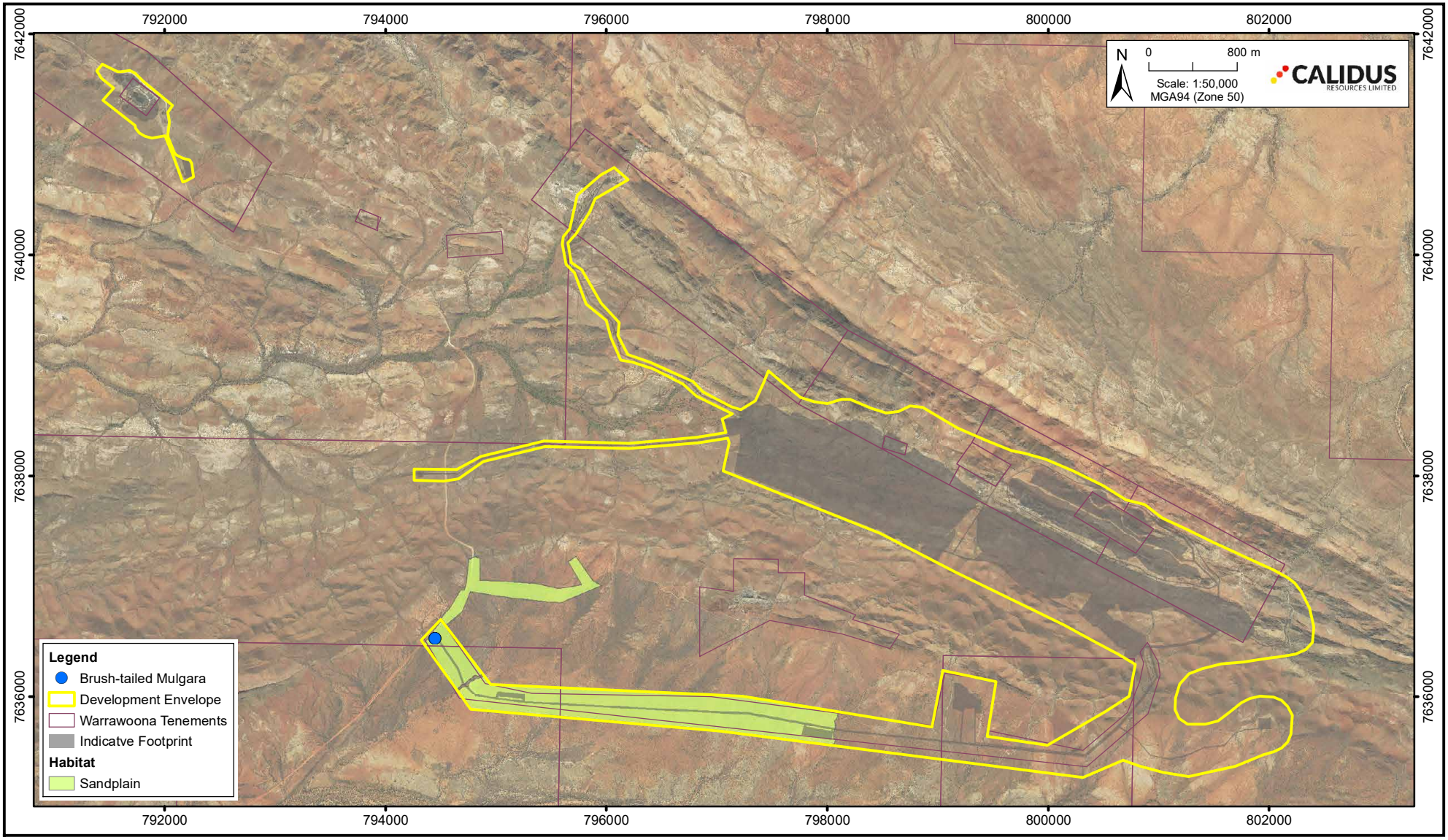
Source: DMIRS - Tenements, Biologic - Habitats, DBCA - Regional Data
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_26, Rev: A

Figure 27: Potential Pilbara Olive Python habitat within proposal area (Source: Biologic 2019g; Appendix 3-2)



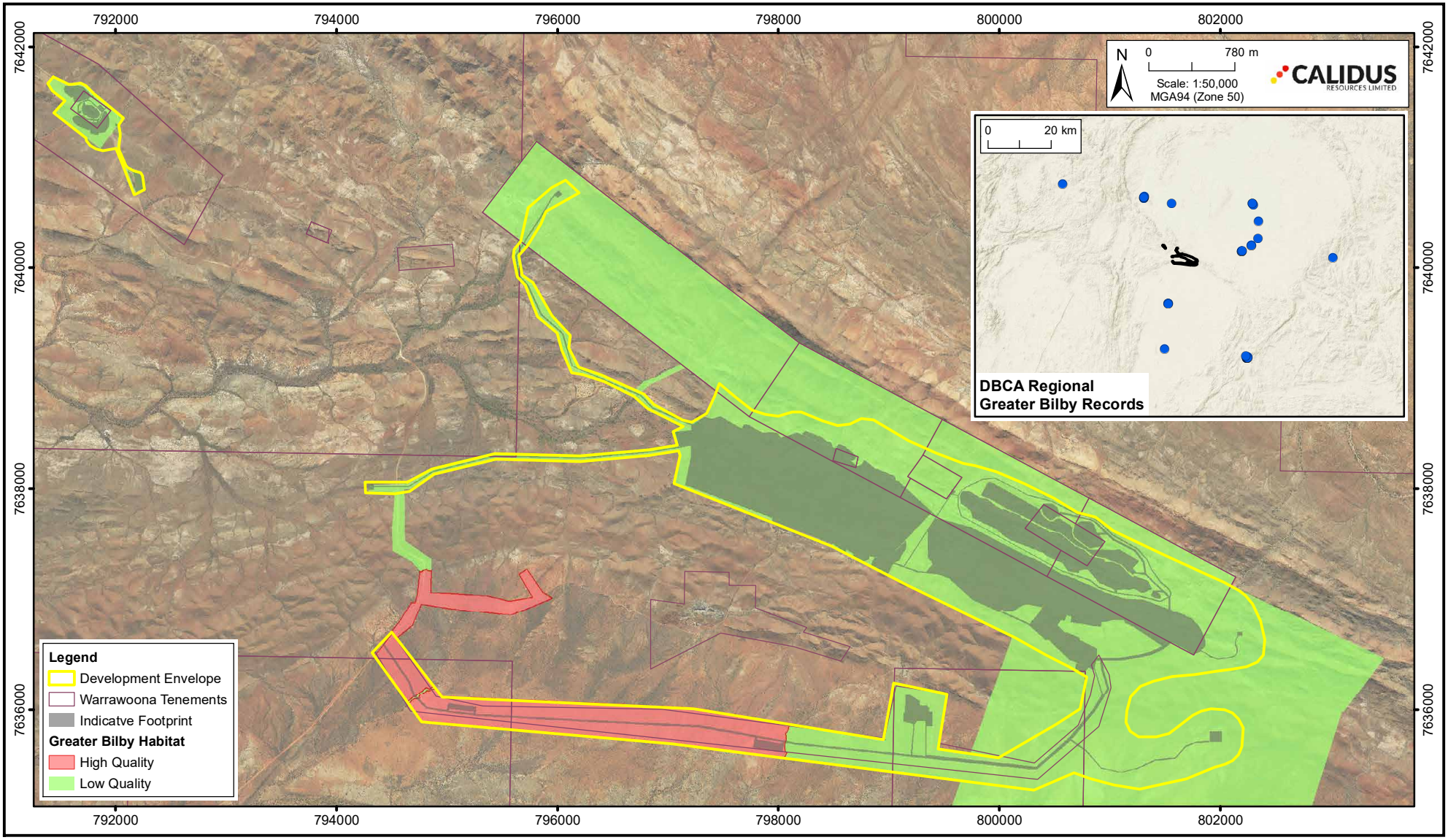
Source: DMIRS - Tenements, Biologic - Habitats, Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_27, Rev: A

Figure 28: Potential Brushtailed Mulgara habitat within proposal area (Source: Biologic 2019g; Appendix 3-2)



Source: DMIRS - Tenements, Biologic - Habitats, Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_28, Rev: A

Figure 29: Potential greater Bilby habitat within proposal area (Source: Biologic 2019g; Appendix 3-2)



Source: DMIRS - Tenements, Biologic - Habitats, DBCA - Regional Data
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_29, Rev: A

Long-tailed Dunnart

The Long-tailed Dunnart is a habitat specialist to rocky scree and plateau areas and thus clearing of such habitat may directly impact the species (Burbidge *et al.* 2008). Clearing for roads is unlikely to cause a barrier to movement between local populations, as small marsupials (as with rodents) are known to readily cross roads and use culverts (Queensland Department of Main Roads 2000, in Biologic 2019g). The preferred habitat type for this species, Rocky Breakaways, will experience very minimal disturbance (~0.8ha).

Night Parrot

The Night Parrot is a habitat specialist in old age spinifex on Sandplains and Stony Plain with Acacia (DPaW 2017). The Proposal area contains Sandplain habitat considered highly suitable to support the species, within which there will be a minimal disturbance footprint (11ha, 8% of the habitats surveyed area). Despite targeted surveys, the species has not been recorded. Night Parrots are known to fly up to 100km per night (Burbidge 2016), and would be able to avoid habitat fragmentation at the scale imposed by the Proposal.

Peregrine Falcon

The Peregrine Falcon is a habitat generalist. It is highly mobile and can easily move away from disturbances, making it less susceptible for any impact at a local scale. Although there are no records within the Proposal area, the Peregrine Falcon was recorded in 2001 approximately 10km west of the Proposal area (DBCA 2019a).

Spectacled Hare-wallaby

There are no records of the Spectacled Hare Wallaby within the Proposal area, and the species is highly unlikely to experience significant loss of core habitat. There is connectivity to similar habitat outside the boundary. It is a larger species with higher dispersal capabilities, thus would be able to move away from disturbances.

Northern Brush-tail Possum

The former range of the Brush-tail Possum has been considerably reduced by habitat clearing and fox predation (DEC 2012). Although there will be clearing and disturbance to habitat suitable to support the species, there are no records of the species occurring within the Proposal area and habitat preference of Medium/Minor Drainage Lines are only marginally suitable and make up a small proportion of the Proposal area.

5.6.2.2 Death of injury from vehicle strike

Road Network

The Proposal will establish 31km of roads, haulage, tracks, pipelines and maintenance corridors throughout the Proposal area. The majority of road corridors are associated with Moderate value habitat types (26.6km in total, 85%), including Stony Plains (12.2km), Hillcrest/Hillslope (5.7km) and Rounded Hills (7.1km) (Table 26). The habitat preference for each species of conservation significance will influence the likelihood of vehicle strike within the Proposal area.

Note, further information on the road network across the Proposal area, including the breakdown in length of the 'faster' main access road compared to the smaller internal tracks, is provided in Section 5.6.1.2 under vehicle strike impacts for bat species (Table 21).

Table 26 Road network within Proposal area

Habitat value for Terrestrial Fauna	Habitat type	Length of Road (km)
High	Rocky Breakaway	0
High	Sandplain	4.0
Moderate	Medium Drainage Line	0.6
Moderate	Minor Drainage Line	0.9
Moderate	Stony Plain	12.2
Moderate	Hillcrest/Hillslope	5.7
Moderate	Rounded Hills	7.1
Low	Claypan	0
NA	Disturbed	0.4
TOTAL		**31.0**

Northern Quoll

Northern Quolls are known to cross roads (Dunlop *et al.* 2014) and are opportunistic foragers known to scavenge roadkill (Radford 2012), which can lead to vehicle strike and mortality. No records of Northern Quoll vehicle strike exist within the roads of the Proposal area to date, with no road corridors proposed within high value Northern Quoll Rocky Breakaway habitat.

Pilbara Olive Python

Road kill associated with increased road traffic from tourism and industry, are a listed threat for the Pilbara Olive Python (Threatened Species Scientific Committee 2008b). The species is slow-moving, and many have died on roads due to a natural instinct to remain still in response to the vibrations of an approaching vehicle (Pearson 2003). Road mortality is more likely to occur during breeding season when males are in search of females (Eco Logical Australia 2015). Only 1.5km of road corridor is proposed within core Pilbara Olive Python habitat (Drainage lines), and no roads are proposed within in the core Rocky Breakaways habitat.

Brush-tailed Mulgara

Road corridors traverse 4km of core Brush-tailed Mulgara Sandplain habitat, the same habitat the Brush-tailed Mulgara was recorded from in previous surveys. It is possible therefore that vehicle strike may impact individual Mulgaras within the Proposal area, although the probability is low and the ability for the population to recover is high.

Western Pebble-mound Mouse

At the local scale, the species has multiple records within the Proposal area, and as a rodent has a high fecundity and "boom-bust" life-mode to recover from individual deaths (Start *et al*. 2000). Although a large majority of the road network traverses Western Pebble-mound Mouse core habitat (12.2km) and it is possible that vehicle strike may impact individuals, the ability for the population to recover is high.

Greater Bilby

Road (and rail) traffic is known to cause mortality of bilbies (Bradley 2015). A road corridor will be established within 4km of Sandplain habitat which increases the probability of vehicle strike to Greater Bilby within the Proposal area; however, the impact is considered medium due to a potential for a low

population of Greater Bilbies to possibly occur in the Proposal area, thus a small number of vehicle strikes may have an impact at the local scale.

Spectacled Hare-wallaby

The species is more active at night, when it forages on shrubs, grasses, and herbs (Burbidge, 1983), which reduces the likelihood of vehicle strike. There is the probability of vehicle strike to the Spectacled Hare-wallaby within the Proposal area as its preferred habitat, Stony Plains, has the greatest proportion of road corridor (12.2km). Vehicle traffic along the main access road, where the majority of the Stony Plain Habitat is located, will be lower during night hours when this species is most active. The likelihood of a population in the Proposal area is low, however if present, the impact could be moderate at the local scale as vehicle strikes can significantly impact small, local populations.

Northern Brush-tail Possum

Brush-tail Possums are known to cross roads (Giffney *et al.* 2009), and this can lead to vehicle strike and mortality. However, no records of the species exist within the Proposal area, although road infrastructure is going to increase within suitable habitat. With a potential reproductive rate of nearly two per year (Kerle, 1998), it is probable that populations of the Northern Brush-tail Possum can readily recover from individual deaths.

Long-tailed Dunnart

No records of the species exist within the Proposal area, and Long-tailed Dunnarts have a relatively high fecundity to recover from individual deaths (McKenzie *et al.* 2008).

Night Parrot

Published accounts of Night Parrot behaviour suggest that they may be prone to vehicle strikes, if it is breeding or foraging near roads or tracks in or near the Proposal area. Hamilton (2017) observed a bird crouching on a road, 1-1.5m from the road edge. The bird did not fly when approached but ran under a slow-moving vehicle. A second observation recorded a bird emerging from the base of a group of *Eremophila* shrubs, and the bird ran across the road (Hamilton 2017). The Night Parrots preferred habitat, Stony Plains, has the greatest proportion of road corridor (12.2km) within the disturbance footprint. Furthermore, vehicle traffic along the main access road, where the majority of the Stony Plain habitat type is located, will be lower at night hours when this species is most active.

The species is rare and has not been previously recorded in the Proposal area.

5.6.2.3 Wildlife toxicity

Pilbara Olive Python

Waterholes and sources are an important feature of Pilbara Olive Python core habitat, although the species is not reliant on, or restricted to, areas near permanent water - the habitat simply offers an abundance of suitably-sized prey (Pearson 2003). Pilbara Olive Pythons have been observed using artificial water sources, such as sewage treatment ponds and recreational lakes, as well as overburden heaps and railway embankment (Pearson 2003). As a result, the TSF may attract individuals and cause direct impacts, however the exposed nature of the TSF should also act as a deterrent.

As discussed in Section 5.6.1.3 and Section 2.3.5.7, Calidus has committed to a concentration of WAD cyanide discharge well below the 50mg/L WAD cyanide, which is currently the mining industry benchmark for the protection of wildlife (Donato *et al*. 2007).

5.6.2.4 Altered fire regime

Northern Quoll

The most detrimental local impact of fire on Northern Quolls is likely to be through consequential changes in habitat structure and floristics (Hill and Ward 2010); however certain habitats such as deeply incised Valleys, Gorge/ Gully habitats and Rock Outcrops provide refuge from fire. Fire also affects reproductive characteristics of Northern Quolls, or cause increased predation after removal of cover (Hill and Ward 2010).

Brush-tailed Mulgara

Fire can have a significant effect on Mulgara populations by loss of individuals and prey items (Masters *et al.* 2003), with extreme fire events potentially leading to a severe reduction or loss in localized populations. Mulgara are vulnerable to changes in vegetation cover through removal or fire, preferring a habitat mosaic that includes patchiness in cover and mature Spinifex hummocks, although they will continue to use burnt areas (Körtner *et al.* 2007). Mulgaras are also subjected to increased predation risk after removal of mature spinifex cover following fire (Koertner *et al.* 2007).

Western Pebble-mound Mouse

Western Pebble-Mound Mice persist in their core spinifex habitats, and mounds are still actively tended, after fires have removed surrounding vegetation (Start *et al.* 2000). Populations can retain density well in the initial post-fire period (Start *et al.* 2000).

Spectacled Hare-wallaby

All sites known to be occupied by the Spectacled Hare-wallaby have potentially suitable shelters (shrubs, grass tussocks or spinifex hummocks) within 50m of the feeding areas (Ingleby and Westoby, 1992). Although it may feed in areas regenerating after fire (Maxwell *et al.* 1996), frequent or recent fires in the Proposal area may result in a moderate local impact and decrease the suitability of the core habitats to provide shelter for the species.

Greater Bilby

It is known that smaller and more frequent fire increase habitat and resource diversity for bilbies (Bradley 2015). Recently burnt habitat (within the last 1-3 years) is included as a suitable habitat type for Greater Bilby (DBCA 2017), due to promotion of a key food source (Bradley 2015). However, there is a lack of knowledge concerning both increases in efficiency of predation on bilbies following fire (from decreased vegetation cover) and high vegetation cover becoming impenetrable to bilbies from a lack of fire (Bradley 2015). Despite targeted surveys, the species has not been recorded in the Proposal area.

Northern Brush-tail Possum

On a local level, inappropriate fire regimes are likely to impact any individuals present through consequential changes in habitat structure and floristics. In particular, the availability of the tree hollows and ground refuges (hollow logs, rockpiles and the burrows of other animals) utilized by the species (Kerle *et al.* 1992) will be detrimentally impacted by frequent fire. Fire may also cause increased predation after removal of cover (Carwardine *et al.* 2014). However, the high fecundity of the species means that they can readily recover from short periods of unfavourable conditions within their preferred habitat (Kerle, 1998).

Night Parrot

The Proposal area occurs within the species former distribution, thus further degradation to habitat within this area will have an ongoing effect on the species. The core habitat of the species is old age spinifex (>50 years) (DPaW 2017) and so changes to regimes that increase fire frequency will detrimentally affect core habitat and likelihood of species (Threatened Species Scientific Committee 2008c). Despite targeted surveys, the species has not been recorded in the Proposal area.

5.6.2.5 Introduced species

Overall, given that feral animals such as cats exist within the Proposal area and management and control will be implemented, it is unlikely that there will be a significant impact on native fauna as a result of the Proposal.

Proposed roads cover relatively small distances for the Pilbara and are unlikely to result in a significant increase in feral species, given also the presence of roads, tracks and other disturbance already in the local area as a result of historic mining and prospecting since the 1800's.

Plate 8. Feral cat recorded on motion cameral in the Proposal area (Source: Biologic 2019g; Appendix 3-2)

Northern Quoll

Feral predators are considered likely to occur in greater numbers near human settlements and roads/tracks (Eco Logical Australia 2015). The threat posed by cats to the Northern Quoll is thought to be severe, although the impacts of cats may be reduced in rugged refuge areas (Woinarski *et al.* 2014). Northern quoll are susceptible to cane toad toxins (Hill and Ward 2010), and if cane toads expand south through the Pilbara, any temporary creation of artificial water sources from discharge may attract these introduced species.

Pilbara Olive Python

Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat (Threatened Species Scientific Committee 2008b), as well as predation from these species on the Pilbara Olive Python's food sources (Ellis 2013). Feral predators are considered likely to occur in greater numbers human settlement and roads/tracks (Eco Logical Australia 2015).

Brush-tailed Mulgara

Brush-tailed Mulgara is preyed upon by feral predators (e.g. cats, foxes, dogs etc) (Woinarski *et al.* 2014 2015) , which are more likely to occur in greater numbers near human settlement and roads/tracks (Eco Logical Australia 2015). However, numbers are unlikely to significantly increase with suitable monitoring and management.

Introduced grazers such as cattle have been found to favour dune swales as "alleyways", a habitat type suitable to Mulgara, which is of lower habitat value in areas grazed by cattle (Frank *et al.* 2008).

Greater Bilby

Feral cat and fox predation are major driving factors in the decline of bilbies. Mining activities and development have the potential to facilitate increased predation through the development of linear corridors, and increased water availability and storage (Bradley 2015). With management and control measures implemented during the life of mine, it is not expected that numbers of feral animals will increase as a result of the Proposal.

5.6.2.6 Altered behaviour from increased light, noise or dust emissions

Northern Quoll

Northern Quoll are known to occur around mine sites and human dwellings, and shelter amongst mine infrastructure such as vehicles, machinery and laydown areas (Oakwood 2008) where there are enhanced levels of light and noise. There may be a higher concentrations of prey items e.g. insects around lights (Oakwood 2008). It unlikely that there will be a significant impact on quoll populations as a result of changes to amenity (light, noise, dust).

Western Pebble-mound Mouse

The species is quite adaptable and may acclimatise to certain disturbances such as noise and light as evident from active mounds been observed adjacent to exploration camps (e.g. Jinidi; M. O'Connell, pers. obs.). No significant impact is expected for the Western Pebble-mound mouse as a result of changes to amenity (light, noise, dust).

5.6.3 Short range endemics

5.6.3.1 Habitat loss

No habitats of 'high' suitability for SRE invertebrate fauna were identified in the Proposal area, with only a small portion of the Proposal area considered 'moderately/high' suitable for SRE, with the majority of the Proposal area considered to have 'low/moderate' suitability (Biologic 2018d) (Figure 30). Generally, it appears that all the habitat zones extend outside of the Proposal area with the habitats appearing to be of lower complexity than those to the southwest, such as the Corunna Downs area (Biologic 2018d).

Of most importance to SREs are the Rocky Crests and Slopes habitat type. This habitat zone comprises low to high slopes and crests with rocky, mountainous habitats such as extensive ridges, breakaways, gullies and cliff faces (Biologic 2018d). The larger, steeper faces and features of these rocky habitats generally provide more shelter and habitat complexity than surrounding areas. The Rocky Crests and Slopes of the Proposal area are part of a largely continuous system that continues to the east, west and north (Figure 31). Within the Proposal area, this habitat zone is regarded as moderately suitable for SRE fauna as there are no significant, protected landform features such as major gorges or gullies and the Proposal area is part of a system that extends well beyond its boundaries (Biologic 2018d).

All other habitat types within the Proposal area were either Low/Moderate or Low (Biologic 2019d).

5.6.3.2 Direct habitat removal

Low Suitability SRE habitat

The Low Suitability habitat includes Stony Plain and Sandplain habitats, which will have an indicative disturbance Footprint of 141.7ha and 11.1ha respectively. These habitats and the microhabitats contained within are common and widespread through the region. Due to the homogeneity and continuity of the habitats, it is less likely that species inhabiting this habitat type are restricted. There are however small and isolated microhabitat features present within these broader habitats (i.e. small boulder piles and outcrops, although these may be unlikely to be of sufficient size to promote endemism).

Low/Moderate Suitability SRE habitat

This comprises Minor Drainage Line, Rounded Hills and Hillcrest/Hillslope habitats within the Proposal area, which have a proposed disturbance footprint of 8.5ha, 89.2ha and 138.1ha respectively. While Minor Drainage Lines can be disturbed by the movement of water, it tends to be in lower volumes and at slower rates in comparison to Medium Drainage Lines. Therefore, there is likely to be less disturbance of the microhabitats present, which allows for the establishment of stable microhabitats over a longer period of time.

Moderate Suitability SRE habitat

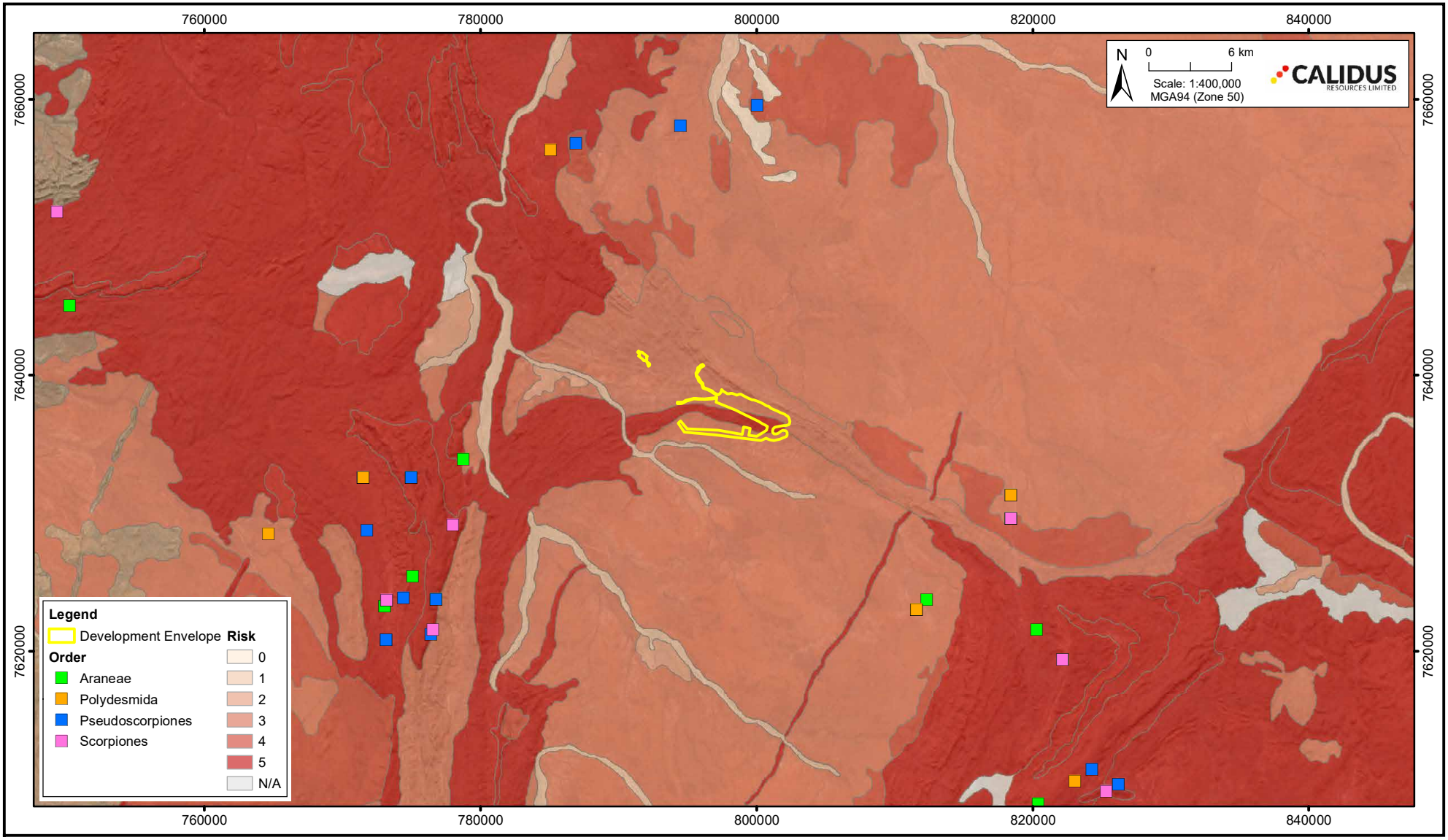
This comprises Claypan and Medium Drainage Line habitats, of which there will be no disturbance to any claypan habitat, and only 5.8ha disturbance is proposed for the Median Drainage habitat. Medium Drainage Lines can be disturbed more regularly (seasonally) in comparison to Minor Drainage Lines when water flows, making them important dispersal pathways. Medium Drainage Lines also incorporates rocky microhabitats when it intersects other habitats such as ranges. The Claypan is a restricted habitat type and therefore may contain potentially endemic species; however, there are very few stable microhabitats suitable for SRE groups within this habitat. There is no impact proposed to Claypan habitat types.

Medium/High Suitability

This comprises Rocky Breakaways within the Proposal area associated with the higher slopes and crests of the hills and ranges. Such habitats often contain deep cracks and crevices which provide suitable habitat for many SRE groups. Furthermore, this habitat type is isolated within the landscape and therefore some species within this habitat type may have limited capacity to disperse to other suitable habitats.

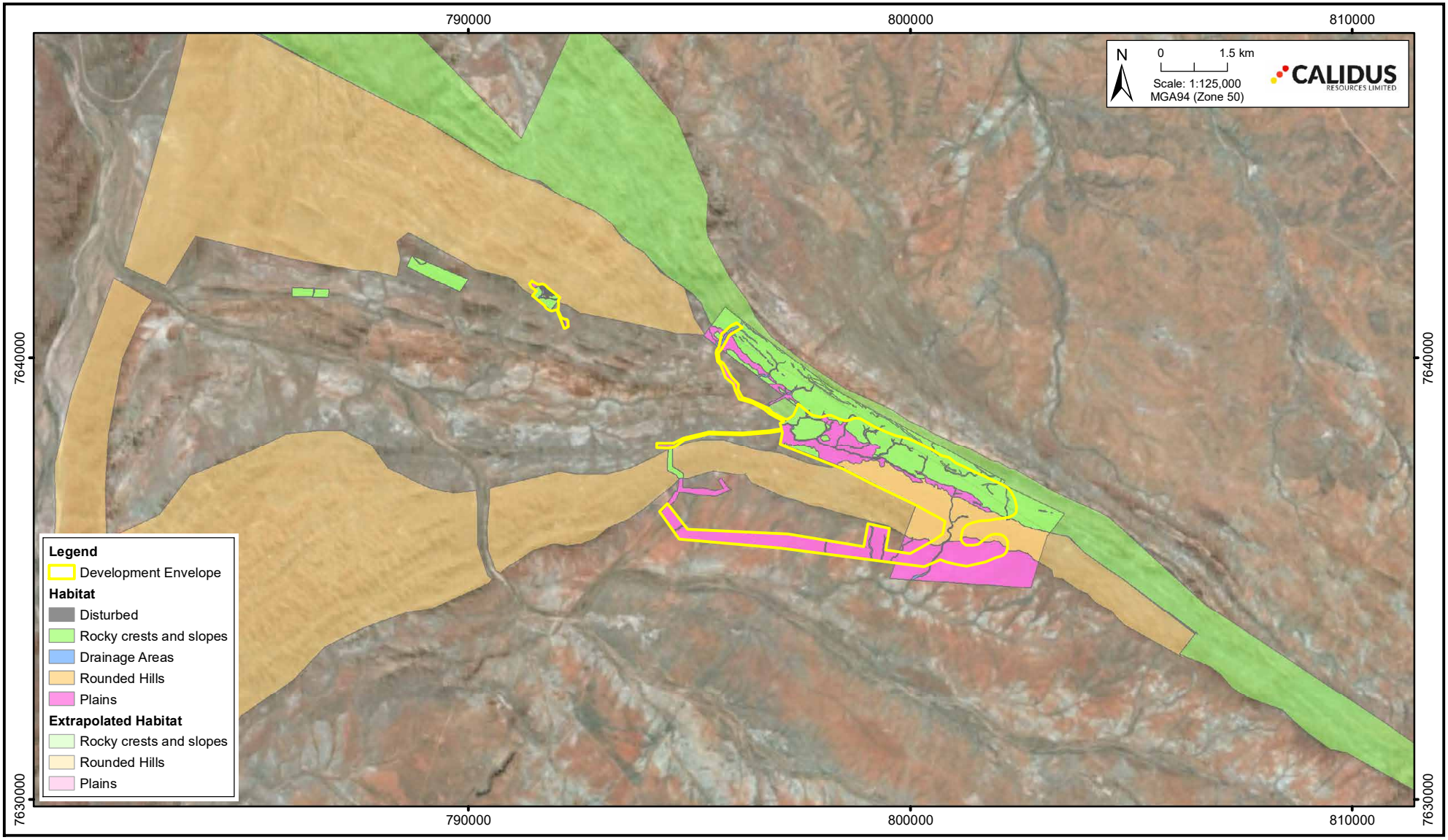
Impact to this medium/high suitable SRE habitat is minimal as the proposed disturbance footprint within the Rocky Breakaways is 0.8ha.

Figure 30: Habitat suitability for SRE species near the Proposal area (Source: Biologic 2018d; Appendix 2-1)



Source: Biologic - Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_30, Rev: A

Figure 31: Extrapolated SRE Invertebrate fauna habitat zones (Source: Biologic 2018d; Appendix 2-1)



Source: DMIRS - Tenements, Biologic - Habitats, Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_31, Rev: A

5.6.4 Cumulative and regional impacts

Northern Quoll

The preferred habitat for this species extends well outside the Proposal area and the species is widespread in a regional context. In the Pilbara, the distribution of Northern Quolls is already fragmented (Hill and Ward 2010) and there is good dispersal habitat present (drainage lines and the Warrawoona Ranges). Minor or no impacts at a regional scale are expected.

Pilbara Olive Python

The species is known to be widespread in the surrounding region, and the preferred habitat for this species extends well outside the Proposal area. Although males occupy a distinct home range, travelling up to 4km during breeding season to locate females (Pearson 2003), minor to no impacts at a regional scale are expected.

Brush-tailed Mulgara

Mulgara have a low propensity for dispersal once a home range has been established, with high site fidelity recorded (Masters 2003; Thompson and Thompson 2007). The preferred habitat for this species extends well outside the Proposal area, and the species is widespread in a regional context. Hence low impacts at a regional scale are expected.

Western Pebble-mound Mouse

The distribution of the species is strikingly fragmented by unsuitable plains (e.g. sand dunes) and it is unlikely that the species can disperse across substantial barriers within the region (Ford and Johnson 2007). However, the species and its core habitat are widespread in the local region and throughout the Pilbara, and despite the smaller body size (which limits long-distance dispersal) (Whitmee and Orme 2013), only minor or no impacts at a regional scale are expected.

Greater Bilby

Greater Bilbies are recorded as having low site fidelity and high mobility (Southgate *et al.* 2007); males regularly move three to five kilometres between burrows on consecutive days; and have been recorded moving up to 15km in a few weeks (Southgate and Possingham, 1995). This high mobility, together with low population density, ensures that the area of occupancy is often far less than the extent of occurrence, and the distribution is highly fragmented within the Pilbara bio-region (Friend *et al.* 2012). However, it is not a commonly recorded species during surveys and on a regional scale, the loss of individuals and core Sandplain habitat may have a potential impact. Note, there is no confirmation of Greater Bilbies within the Proposal area.

Spectacled Hare-wallaby

Little is known of the regional distribution of this species. Impacts are not expected at a regional scale.

Northern Brush-tail Possum

Little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA 2019a). The preferred habitat for this species therefore extends well outside the Proposal area. Although the species is widespread in a regional context, it is infrequently recorded in the Pilbara region, with less than 20 records existing on NatureMap (DBCA 2019a). The nearest record is 26km SW of the Proposal area from 2014 (DBCA 2019a). Based on the flexibility of their habitat preferences (Kerle *et al.* 1992), and lack of records, minor or no impacts at a regional scale are expected.

Long-tailed Dunnart

In consideration of the species smaller body size (which limits long-distance dispersal), the highly patchy nature of records and the distance between populations, the dispersal ability of this species is potentially very poor (WAM 2019). However, the core habitat extends beyond the Proposal area boundary and is considered widespread in the region and throughout the Pilbara. Hence only minor impacts at a regional scale are expected.

Peregrine Falcon

Suitable habitat for the Peregrine Falcon is widespread and common regionally outside the Proposal area. The proposed development is unlikely to have an impact on this species at a regional scale due to its general habitat preference, high mobility and large distribution.

Night Parrot

The proposed development is unlikely to have a significant impact on the species at a regional level due to the low likelihood of occurrence. Note, there is no confirmation of the Night Parrot within the Proposal area, despite targeted surveys.

5.6.5 Impact assessment summary

The significance of each potential impact on relevant conservation significant fauna, as discussed in detail in Sections 5.6.1, 5.6.2 and 5.6.3, has been assessed against four categories: 'Extent'; 'Duration'; 'Magnitude' and 'Certainty' (Biologic 2019f and 2019g; Appendix 3-1 and Appendix 3-2).

To broadly summarise the impact on terrestrial fauna, a matrix has been developed based on the 'Magnitude' category. Each magnitude value is defined in Table 27. A summary of the magnitude of each potential impact is presented on a local and regional scale in Tables 28 and 29. Note, this assessment approach has not considered the likelihood of impacts and is based on an inherent risk, with limited controls applied, and as such is considered a very precautionary approach to summarising the potential impacts of the Proposal.

Table 27 Impact criteria used for each impact source assessed in the Proposal area

Criteria	Assessment value	Definition
Magnitude	Negligible	Displacement or loss of condition in individual animals
	Low	Loss of individuals but no measurable change in locality population size
	Moderate	Demonstrable change in population
	High	Population persistence threatened

Migratory birds were considered unlikely to be affected by the Proposal (and unlikely to be found in the area), however as a precautionary approach, an impact assessment was undertaken for migratory birds (Biologic 2019g, Appendix 3-2). The assessment found that the potential impact of toxicity due to water associated with the TSF or metalliferous drainage rated as Low, due in part to the rare likelihood that migratory birds would occur at the Proposal area, and due to the mitigation measures to be implemented by Calidus to reduce the risk of poor water quality (Significant Species Management Plan, CRL-ENV-PLN-006-19; TSF and Cyanide Monitoring Procedure, CLR-ENV-PRO-019-19; and the Metalliferous Drainage Management Procedure, CRL-ENV-PLN-005-19).

All impact assessment results, including migratory birds, are presented in Biologic (2019g, Appendix 3-2 (Table 5.1)). A summary of key conservation significant species is presented in Tables 28 and 29.

Table 28 Risk assessment summary of the magnitude of potential impacts on terrestrial fauna at a local scale, based on Biologic (2019f and 2019g) (Appendix 3-1 and Appendix 3-2). (Mod = Moderate)

Impact	Species confirmed with the Proposal area						Species considered likely or possible to occur in Proposal area					
	Ghost Bat	PLNB	Northern Quoll	POP	Brush-tailed Mulgara	Western Pebble-mound Mouse	Greater Bilby	Spectacled Hare-wallaby	Northern Brushtail Possum	Long-tailed Dunnart	Peregrine Falcon	Night Parrot
Changed Fire Regimes	Low	Low	Low	Low	Mod	Low.	Low	Mod	Low.	Low		Low
Increased vibration/noise	Mod	Mod	Low			Low			Low	Low		
Light spill and dust	Low	Low										
Change water regimes	Mod	Mod										
Introduced Species	Low	Low	Mod	Mod	Mod	Low	Mod	Low	Low	Low		Low
Pollution and toxicity	Low	Low		Mod					Low			
Removal of habitat	Mod	Mod	Mod	Mod	Low	Mod	Low	Low	Low	Low.	Low	Low
Vehicle Strike	Low	Low	Mod	Low	Low	Low	Mod	Mod	Low	Low		Low

Table 29 Risk assessment summary of the magnitude of potential impacts on terrestrial fauna at a regional scale, based on Biologic (2019f and 2019g) (Appendix 3-1 and Appendix 3-2). (Neg = Negligible)

Impact	Species confirmed with the Proposal area						Species considered likely or possible to occur in Proposal area					
	Ghost Bat	PLNB	Northern Quoll	Pilbara Olive Python	Brush-tailed Mulgara	Western Pebble-mound Mouse	Greater Bilby	Spectacled Hare wallaby	Northern Brushtail Possum	Longtailed Dunnart	Peregrine Falcon	Night Parrot
Changed Fire Regimes	Low	Low	Low	Low	Low	Low.	Low.	Low	Low.	Low		Low
Increased vibration/noise	Low	Low	Neg			Neg			Low	Neg		
Light spill and dust	Neg	Neg										
Change in water regimes	Low	Low										
Introduced Species	Neg	Low	Low	Low	Low	Low	Low	Low	Low	Low		Low
Pollution and toxicity	Low	Low		Low					Low			
Removal of habitat	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low.	Neg	Low
Vehicle Strike	Low	Low	Low	Low	Low	Neg	Low	Low	Low	neg		Low

5.7 Mitigation and management

5.7.1 Management approach

Mitigation and management of impacts to terrestrial fauna by the Proposal will be achieved in accordance with the mitigation hierarchy recommended by the EPA (EPA 2016e) (avoid, minimise, rehabilitate).

Calidus has commenced development of a series of procedures to help manage and mitigate potential impacts to terrestrial fauna by the Proposal. Procedures most relevant to managing impacts to terrestrial fauna are summarised in Table 30. The management actions described in the documents listed in Table 30 have been adapted from DoE (2016) and the Threatened Species Scientific Committee (2016a and 2016b). Key management actions are summarised below, within the framework of the EPA mitigation hierarchy (avoid, minimise and rehabilitate).

Table 30 Key environmental management documentation relevant to terrestrial fauna

Environmental Management Document	Reference	Appendix
Environmental Management		
Environmental management standard	CRL-ENV-STA-001-19	
Fauna management		
Significant Species Management Plan	CRL-ENV-PLN-006-19	Appendix 9-1
Fauna management procedure	CRL-ENV-PRO-007-19	
Introduced fauna control procedure	CRL-ENV-PRO-009-19	
Ground disturbance permit procedure	CRL-ENV-PRO-002-19	
Blast Management Procedures	CRL-ENV-PRO-017-19	Appendix 9-2
Water Management		
Surface Water Monitoring Procedure	CRL-ENV-PRO-020-19	Appendix 9-3
Groundwater Monitoring Procedure	CRL-ENV-PRO-021-19	Appendix 9-4
TSF and Cyanide Monitoring Procedure	CRL-ENV-PRO-019-19	Appendix 9-5
Metalliferous Drainage Management Procedure	CRL-ENV-PRO-022-19	Appendix 9-6
WRD and TSF Closure Procedure	CRL-ENV-PRO-023-19	Appendix 9-7

5.7.2 Avoid

5.7.2.1 Avoid core habitat

Potential impacts to bats will be avoided by not removing any known core bat roosting habitat.

Significant roosting and breeding bat habitat will be further protected through the establishment of a mining exclusion zone inside the development envelope, including the opportunity for a dam/fresh water resource to distract from other potentially lower quality water sources within the Proposal area. No mining activities will occur within this exclusion zone. The location and size of the mining exclusion zone has been selected to offer a significant protection to the conservation values of conservation significant fauna through the protection of the Klondyke Queen roost. The exclusion zone is discussed in detail in Section 5.7.5.

Establish a 200m buffer between mining activities (in particular blasting) and core breeding and roosting habitat at the Klondyke Queen roost. No blasting will occur past the 200m buffer/setback.

5.7.2.2 Avoid harm to individuals through fauna protection measures

- Potential impacts to the Ghost Bat and Pilbara Leaf-nosed Bat colonies at the Klondyke Queen and Bow Bells roosts are recognised and communicated to mine planners (i.e. blasting and dewatering).
- Include fauna protection specifications in all construction related contracts and sub-contracts, including no barbed wire fencing at the Proposal area
- Induct workforce on fauna identification and encounter (including physical interaction, littering, feeding, approaching and unexpected encounters) and educate the mine site personnel about the fauna of conservation significance within the Proposal area.
- During construction, any trenches that remain open overnight must follow trench management procedures, including a provision for ramps to assist trapped fauna and to relocate trapped fauna unable to escape (using trained fauna handlers).

5.7.3 Minimise

5.7.3.1 Adaptive monitoring and management measures

- Implement the Significant Species Management Plan (CRL-ENV-PLN-006-19; Appendix 9-1), which contains specific management and monitoring targets for fauna of conservation significance, to be reviewed on a regular basis. The plan will incorporate:
    - Significant bats: Monitoring significant roosts, bat activity at impact and non-impact (control) sites. Monitoring is required to better understand if the exclusion zone (and its dam) is effective at protecting conservation significant species, if night infrastructure (i.e. plant site) is influencing behaviour due to potential light spill impacts, the bat activity levels at Copenhagen throughout different seasons, roost/colony activity during key project development (e.g. blasting for the first time, blasting at significantly closer locations, first outflow of TSF or when pooling starts etc).
    - Other conservation significant species (Northern Quoll, Pilbara Olive Python, Bilby): including pre clearance surveys for key species using approved DBCA methodology, targeted surveys of suitable habitat adjacent the mine areas and monitor population changes over time;
    - Refer to the Significant Species Management Plan (CRL-ENV-PLN-006-19) for further details on monitoring.
- Monitor and assess the predicted move of the Pilbara Leaf-nosed Bat from Klondyke Queen to Bow Bells South following initial disturbance.
- Monitor groundwater levels and quality along the predicted drawdown gradient between the Klondyke pit and Bow Bells. Following 12 months of pumping and monitoring, recalibrate the groundwater model using data collected from dewatering and water supply bores. Dewatering rates will be adaptive based on the recalibrated model.
- Implement the Blast Management Procedure, which will include ongoing geotechnical assessment of Klondyke Queen following blasting activities and adaptive management measures/contingencies depending on assessment outcomes.
- Implement the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5).

5.7.3.2 Measures to reduce impacts from habitat removal, fragmentation and modification

- Incorporate environmental and social values and constraints into mine planning and infrastructure establishment. Where there is flexibility with placement of mine infrastructure, avoid disturbance in areas identified as being of high conservation significance (i.e. high value habitat, heritage places, locally significant vegetation types etc.).
- Implement Ground Disturbance Permitting Procedure (CRL-ENV-PRO-002-19) to ensure disturbance remains within authorised boundaries.
- Prevent unauthorised access to habitats of conservation significance, including the mining exclusion zone.
- Develop and implement rehabilitation and mine closure principles and procedures that include aims to rehabilitate self-sustaining fauna habitat.
- Maintain natural drainage flows where practicable and prevent ponding of water.
- Consider timing of clearing activities to reduce the impact on events such as weaning for Northern Quolls (July - September; Hernandez-Santin *et al*. 2019).

5.7.3.3 Measures to reduce impacts from toxicity and poor water quality

- A cyanide reduction/destruction process (detoxification) will be established during secondary processing to reduce the concentration of WAD cyanide discharge to less than 30mg/L (40% lower than current industry standards for wildlife protection (DoIIS 2016)), which, following volatilization of cyanide post discharge, is likely to be even lower.
- Implement Significant Species Management Plan (SSMP), which will allow for adaptive management of WAD cyanide discharge concentrations within the approved maxima as the project progresses and data becomes available.
- Implement the actions prescribed in the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5)
- Minimise and manage impacts to natural surface hydrology to ensure the drainage line habitat types are maintained and protected.
- Minimise the potential for fauna to be attracted to artificial water sources, particularly where cyanide may be present, through the provision of alternative water sources (i.e. mining exclusion zone freshwater dam).
- Management measures that will be in place to protect fauna from interactions with the TSF include:
    - Minimising the area of supernatant water in the TSF (decant);
    - Monitoring usage of the TSF decant by fauna;
    - Development of procedures for the rescue of fauna;
    - Beach management via spigots placement to avoid ponding of supernatant water in areas other than the decant
    - Fauna monitoring at the TSF will occur twice a day to observe and record fauna usage. One patrol will be conducted after dawn and the other in late afternoon. The monitoring results will be utilised to determine the requirement for modification to the mechanisms being implemented to keep fauna away from the TSF.
- Key cyanide and TSF control strategies include:
    - Automated cyanide detection in the plant will frequently test for WAD cyanide concentration in the hopper(s)

- Containment of all tailing's waters within the TSFs, processing plant and processing plant dams
- Provision of emergency containment channels alongside tailings storage pipelines to and from the TSF
- Maintenance of process pipe work, equipment and leak detection equipment
- Use of cyanide destruction/reduction method tailings slurry to permissible levels before the processing plant slurry discharge is pumped to the TSF
- Routine monitoring and reporting of cyanide levels from tailings facility flows, groundwater and employee work areas
- Routine patrols of tailings and process areas to ensure the potential for spillage, dust or native fauna and flora impacts are minimised.
- The processing plant will be designed such that process water containing cyanide is recycled and kept within the area encompassed by the processing plant run-off collection drain and storage.
- In the event of spillages, all solutions will be contained within the process plant bunding, and the appropriate spill response procedure will be initiated. Portable pumps will be provided within the processing area for the pumping of spills within the bunded areas back to the storage tanks or emergency holding tanks (TSF and Cyanide Monitoring Procedure CRL-ENV-PRO-019-10; Appendix 9-5).
- The tailings delivery and return water lines will be contained within bunded pipeline corridors.
- Daily inspections of the tailings delivery and water return pipelines will be undertaken for physical integrity and to identify any minor leaks.
- Automatic, pressure activated shut-down mechanisms will be provided on the tailings discharge pipeline to enable the early detection and stoppage of significant leaks or failures.
- The tailings pipeline will be fitted with a low flow alarm linked to the central control room with automatic shutdown capability. Further information on cyanide management at the proposal area, refer to the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5).

5.7.3.4 Measures to reduce impacts from blasting

- Implement Blasting Management Procedure (CRL-ENV-PRO-017-19; Appendix 9-2)
- Drill and blasting will occur on 5m bench heights using 102mm diameter holes (when between 200m and 350m from Klondyke Queen roost). At distances greater than 350m from the Klondyke Queen roost, 127mm or 165mm diameter blast holes will be used.
- All blasts within 1,000m of Klondyke Queen roost will be monitored with a permanent blast monitors located within 10m of roost, as well as between the roost and the open pit. The monitoring will record both air overpressure and ground vibration for all nearby blasts. The resultant data plus blast parameters should be used to develop site prediction equations;
- Conservative blast targets include:
  - Airblast Overpressure (< 125dBL within 20m of any Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat entry points);
  - Blast Vibration (< 10 mms-1 within 20m of any Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat entry points);
  - Fly Rock (no flyrock within 50m of the Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat entry points);

  - Dust and Fume (no fume (NOx) orange gas or dust to drift within 200m of the Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat entry points)
- Initial site blasting should commence a minimum of 1000m from the Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat, until the site prediction equations are established with a high level of confidence;
- Select suitable explosives that have a low probability of producing toxic post blast fume events;
- Establish controls for blasting when wind conditions will drive post blast dust and potential fume towards the Pilbara Leaf-nosed Bat and Ghost Bat roosting habitat entry point(s);

5.7.3.5 Measures to reduce impacts from light and general operational noise/vibration

- During both construction and operation stages, design artificial lighting to illuminate work areas and limit illumination of the surrounding landscape, such as water sources and substantial rocky outcrops. Directing lights inwards towards work activities will minimise lighting effects on fauna in adjacent areas.
- Implement best available technology to minimise noise emissions from mining operations.
- Reduce traffic and equipment usage at night to minimise noise disruption
- Mine and infrastructure planning has considered the location and position of the plant and accommodation village, to minimise artificial lighting of the bat roost entrances.

5.7.3.6 Measures to reduce impacts from vehicle strike

- Investigate strategies to reduce impacts on fauna from all construction and mine traffic, especially for nocturnal species or those prone to vehicle collisions, including speed limits, signage, fences or barriers.
- Prevent unauthorised off-track driving.
- Report and record any incident that results in the injury or death of a fauna species from vehicle strike.

5.7.3.7 Measures to reduce impacts from introduced species

- Conduct opportunistic monitoring and control of feral animals and implement measures to reduce the abundance of feral species in the Proposal area
- Employ housekeeping measures such as covering up landfill and bin management.
- Implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads and other introduced species (including weeds).

5.7.3.8 Measures to reduce impacts from dust

- Implement Blast Management Procedure (CRL-ENV-PRO-017-19; Appendix 9-2), which will consider factors such as timing, mine progression (i.e. east to west mining) and weather conditions to ensure that dust emissions are minimised.
- Prepare and implement dust management procedures to reduce the effects of dust on nearby vegetation and fauna habitats, including management of vehicle speed on unsealed roads, dust suppression measures (spray trucks) and proximity of habitats to blasting and excavation.
- Implement standard dust suppression measures across the proposal area during construction and operation
- Blast management, blasting and associated dust impacts will be limited to daytime operations when bats are not active

5.7.3.9 Measures to reduce impacts from changed fire regimes

- Prepare and implement best practice fire control strategies to manage unplanned fires, including educating and training staff on equipment and procedures.
- Control and manage weeds as they contribute to an increased fuel load and fire risk.

5.7.4 Rehabilitate

Rectification of disturbance to habitat areas can be achieved through progressive rehabilitation.

5.7.5 Mining exclusion zone

The most ideal bat habitat includes an "apartment block" of accommodation types and roosting opportunities, which contain the following elements (R. Bullen, Bat Call WA, pers. comm. May 2019):

- at least one deep cave with characteristics of a maternity roost,
- multiple caves, shelters and overhangs in close proximity, offering nocturnal feeding and refuge opportunities,
- a local productive set of gullies and gorges,
- a productive foraging area within a 5-10km radius
- good quality riparian line or ephemeral fresh water lake and
- appropriate protection from human interference.

Calidus has proposed a mining exclusion zone within a 32ha area of the development envelope, to protect one such "apartment block", stretching 1.1km along the Warrawoona Ranges (Figure 32). This Mining Exclusion Zone will provide protection from mining for seven known roosting sites, including two maternity roosts and two diurnal roosts for the Ghost Bat (including the Klondyke Queen roost), and one diurnal roost and breeding roost for the Pilbara Leaf-nosed Bat (Table 31).

The exclusion zone is also deemed adequate (R. Bullen, Bat Call WA, pers. comm. May 2019), as the topography between the Klondyke Queen roost and the Klondyke pit crest are located on a separate hill on the opposite side of a gully, which acts as a natural shield and prevents noise and vibration impacts (from haulage, drilling and blasting activities) from reaching the roost, which is located at the western end of the Klondyke Queen workings. The distances to the north, south and west from the estimated roost location within the Klondyke Queen roost to the exclusion zone edge is greater than 200m, exceeding the recommended minimum distance of 185m for blasting (Blast It Global 2019) (Appendix 3-3 and Appendix 3-4).

The mining exclusion zone also contains a number of good quality natural refuges including caves, shelters and overhangs near the Klondyke Queen roost. These sites are important if bats are flushed in daylight as they almost immediately find an alternate refuge to rest before returning to the diurnal roost cave (R. Bullen, Bat Call WA, pers. comm. May 2019). These refuge sites are considered important if the Ghost Bat colony is to be protected and maintained at Klondyke Queen in the long term.

In addition to providing core roosting habitat for bats, the mining exclusion zone also includes Moderate value habitat for a number of other conservation significant fauna species, including the Northern Quoll, Pilbara Olive Python, Western Pebble-mound Mouse, Spectacled Hare-Wallaby and the Night Parrot (Table 32).

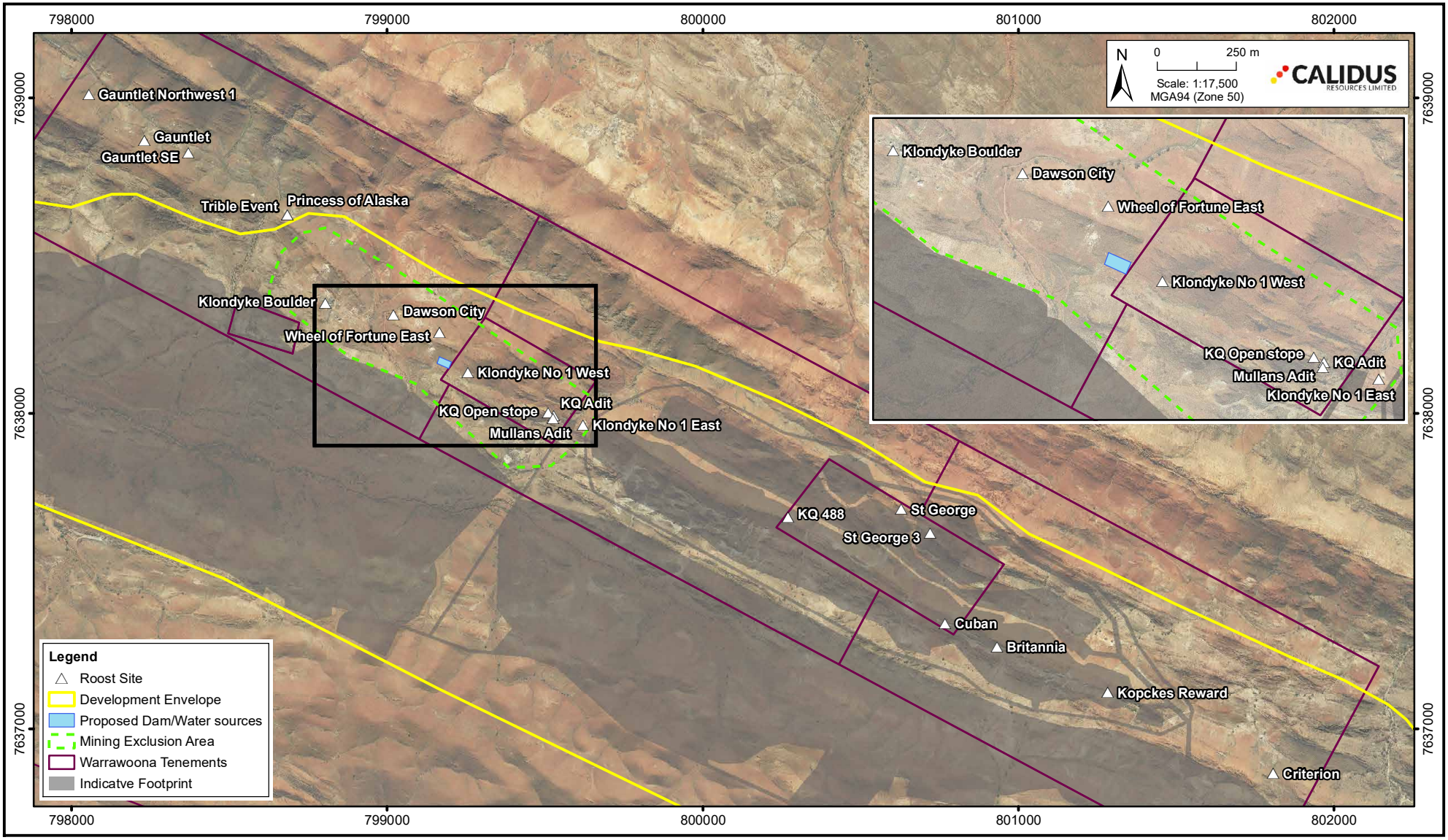
Table 31 Bat roost sites within the Mining Exclusion Zone and their significance

Roost site recorded within the mining exclusion zone	Roost Significance: Pilbara Leaf-nosed Bat	Roost Significance: Ghost Bat
Klondyke Queen adit	Permanent diurnal roost	Permanent maternity roost
Klondyke No 1 West	Nocturnal refuge	Night roost
Klondyke No1 East	Nocturnal refuge	Night roost
Dawson City	Nocturnal refuge	Occasional diurnal roost
Wheel of Fortune East	Nocturnal refuge	Night roost
Mullans adit	Nocturnal refuge	Possible diurnal roost

Table 32 Habitat types within the Mining Exclusion Zone and their significance

Habitat Type	Conservation Significant species use	Area (ha)
Hillcrest/Hillslope	• Northern Quoll - Provides dispersal and foraging habitat • Western Pebble-Mound Mouse – provides core habitat	29.0
Stony Plain	• Western Pebble-Mound Mouse – core foraging habitat and shelter • Spectacled Hare-Wallaby – core foraging habitat and shelter • Night Parrot – potential habitat	0.7
Minor Drainage Line	• Northern Quoll - dispersal and foraging habitat • Pilbara Olive Python - dispersal and foraging habitat	2.2
TOTAL		**31.9**

Figure 32: Ghost Bat and Pilbara Leaf-nosed Bat roost immediately adjacent the Klondyke mine pit, including within the mining exclusion zone



Source: DMIRS - Tenements, Biologic - Habitats
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_32, Rev: A

5.8 Predicted outcome

Conservation significant bats

The Proposal will not remove any diurnal roosts. Proposed disturbance to bat habitat is limited to five old mine workings, considered temporary and low value refuge sites (R. Bullen, Bat Call WA, pers. comm. 2019; Biologic 2019f), as well as foraging habitat types typical of the drainage lines and plains that are well represented throughout the broader Pilbara IBRA region.

Neither the temporary refuge sites or the foraging habitat types within disturbance footprint are considered critical to the survival of the local Pilbara Leaf-nose Bat and/or Ghost Bat colonies (Biologic 2019f).

Mine pit dewatering at the proposed Klondyke mine will cause groundwater levels in the vicinity to decrease, which may influence the humidity levels at nearby bat roost sites. Dewatering is not expected to significantly impact the local colony of Ghost Bats at the Klondyke Queen roost as they are known to tolerate a wide range of roosting conditions (R. Bullen, Bat Call WA, pers. comm. 2019). However, the Pilbara Leaf-nosed Bats are considered more sensitive to changes in roosting conditions, and if humidity levels at Klondyke Queen reduce, the local population may vacate the Klondyke Queen roost in favour of the other alternative local diurnal roost sites concurrently used by the colony, including Bow Bells South, the main maternity roost in the local area for this species (R. Bullen, Bat Call WA, pers. comm. 2019; Biologic 2019f). Bow Bells South roost is approximately 4km from the Klondyke mine and is expected to maintain a significant saturated thickness (Groundwater Resource Management 2019b).

Poor water quality at the TSF and the eventual mine pit lake at Klondyke was also considered a key potential impact. By committing to a concentration of WAD cyanide discharge of less than 30mg/L, which is 40% lower than the 50mg/L level currently recognised as safe for wildlife (Donato 1999; DoIIS 2016), Calidus will avoid any toxicity related impacts at the TSF. The pit lake that will form following mining at proposed Klondyke mine is expected to reach salinity levels that exceed that tolerated by bats within 3 to 4 years of mine closure. In the 3-4 years post closure, but prior to salinity levels reaching intolerable levels for bats, the arsenic levels (naturally occurring in the local groundwater) in the mine pit lake will be at a concentration that would require bats to consume large volumes of pit lake water each day (i.e. body weight equivalent of pit lake water each day) for acute poisoning to occur, which is considered highly unlikely by R. Bullen (Bat Call WA, pers. comm. 7 October 2019).

The Proposal will establish a mining exclusion zone, which is a Calidus initiative that will ensure the long-term protection of important diurnal roost sites for Ghost Bat and Pilbara Leaf-nosed Bat colonies in proximity to the proposed Klondyke pit, including the Klondyke Queen roost complex.

Other conservation significant species, including SREs

Two habitat types of the Proposal area are considered high value habitat types for other conservation significant fauna known from (or potentially from) the Proposal area, and disturbance to these habitat types has been avoided where possible. It is proposed to clear less that 12ha of these high value habitat types, which represents just 3% of the total disturbance footprint. The two high value habitat types of the Proposal area include:

- The Rocky Breakaway habitat type, which provides high density denning and foraging habitat for the Northern Quoll, and foraging habitat for the Pilbara Olive Python, Ghost Bat, Pilbara Leaf-nosed Bats and SREs. The Proposal will disturb 0.8ha of this habitat type, which represents just 4.6% of the rocky breakaway habitat type recorded across the Proposal area, and only 0.2% of the total disturbance footprint. This habitat type is well represented outside the Proposal area, across the Warrawoona Ranges and throughout other rangelands of the Pilbara IBRA region.

- The Sandplain habitat type in the southern portion of the Proposal area supports Brush-tailed Mulgara, and potentially the Night Parrot and Greater Bilby (the latter two species are not confirmed within the Proposal area, despite multiple targeted surveys by Biologic (2019f)). The Proposal will disturb 11.1ha of this high value habitat type, which represents 8.1% of the recorded sandplain habitat type in the Proposal area, and only 2.8% of the total disturbance footprint. This habitat type is also well represented outside the Proposal area, across the plains north and south of the Warrawoona Range and throughout the plains of the Pilbara IBRA region.

General outcomes

Overall, there will be no loss of any Threatened Ecological Community or Priority Ecological Community and no loss of important populations of conservation significant fauna.

The Proposal will not conflict with the intent of the Biodiversity Conservation Act 2016, as no terrestrial vertebrate or invertebrate fauna species will experience a change in conservation status as a result of the Proposal.

Regional biodiversity is also unlikely to be affected by the implementation of the Proposal.

Management

The Proposal will protect high value habitat for many conservation significant species through the establishment of a mining exclusion zone within the development envelope. This exclusion zone will provide protection from mining for important bat roosting sites, including maternity and diurnal roosts for the Ghost Bat and the Pilbara Leaf-nosed Bat, as well as core denning and foraging habitat for other species of conservation significance such as the Northern Quoll and the Pilbara Olive Python.

Other key mitigation strategies include blast procedures with drill hole diameter and 200m setback/buffer restrictions, and cyanide reduction (detoxification) processes that will reduce the concentration of WAD cyanide discharge to well below industry standards for wildlife protection (DoIIS 2016).

Potential direct and indirect impacts to conservation significant bats and other terrestrial fauna of the Proposal area are expected to be managed through the implementation of the Significant Species Management Plan (CRL-ENV-PLN-006-19); the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19); the Blast Management Procedure (CRL-ENV-PRO-017-19) and the Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19).

By avoiding core habitat for many of the conservation significant species, implementing adaptive management that responds to ongoing monitoring and adopting the measures detailed in the management and monitoring procedures developed by Calidus, the residual impact is not considered significant, and the Proposal will effectively meet the EPAs objective “to protect terrestrial fauna so that biological diversity and ecological integrity are maintained”.

6 OTHER ENVIRONMENTAL FACTORS OR MATTERS

Other environmental factors that have the potential to be affected by the Proposal include:

- Inland waters
- Terrestrial environmental quality
- Vegetation and flora
- Social surroundings (Aboriginal heritage and culture)
- Subterranean fauna
- Air quality (dust)

Due to the low level of impact, application of industry standard controls and other regulatory mechanisms, it is not expected that these factors will require assessment in detail by the EPA. The following section provides a summary of the potential impacts, proposed mitigation and predicted outcomes for these 'other' factors.

6.1 Inland waters

Element	Description - Inland Waters
EPA Objective	To maintain the quality of groundwater and surface water so that environmental values are protected.
Policy and Guidance	• Statement of Environmental Principles, Factors and Objectives (EPA 2018b). • Environmental Factor Guideline: Inland Waters (EPA 2016f). • Western Australia water in mining guideline (Water licensing delivery report series: Report No. 12) (DoW 2013a). • Preventing acid and metalliferous drainage – Leading practice sustainable development program for the mining industry (DoIIS 2016). • Western Australian water in mining guideline, Report No 12 (DoW 2013a). • WQPN 15: Extractive industries near sensitive water resources (DoW 2013b). • WQPN 51: Industrial wastewater management and disposal (DoW 2009). • WQPN 52: Stormwater management at industrial sites (DoW 2010). • WQPN 83: Infrastructure corridors near sensitive water resources (DoW 2007).
Supporting Studies	• Hydrogeological Investigations Report. Groundwater Resource Management (2019b); Appendix 4-2 • Hydro-Meteorological and Surface Water Management Study. Groundwater Resource Management (2019a); Appendix 4-1 • Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management. GCA 2019a; Appendix5-1 • Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management. GCA 2019b; Appendix 5-2 • Tailings storage facility design report. ATC Williams 2019; Appendix-5-3 • Metalliferous Drainage Management Procedure. CRL-ENV-PRO-022-19 (Trajectory 2019); Appendix 9-6
Existing Environment	Existing environment information is based on results and findings from supporting studies commissioned by Calidus, as summarised above.

Element	Description - Inland Waters
	Conceptual hydrogeological model Following hydraulic testing at the proposal area, a conceptual hydrogeological model was developed for the Klondyke deposit area, based on an assessment of the available data (Figure 33). Key outcomes of the model include: • The rocks in the Klondyke area comprise a northwest trending sequence of metamorphosed basalt, ultramafic with pelitic schists. Although some enhanced permeability is possibly developed in the weathering zone, this zone is thin in the elevated areas with much of it unsaturated. • The fresh bedrock has generally low to very low permeability and storage, where it is unfractured. • Average groundwater levels in the higher elevations along the Warrawoona Range such as in the Klondyke area can be around 25mbgl. • The Klondyke shear, which runs along the axis of the Klondyke pit, can have moderate to high permeability along it, however the width of the permeable zone can be highly variable depending on the nature of deformation in local lithologies. • Transmissivity around the proposed Klondyke pit, away from major fracture zones is generally low, however the Klondyke shear, which strikes northwest through the centre of the deposit provides a zone of preferential flow and permeability. • Transmissivity values along parts of the Klondyke Shear was moderately high in parts, but varied, suggesting that the width of the more permeable zones along the Klondyke Shear may vary significantly over short distances. • A mapped chert unit striking northwest along the northern side of the proposed Klondyke pit could also have moderate permeability developed in places. • Moderate to high permeabilities can be present along northeast trending cross structures in the Klondyke area and probably along the Warrawoona Range. The extent of these fracture zones will require further investigation with targeted hydrogeological drilling to assess their water supply potential. • Dolerite dykes likely form aquitards in the Proposal area, probably diverting and inhibiting groundwater flow locally, and regionally around the more extensive dykes. The results of the drilling at Copenhagen found that the permeability around the Copenhagen pit is low to very low with airlift yields between 0.1 and 0.2 L/s, with no significant permeable structures intersected. **Groundwater quality** The groundwater quality in the Copenhagen and at Klondyke pit areas is fresh to slightly brackish, and slightly alkaline. Dissolved metals concentrations in the groundwater were generally low, apart from arsenic and iron (GRM 2019b; Appendix 4-2.) Arsenic (As) was above the Australian Drinking Water Guideline for human consumption (0.01mg/L), in approximately half of the bores sampled (56%). Of the nine sites that As levels were higher than the guidelines for human consumption, six recorded levels close to guideline value (between 0.01 and 0.06mg/L), with only three sites recording levels between 0.1-0.2mg. Regardless, all sites were well below the guideline value of 0.5mg/L for livestock watering. The presence of arsenic in the local groundwater is probably naturally occurring (at low levels). **Waste material characterisation** Geochemical Characterisation was undertaken for all waste rock types at the Proposal area in accordance with the DMIRS Draft Guidelines on Materials Characterisation. The characterisation program involved the selection of 209 waste rock samples for static testing from which a representative subset of 62 samples, both waste rock and ore, were selected for a second phase of testing and analysis including kinetic testing on some lithotypes. Results found that all lithologies within the Proposal area are classified as Non-Acid Forming (NAF). One lithological unit, the nickel arsenic lithological zone (NAZ), was identified during materials characterisation as having the potential to leach soluble arsenic at neutral pH from the waste rock.

Element	Description - Inland Waters
	Catchment The Proposal is located centrally within the Coongan River catchment, which is situated in the larger De Grey River Basin. Although located within the Pilbara Surface Water Area, the creek systems associated with the Proposal do not intersect any proclaimed Surface Water Management Areas or Irrigation Areas. The Proposal straddles the Warrawoona Range, a ridgeline that forms the local catchment divide between the Brockman Hay Cutting Creek/Sandy Creek/Camel Creek system to the south of the ridge and the Brockman Creek in the north (Groundwater Resource Management 2019a) (Figure 34). The Brockman Hay Cutting Creek/Sandy Creek/Camel Creek system reports directly to the Coongan River approximately 20km to the west of the Proposal area, while the Brockman Creek empties into the Talga River approximately 35km to the north of the Proposal, before also discharging into the Coongan River. The Coongan River feeds the De Grey River, which eventually discharges into the Indian Ocean at Poissonnier Point some 70km northeast of Port Hedland. Minor and medium drainage lines and washplains cross the Proposal area south of the Warrawoona Range in a northeast to southwest direction, including Brockman Hay Cutting Creek and Sandy Creek, both of which report to Camel Creek. Table 33 summarises the local catchments of the Proposal area. While there is a sparsity of flow gauging data across the region, the Coongan River and both creek systems of the Proposal area are typical of the Pilbara in that they are ephemeral and only carry runoff following significant rainfall events. Surface water flow field investigations have commenced at the Proposal area, with flow meters currently being installed in drainage lines that are within the development envelope, to record baseline flows (if any) that may occur during the 2019/2020 wet season. No permanent pools are evident on the 1:250,000 map sheets within the Brockman Creek/ Brockman Hay Cutting Creek/Sandy Creek or Camel Creek catchment, and no permanent pools have been located within the Proposal area, despite searches over the entire site during extensive flora and fauna surveys and discussions with local pastoralists/land managers. Some ephemeral pools develop in creek beds after rain; however, these are not permanent and are not found in the immediate area surrounding the Proposal, with ephemeral pools located between 3-15km from the Proposal area, and outside of the he predicted drawdown contours.
Potential Impacts	**Groundwater drawdown** The Proposal has the potential to produce localised and temporary decline in groundwater levels. Groundwater drawdown from mine pit dewatering has the potential to modify groundwater and surface water flows. **Pit lake water quality** Following the formation of a pit lake after closure, evaporation and groundwater flow into the pit has the potential to affect water quality within the pit lake and surrounding environmental values **Loss of catchment area and surface water flow** The proposed TSF will be established as a valley fill system, prevent surface flow downstream and reduce the catchment area. **Reduced surface water quality from metalliferous drainage** The quality of surface water runoff around waste rock storage facilities may be affected by the potential exposure of metalliferous waste rock (NAZ) material
Assessment of Impacts	**Groundwater drawdown** The predictive model results indicate the following for the Klondyke mine: • Groundwater inflows will potentially range from 20 to 35 L/s after the first few months of mining, up until around mid-way through Year 5 (Figure 35). • From Year 5 until the end of mining, combined open pit and underground mine dewatering rates could potentially increase up to around 50 L/s.

Element	Description - Inland Waters
	• Advanced dewatering of the Klondyke pit is required to augment the process water supply and reduce the projected longer-term pit inflows. The modelling also simulates the propagation of a cone of depression in the groundwater table from the dewatering over the six-year life of the project (Figure 23 and Figure 24, Section 5.6.1.4). • At the end of mining the drawdown impact is predicted to extend up to around 3 to 3.5km to the northwest and southeast along the strike of the Warrawoona Range, and around 2 to 2.5km laterally to the northeast and southwest from Klondyke. However, given the frequency of large seasonal recharge events (such as thunderstorms and tropical cyclones crossing the Pilbara coast), it is likely the final drawdown impact will be smaller than that predicted (Groundwater Resource Management 2019b). • The modelling results also show that mine dewatering will develop a strong local hydraulic gradient towards the Klondyke pit over time, such that any potential seepage from the TSF, which reaches the water table, will migrate towards it. • At the end of mining at Klondyke, the pit will form a mine pit lake with a groundwater (hydraulic) sink. For the Copenhagen pit, the predictive model results indicate the following: • Inflows into the Copenhagen pit are predicted to range between 2 and 8 L/s, however, due to low permeability results from the hydraulic testing, it is more likely the Copenhagen pit inflows will be at the lower end of this estimate, probably only up to a few litres per second. • The drawdown impact from dewatering at the end of Copenhagen mining (seven months), is predicted to extend out radially to around 500m from the Copenhagen pit perimeter. • At the end of the project mining (Year 6), the groundwater level around the Copenhagen pit will have rebounded substantially, with the local aquifer predicted to have recovered to pre-mining levels (assuming no water supply bores are installed nearby, which may impede aquifer recovery). **Pit lake** Of the four pits to be developed, only Klondyke pit will form a pit lake, with Copenhagen and the two 'St George' satellite pits to be backfilled. A pit lake water balance model was developed using the generic systems modelling package GoldSim, which is ideally suited to coupled water and solute balance modelling. The model was setup and run over a 100-year period to estimate pit lake conditions after mine closure. In the Pilbara region, where evaporation exceeds rainfall by more than an order of magnitude, the main drivers controlling the pit lake level will be groundwater inflow, rainfall runoff into the pit, and evaporative outflow (from the pit lake). The model results indicate that: • Following mine closure, a pit lake will remain at the Klondyke pit, forming a hydraulic (groundwater) sink (Figure 33). • Under both the "drier" and "wetter" climatic conditions, the pit lake level rises quickly from the pit base (170mRL), to around 180mRL within a month or so of mine closure; • During the subsequent 100 years following closure, the Klondyke pit lake level is predicted to fluctuate between about 180 and 195mRL; with an overall average base level across the 100-year period predicted to be around 180mRL to about 183mRL; • The fluctuations in-pit lake levels are predicted to be slightly higher under wetter average conditions (180 to 200mRL), compared to drier conditions (180 to 195mRL); Given the current elevation at the proposed Klondyke pit area (based on the elevation recorded across ten groundwater investigation bores) ranges between 278.1mRL and 304.8mRL (Groundwater Resource Management 2019b), the risk of pit overflow under extreme rainfall events is therefore negligible. The salinity of the pit lake will also increase with time becoming hypersaline at around 90,000mg/L TDS 100 years post closure, due to evaporative concentration of salts.

<table>
<tr><th>Element</th><th>Description - Inland Waters</th></tr>
<tr><td></td><td>

Reduction in catchment area

The three local catchments affected by the Proposal all discharge into the Coongan River Catchment (Groundwater Resource Management 2019a).

An assessment of post-mining catchment conditions by Groundwater Resource Management (2019a), estimated a very minor loss to catchment area, particularly for the broader Coongan River Catchment (Table 33) (Groundwater Resource Management 2019a).

The total area of catchment reduction across all three catchments was estimated at approximately 6.8km^2, representing an almost 0.10% loss to the total Coongan River catchment, including:

- Brockman Hay Cutting Creek Catchment Area, with 5.9% of local catchment loss (and 0.03% loss to Coongan River catchment).
- Sandy Creek Catchment Area, with 0.8% catchment loss (and 0.01% loss to Coongan River catchment).
- Brockman Creek Catchment Area, with 0.1% local catchment loss (and 0.001% loss to Coongan River catchment).

Table 33 Proposed post mining catchment areas

Catchment	Pre-Mine area		Post Mine area		
	Catchment area (km^2)	% of Coongan River	Catchment area lost (km^2)	portion of catchment lost (%)	portion of Coongan River catchment lost (%)*
Brockman Hay Cutting Creek Catchment	46.5	0.7%	5.9	12.7%	0.083%
Sandy Creek Catchment	199.2	2.8%	0.8	0.39%	0.011%
Brockman Creek Catchment	396.8	5.6%	0.1	0.02%	0.001%
TOTAL	**642.4**	**9.1%**	**6.8**		**0.096%**

*Coongan River is Catchment area is 7,080km^2

Acidic and Metalliferous drainage

One lithological unit, the Nickel Arsenic lithological zone (NAZ) was identified during materials characterisation to have the potential to leach Nickel and Arsenic from the waste rock.

A Nickel Arsenic NAZ-waste block model for the entire Klondyke deposit has been developed based upon geochemical analysis of RC and diamond drill holes. A handheld portable X-ray fluorescence analyser (pXRF) has also been used as a screening tool to identify rock volumes with elevated Ni and As contents.

The resulting Nickel Arsenic NAZ-waste block model provides a 3D spatial location of the NAZ-waste within the mine plan, as shown in red in Figure 36.

Based on the outcomes of this screening study, the waste block model currently predicts the occurrence of NAZ across approximately 8-10% of the total waste rock.

Refer to the Metalliferous Drainage Management Procedures (CRL-ENV-PRO-022-19, Appendix 9-6) for further information about metalliferous drainage within the proposal area.

</td></tr>
<tr><td>Mitigation</td><td>

Calidus has developed a series of management plans and procedures to mitigate potential impacts from the Proposal. Plans and procedures most relevant to the management of impacts to inland waters are summarised below:

- Groundwater Monitoring Procedure, CRL-ENV-PRO-021-19 (Appendix 9-4)
- Surface Water Monitoring Procedure, CRL-ENV-PRO-020-19 (Appendix 9-3)
- Metalliferous Drainage Management Procedure, CRL-ENV-PRO-022-19 (Appendix 9-6)

</td></tr>
</table>

Element	Description - Inland Waters
	• TSF and Cyanide Monitoring Procedure, CRL-ENV-PRO-019-19 (Appendix 9-5) • WRD and TSF Closure Procedure, CRL-ENV-PRO-023-19 (Appendix 9-7) • Hydrocarbon management procedure, CRL-ENV-PRO-004-19 • Hydrocarbon (and chemical) Spill Management Procedure, CRL-ENV-PRO-005-19 • Bioremediation Management Procedure, CRL-ENV-PRO-006-19 • Land rehabilitation procedure, CRL-ENV-PRO-016-19 • Significant Species Management Plan, CRL-ENV-PLN-006-19 (Appendix 9-1) The key management actions prescribed in these plans and procedures is described below under the EPA mitigation hierarchy framework (of avoid, minimise and rehabilitate).
avoid	• Avoid impacts to inland waters from metalliferous drainage through early identification, appropriate handling, containment/encapsulation and monitoring (details are provided below).
minimise	**Impacts to groundwater resources** • Implement the Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19), which will incorporate groundwater levels and water quality monitoring. • Licence all groundwater abstraction under the RIWI Act and manage in accordance with licence conditions and Water Management Plan (to be developed in consultation with DWER under any licences issued in the provisions of the RIWI Act) • Backfill pits at Copenhagen and St George (Klondyke satellite pits) to prevent exposure of groundwater to evaporation • Construct and manage hydrocarbon and chemical storage facilities in accordance with Australian standards **Impacts to surface water quality** • Implement Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19) and Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19). • Prior to project implementation, commence surface water flow monitoring within the drainage systems of the Proposal area as per the Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19) (Appendix 9-3), including baseline surface water flow monitoring in drainage lines of the Proposal area • During operations, all chemical, oil and other hazardous material storage areas within the Proposal area will be enclosed within a bund in accordance with the relevant codes and standards. • Water collected within bunds will be assessed: if suitable, it will be recycled back to the plant; and if it is impacted, it will be disposed of appropriately either by a licenced operator offsite or via the site bioremediation facility. • All dump tops and upper surfaces will be back-graded and/or edge bunding used to ensure positive drainage and to prevent runoff from reporting over dump crests and eroding dump slopes. Intermediate benches on dumps will be back-graded to break up long slope lengths and longitudinal grades will be used on benches to direct runoff either off the dump or to rock-armoured chutes and drains. Toe drains leading to sediment traps and basins constructed opportunistically along the WRD toe will be used to temporarily detain runoff and to ensure that water reporting off-site satisfies Total Suspended Sediment requirements. • Run-off from disturbed catchment areas upstream of the TSF will report to the reclaim pond and returned to the Plant for re-use. The TSF will function as a “zero-discharge” facility during Operations and sufficient freeboard will be provided on the embankment to store runoff from upstream areas in addition to the tailing’s impoundment for the 1% AEP 72-hour duration event (280 mm).

Element	Description - Inland Waters
	• During operations, all practical steps will be taken to direct runoff from undisturbed catchment areas around all proposed mine facilities to minimise potential lowering of water quality. Flow velocities along any diversion channels will be limited to minimise erosion and the generation of sediment. • At closure, water will report to the Klondyke pit and a pit lake will form. The Copenhagen pit will be backfilled above the water table post closure. • At closure, run-off from undisturbed areas will be diverted around remnant facilities and into existing natural watercourses or drainage lines by providing diversion bunds and drains. Flow velocities along all diversion drains will be limited to minimise erosion and the generation of sediment. **Impacts from waste rock metalliferous drainage** The following measures are based on mitigation described in the Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-7), which was developed to ensure that material from the NAZ does not leach in to the environment. The actions described within the Metalliferous Drainage Management Procedure are broadly based on following principles: **Identification and segregation** • During mining, the NAZ-waste model will be updated on a regular basis using close-spaced grade control drilling programmes results and samples from blast hole rigs. • The NAZ-waste model will be incorporated in "flitch plans" which outline the respective mining blocks on each bench within the pit showing location and mineral concentration variability. Where a mining block is predicted to contain NAZ-waste, geological technicians ("ore spotters") will be used on the pit floor utilising pXRF machines (portable X-ray fluorescence analysers) to verify the 3D data which will be uploaded to the excavator using GPS. **Storage and encapsulation** • The Management of NAZ-waste rich material will occur either via: o Backfill into an existing pit over which an infiltration limiting, water shedding earthen cover will be constructed. The majority of the NAZ-waste will be managed using this approach via the St George pits. St George pits consist of two, shallow satellite pits, above the water table and immediately north of the Klondyke pit. o Encapsulation within an impermeable synthetic liner or benign tailings (for more detail, refer to Metalliferous Drainage Management Procedure, CRL-ENV-PRO-022-19, Appendix 9-6). Some minor volume of material may require encapsulation within an impermeable liner with the WRD. • Encapsulation Specifications In-Pit Storage will include: o NAZ-waste will be backfilled into the St George open pit, comingled with benign material and placed to a depth not more than 2m below the pits lowest point in the landscape. o Benign waste rock, of the highest fines content available, will be placed over the open pit in two paddock dumped layers, each layer being compacted with a heavy dozer. o More waste will be placed until there is a minimum one-degree grade away from the centroid of the pit such that it is a free draining landform. Local plant root depths are generally <4m, however only shallow rooted species will be seeded in this location. • Storage within a Synthetic Liner will include: o A traffic compacted layer will be prepared on the WRD surface not less than 2m from the contact with natural ground. A synthetic liner will be laid on the base and with dumping, will be progressively joined up the walls until the target plan volume has been achieved. o The liner and/or tailings will be extended over the NAZ-waste cell and the entire cell sealed for permanent encapsulation. The cell will not come within 4m of the top surface and 5m of any side surface.

Element	Description - Inland Waters
	Monitoring and adaptive management • Implement monitoring programmes in accordance with the Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19; Appendix 9-3), Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19; Appendix 9-4), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6), TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5) and the Significant Species Management Plan (CRL-ENV-PLN-006-19 Appendix 9-1). • Implement adaptive management practices based on the above monitoring programs to refine mitigation measures and more effectively meet the objectives for inland waters. • The monitoring programs will themselves also be adaptive, dependent on flow events, the quantity and quality of the data collected and innovations in monitoring techniques/approaches over time. The monitoring program will utilise baseline/ambient water values prior to implementation and use these values as guides for trigger or threshold values following implementation, which will activate contingencies or adaptive mitigation measures.
rehabilitate	• Develop a comprehensive Mine Closure Plan, which incorporates measures from WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19) and the Land rehabilitation procedure (CRL-ENV-PRO-016-19). • back fill Copenhagen and St George pits to above post mining groundwater levels • Progressively rehabilitate disturbed areas. • At closure, maximise the disturbed catchment areas to be diverted towards pit voids (using techniques such as modified dumping strategies, revised road grading, training bunds, channel cuttings etc.), to ensure that the minimum amount of runoff from disturbed catchment areas reports off-site • All dump tops and upper surfaces will be graded to promote infiltration. • A closure spillway will be constructed to convey run off from natural ground and portions of the tailings surface which cannot be configured into containment cells. This spillway will be constructed over high durability natural ground and the area which is not covered by cells and the spillway will be covered with durable waste rock to act as a sedimentation trap. • Following the cessation of operations, roads will be breached at various locations and drainage lines reinstated to a natural, pre-development state.
Predicted Outcome	Groundwater will be affected primarily through dewatering at the proposed Klondyke pit and the subsequent development of a pit lake at closure. Future hydrological investigations to identify additional production bore targets will also be used to further refine both the groundwater flow model and the adaptive management strategies required to monitor and protect the local groundwater environment. Management of groundwater and surface water resources will be based on licence requirements issued under the RIWI Act, Mining Act (including approved Mine Closure Plan) and Part V of the EP Act, and will occur in consultation with DWER and DMIRS. Management requirements for inland waters will also be achieved through the implementation of a number of monitoring and management procedures, including a Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19), Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19), TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19), Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19) and a Hydrocarbon (and chemical) Spill Management Procedure (CRL-ENV-PRO-005-19). Through appropriate planning and management, overseen by DWER and in consultation with DMIRS, this Proposal will meet the EPA objective to “maintain the quality of groundwater and surface water so that environmental values are protected.”

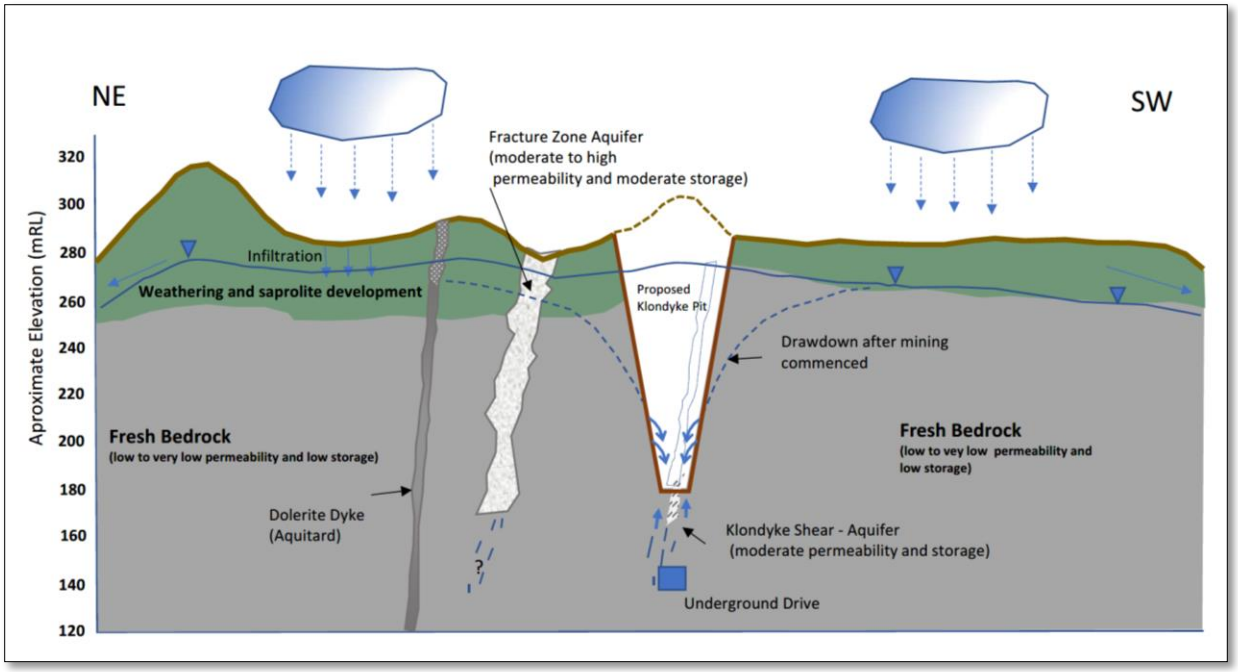
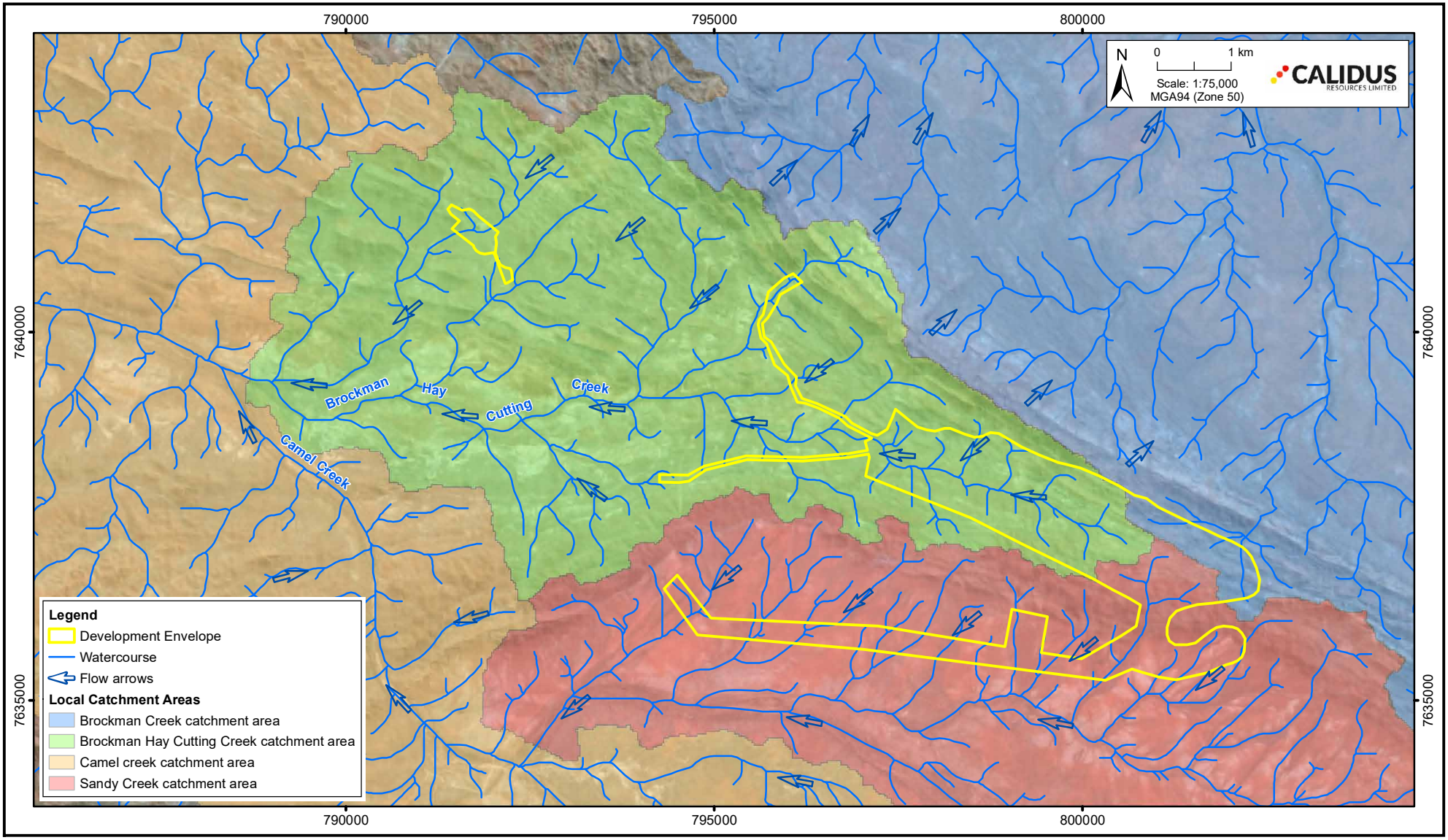


Figure 33 **Conceptual hydrogeological model for Klondyke deposit (Source: Groundwater Resource Management 2019b; Appendix 4-2)**

Figure 34: Hydrology of the Proposal area



Source: ESRI/DigitalGlobe - Imagery, Geoscience Aust. - Watercourses
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_34, Rev: A

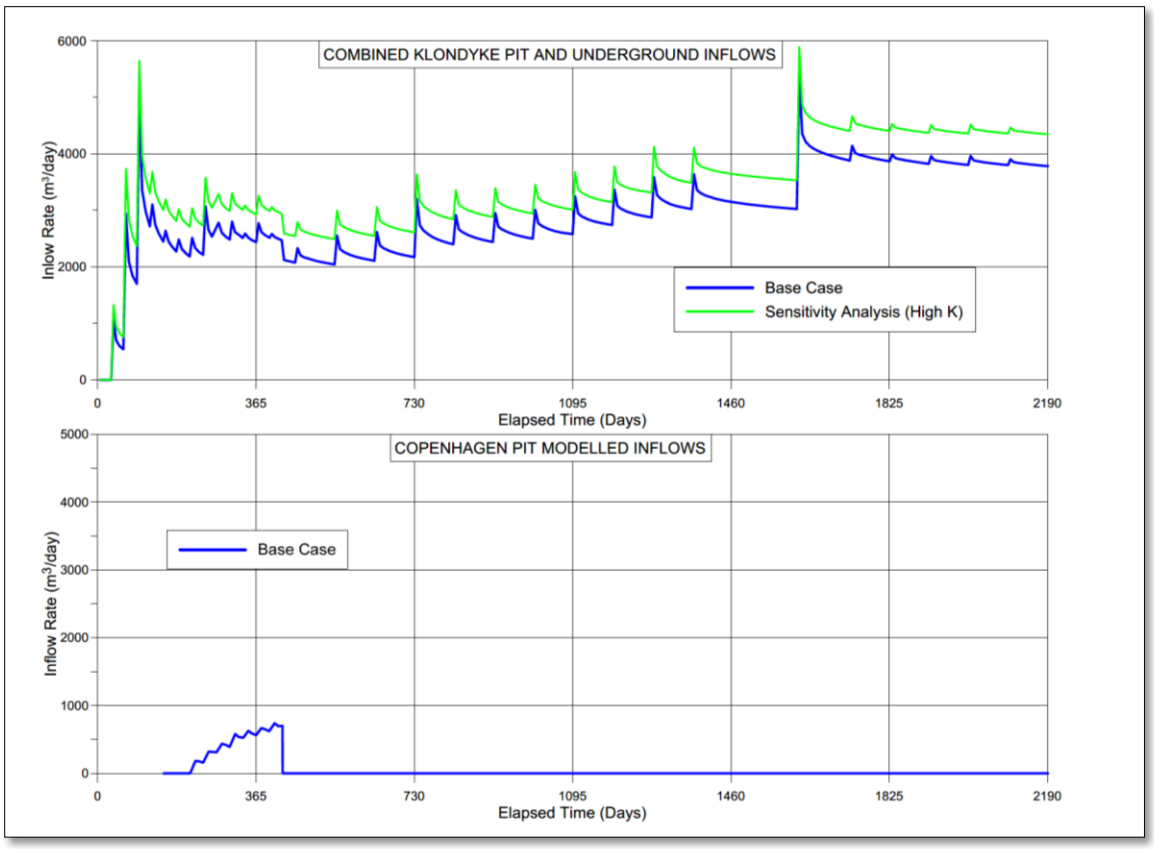


Figure 35 Modelled pit and underground inflows (Source: Groundwater Resource Management 2019b; Appendix 4-2)

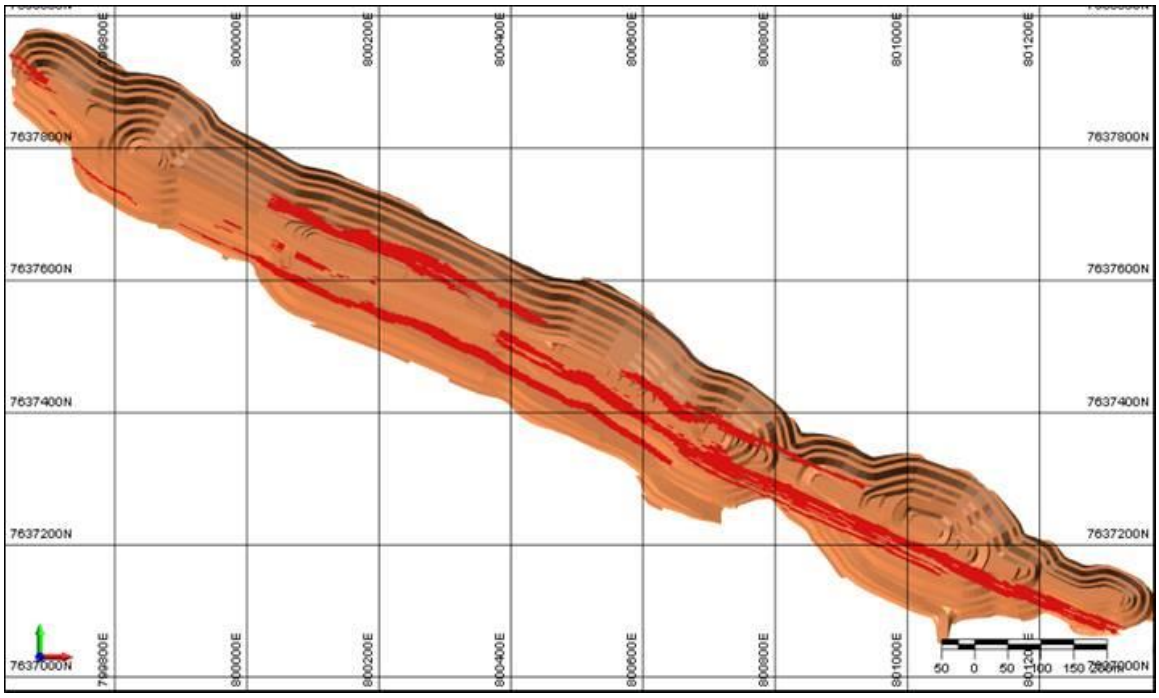


Figure 36 NAZ waste model locations within Klondyke pit (Red) (Source: Trajectory 2019, Appendix 9-6)

6.2 Terrestrial environmental quality

Element	Description – Terrestrial Environmental Quality
EPA Objective	To maintain the quality of land and soils so that environmental values are protected.
Policy and Guidance	• Statement of Environmental Principles, Factors and Objectives (EPA 2018b). • Environmental Factor Guideline – Terrestrial Environmental Quality (EPA 2016f) • Appendix B: Potentially contaminating industries, activities and land uses, in Assessment and management of contaminated sites: Contaminated sites guidelines (DER 2014). • National Environment Protection (Assessment of Site Contamination) Measure (NEPM 2013). • Planning for integrated mine closure: toolkit. International council on mining and metals. (ICMM 2019). • Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015).
Supporting Studies	• Soils and Landform Assessment. Mine Earth (2019); Appendix 6-1 • Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management. Graeme Campbell and Associates (GCA 2019a); Appendix 5-1 • Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management. Graeme Campbell and Associates (GCA 2019b); Appendix 5-2 • Tailings Storage Facility Design Report. ATC Williams (2019); Appendix 5-3
Existing Environment	Existing environment information is based on results and findings from supporting studies commissioned by Calidus, as summarised above. **Soils and landform assessment** A baseline soil assessment by Mine Earth (2019) identified five soil-landform associations within the Proposal area: 'drainage channels', valley floor', 'low hills / rises', 'ridgelines / rocky outcrops' and 'sandplain / stony flats'. The assessment of physical and chemical characteristics of surface soil found although soil depth varied between soil-landform associations, there was an overall consistency in the soils across the proposal area, with all soils presenting with the following characteristics: • Relatively coarse grained • Generally low clay contents (a minor increase in clay with depth) • Non- to slightly-saline • Neutral to moderately alkaline pH • Non-sodic • Non- or only partially-dispersive • Free draining (moderate hydraulic conductivity) • Typically, low in organic carbon and plant-available nutrients. A number of soil samples were naturally enriched in total concentrations of As, Cr and Se (relative to the average crustal abundance), with no apparent correlation between enrichment and soil-landform association. Based upon the physical, chemical and morphological characteristics of the soils in the Proposal area, it is recommended that topsoils, to a depth of approximately 20 cm from within the 'valley floor' and 'low hills / ridges' soil-landform associations, are salvaged from areas of disturbance, for use as a rehabilitation resource. Topsoils from the 'ridgelines / rocky outcrops' are also physically and chemically suitable for salvage and use as a rehabilitation resource, however, due to accessibility and the prevalence of outcropping rock, the salvage of these topsoils is likely to be limited to opportunistic stripping in accessible areas where topsoil is present. Salvage of topsoils from these areas should therefore be maximised.

Element	Description – Terrestrial Environmental Quality
	Deeper soils (20 to 90 cm depth) from the 'valley floor' soil-landform association are also physically and chemically suitable for salvage and use as a rehabilitation resource. **Characterisation of Mine-Waste** As highlighted previously (Section 6.1), waste material characterisation identified one lithological unit, the nickel arsenic zone (NAZ), as having the potential to leach soluble arsenic at neutral pH (GCA 2019a). The report concluded that the NAZ needs to be handled and isolated, so that weathering is restricted, and the risk for leaching soluble-As forms is minimised (Trajectory 2019). **Characterisation of Mine-Tailings Slurry** Based on the test work results from characterisation of the mine tailings slurry sample, it is concluded that the tailings in the TSF is classified as non-acid forming (NAF) and geochemically benign (GCA 2019b). **Tailings storage facility design** The proposed TSF is described as a valley facility whereby a cross valley containment embankment, 17m high and 250m long, will be constructed across the alignment of an ephemeral drainage line, Brockman Hay Cutting Creek. Seepage and stability analyses have been completed which indicate the embankment will be geotechnically stable under design static and dynamic loading conditions. The mafic schist rock mass underlying the TSF is inferred to be of low permeability although locally, high permeability zones may be present. Seepage analyses indicates that seepage expression downstream of the facility is not anticipated, although for conservative design, a seepage collection trench close to the embankment toe is incorporated in the design arrangement. In accordance with DMIRS requirements, a certificate of design compliance, a Tailings Storage Data Sheet is provided within ATC Williams (2019) (Appendix 5-3)**.**
Potential Impacts	As many of the potential impacts that may affect Terrestrial Environmental Quality have been discussed and assessed already within Terrestrial Fauna and Inland Waters (i.e. cyanide and the TSF, and metalliferous drainage), the discussion of potential impacts to Terrestrial Environmental Quality will focus on issues as they specifically relate to rehabilitation and closure. As part of the development of a Mine Closure Plan (MCP) for the Proposal, a risk assessment workshop was held during September 2019 and was attended by Mine Earth, Rapallo and Calidus staff members. The risk assessment workshop was undertaken to identify and quantify potential risks at mine closure. The risk assessment process that was adopted aligns with the Australian and New Zealand Risk Management Standard (AS/NZ 31000:2009). The risk assessment determined that the key potential impacts in relation to closure and rehabilitation relate to: • Poor revegetation outcomes. • Impacts from uncontrolled surface water flow. • Metalliferous drainage from waste rock. • Poor water quality in open pits. • Poor geotechnical stability. • Unauthorised access to mine workings. • Disturbance of culturally significant sites.
Mitigation	The MCP for the Proposal is currently being prepared in accordance with the Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015) and will be submitted with the Mining Proposal for assessment by DMIRS. The MCP will describe in detail the control options that will be used to manage any potential impacts associated with mine closure and rehabilitation. Mitigation and management strategies for each of the key potential impacts identified during the risk workshop are described in the following sections.

Element	Description – Terrestrial Environmental Quality
	Calidus has developed a series of procedures to mitigate potential impacts from the Proposal. Plans and procedures most relevant to the management of impacts to Terrestrial Environmental Quality are summarised below: **Waste and hazardous materials** • WRD and TSF Closure Procedure, CRL-ENV-PRO-023-19 (Appendix 9-7) • Metalliferous Drainage Management Procedure, CRL-ENV-PRO-022-19 (Appendix 9-6) • TSF and Cyanide Monitoring Procedure, CRL-ENV-PRO-019-19 (Appendix 9-5) • Hydrocarbon Management Procedure, CRL-ENV-PRO-004-19 • Hydrocarbon (and chemical) Spill Management Procedure, CRL-ENV-PRO-005-19 • Bioremediation Management Procedure, CRL-ENV-PRO-006-19 **Water monitoring** • Surface Water Monitoring Procedure, CRL-ENV-PRO-020-19 (Appendix 9-3) • Groundwater Monitoring Procedure, CRL-ENV-PRO-021-19 (Appendix 9-4) **Rehabilitation and vegetation management** • Land rehabilitation procedure, CRL-ENV-PRO-016-19 • Significant Species Management Plan, CRL-ENV-PLN-006-19 (Appendix 9-1) • Weed Hygiene Procedure, CRL-ENV-PRO-003-19 • Flora Management Procedure, CRL-ENV-PRO-011-19 • Weed Spraying Procedure, CRL-ENV-PRO-012-19 **Ground disturbance** • Ground Disturbance Permit Procedure, CRL-ENV-PRO-001-19
avoid	• No more than 398.5ha of land within the 1,000ha development envelope will be cleared/disturbed. • Restrict clearing to the minimum necessary for safe construction and operation of the Proposal and to within approved areas through the Ground disturbance permit procedure (CRL-ENV-PRO-001-19)
minimise	**Poor revegetation** • Implementation WRD and TSF Closure Procedure, CRL-ENV-PRO-023-19 (Appendix 9-7) • Identify and manage adequate volumes of suitable growth medium (i.e. topsoil and subsoil). • Implement an appropriate rehabilitation plan, as described within the MCP. • Post closure monitoring and maintenance. • Ongoing weed control. • Discourage stock grazing on rehabilitated areas. **Uncontrolled surface water flow** • Design and construct adequate controls to manage surface water on and around permanent features including open pits, WRDs and TSFs. • Shape and stabilise WRD batters, TSF batters and borrow pit embankments where required and placing physically stable materials on slopes in accordance with the approved design, as per WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19) • Cover TSF with physically stable materials in accordance with the approved design and implement an appropriate rehabilitation plan, as described within the MCP.

Element	Description – Terrestrial Environmental Quality

	Metalliferous drainage from waste rock
	• Implement Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6)
	• Placement of waste rock with a metalliferous drainage risk within WRDs or pits, in accordance with an approved design, such that the risk of metalliferous drainage is low.
	• Ensure that waste units are classified prior to mining (during infill and grade control drilling) and managed in accordance with the Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19) (GCA 2019a Appendix 5-1; Trajectory 2019, Appendix 9-6 and Appendix 9-7)
	• Ensure appropriate surface water management is incorporated into the final mine design, in accordance with the following design principles:
	  ○ Divert naturally occurring local surface water around mine infrastructure by means of drainage channels, earth bunds, and road culverts with adequate scour protection where necessary.
	  ○ Runoff from the waste dumps will be directed to the TSF to allow water to be reclaimed back to the Plant via the decant pond.
	Poor water quality in open pits
	• The pits will function as evaporative sinks in perpetuity and therefore the potential for impacts to surrounding groundwater is low.
	• Construct abandonment bunds, approved by the DMIRS and in line with relevant guidelines, to limit access.
	• Rehabilitate roads to limit access.
	• Backfill of St George and Copenhagen pits above the water table.
	Poor geotechnical stability
	• Designing, constructing and rehabilitating TSF and WRDs to meet appropriate geotechnical standards, as per WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19; Appendix 9-7), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6), TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5).
	• Construct all landforms and TSF outside the zone of instability around the pit and underground workings.
	Hydrocarbons and Chemical Handling and Management
	• Implement Hydrocarbon Management Procedure (CRL-ENV-PRO-004-19), Hydrocarbon (and chemical), Spill Management Procedure (CRL-ENV-PRO-005-19) and Bioremediation Management Procedure (CRL-ENV-PRO-006-19).
	• Containment of hydrocarbons in accordance with AS1940:2004 – The Storage and Handling of Flammable and Combustible Liquids, this includes sitting and bunding/containment restrictions, provision and maintenance of relevant MSDS and regular inspections.
	• Refuelling procedures, including the provision of a spill kit at all refuelling stations.
	• Spill recovery and clean up materials maintained at all hazardous material storage areas. Relevant employees and contractors will be trained in the use of this equipment.
	• All spills, irrespective of volume, will be reported. Spills to ground / outside of a bund are reported as an environmental incident and cleaned up appropriately. Spills inside a bund are reported as a hazard and cleaned up appropriately.
	• Contaminated soil shall be taken to the site bioremediation facility (where present), or stockpiled for removal offsite by a licenced controlled waste contractor.
	Topsoil handling and management
	• Topsoil stripping shall only be undertaken in dry conditions to prevent compaction and poor seed viability.
	• Topsoil shall be paddock dumped into stockpiles not exceeding 2m in height.

Element	Description – Terrestrial Environmental Quality
	• Develop and implement topsoil management procedures for the recovery, storage and utilisation of topsoil (as part of the MCP process). • Where practicable, topsoil shall be stripped to a minimum depth of 200 mm below the natural surface unless otherwise stated in conditions within the Ground Disturbance Permit. • Topsoil (and subsoil) shall be stripped to a greater depth where available and necessary (i.e. when the site has a topsoil deficit). • Weeds and weed-contaminated topsoil will be cleared, handled and stockpiled separately to native vegetation and 'clean' topsoil.
rehabilitate	• Progressively rehabilitate disturbed areas • All areas of the indicative disturbance footprint (except for open pits) will be progressively rehabilitated as required by the MCP. Rehabilitation works are expected to return disturbed areas to a stable and vegetated state. • The use/placement of the salvaged topsoil on waste rock landforms will be strategic in that it will only occur in areas likely to be successful in vegetation establishment in the long term. • Ripping of the surface of the waste rock dumps will follow redeployment of topsoil to improve rainfall infiltration and increase root penetrability. • A MCP will be updated as required when significant changes are made to the Proposal.
Predicted Outcome	The Proposal is typical of mined landforms established in the Pilbara and all potential impacts relating to closure and rehabilitation at the Proposal area are also typical of gold mining operations throughout Western Australia. Management of terrestrial environmental quality will be largely driven by an approved Mining Proposal and Mine Closure Plan, to be developed in consultation with DMIRS and DWER. Management requirements for terrestrial environmental quality will also be managed through a comprehensive series of procedures, key to this are WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19; Appendix 9-7), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6) and the TSF and Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19; Appendix 9-5). Through the implementation of management and monitoring strategies described above and with the development of an approved Mine Closure Plan, the risk of significant contamination from problematic waste material and the degradation of the terrestrial environment is low. Calidus expects that the EPA's objective for Terrestrial Environmental Quality, to "maintain the quality of land and soils so that environmental values are protected", can therefore be met.

6.3 Flora and vegetation

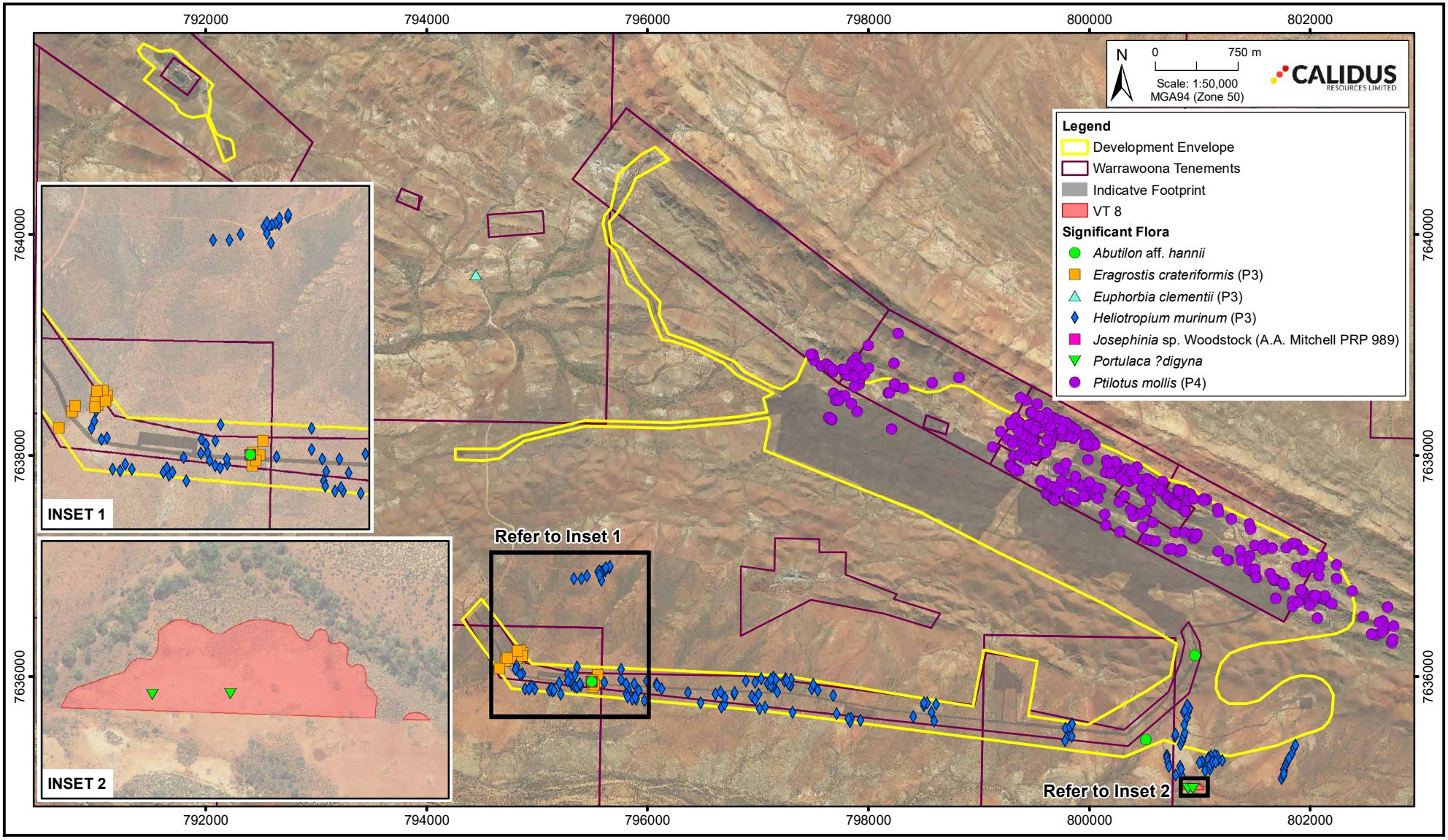
Element	Description – Flora and Vegetation
EPA Objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and Guidance	• Statement of Environmental Principles, Factors and Objectives (Environmental Protection Authority 2016k). • Environmental Factor Guideline: Flora and Vegetation (EPA 2016). • Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (Environmental Protection Authority 2006). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (Environmental Protection Authority 2016l). • Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development (Environmental Protection Authority 2013b).

Element	Description – Flora and Vegetation
Supporting Studies and Documents	• Detailed Flora and Vegetation Survey (formally Level 2). Woodman Environmental (2019a); Appendix 7-1 • Memo of recommendations for referral of Warrawoona Gold Project, assessment against Clearing Principles. Woodman Environmental (2019b), Appendix 7-2.
Existing Environment	**Flora** • A total of 266 discrete vascular flora taxa (including 11 introduced taxa), one known and three putative hybrids, representing 45 families and 122 genera (Woodman Environmental (2019a and 2019b). • Five conservation significant (Priority) flora taxa were recorded: *Eragrostis crateriformis* (P3); *Euphorbia clementii* (P3), *Heliotropium murinum* (P3), *Josephinia* sp. Woodstock (A.A. Mitchell PRP 989) (P1) and *Ptilotus mollis* (P3). • Two other significant (potentially undescribed) flora taxa were recorded: *Abutilon* aff. *hannii* and *Portulaca ?digyna*. • No Threatened taxa, listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or BC Act (Woodman Environmental 2019a and 2019b). • One Declared Pest recorded (**Calotropis procera*) (as listed under Department of Primary Industries and Regional Development 2019), but no taxa recorded were listed as Weeds of National Significance (as listed under Australian Weeds Committee 2019). Six introduced taxa which are ranked as having High ecological impact for the DBCA Pilbara Region (Woodman Environmental 2019a). • The diversity of the flora of the Proposal area is considered 'Moderate', in comparison with survey results from other similar Proposal areas in the Pilbara (Woodman Environmental 2019a). **Vegetation** • Two vegetation system associations (Abydos Plain 93 and George Ranges 82) (Government of Western Australia 2019) and three land systems were recorded (Macroy, Rocklea and Talga) (Van Vreeswyk *et al.* 2004), none of which are considered rare or restricted in the Pilbara region (Woodman Environmental 2019b). • Ten Vegetation Types (VTs) were recorded, of which five are considered to be of potential local significance (VTs 2, 3, 4, 8, 9) and one of potential regional significance (VT 8); • No listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs), listed under the EPBC Act; or BC Act. • One vegetation type containing localised areas of potentially groundwater-dependent vegetation occurs in the Proposal area (VT 3).
Potential Impacts and their assessment	**Clearing significant native flora and vegetation** • No Threatened Flora listed under the BC Act or EPBC Act have been recorded in the Proposal area. • Of the seven recorded species of conservation significance, only three will be affected by the Proposal (*Eragrostis crateriformis* P3 - ephemeral grass; *Heliotropium murinum* P3 -small herb; *Ptilotus mollis* P4 - compact shrub). All conservation significant species within the disturbance footprint are widespread and recorded in abundance throughout the Proposal area (382, 890, and 2808 individuals/patches respectively) (Figure 37). • No TECs listed under the BC Act were recorded in the proposal area • Overall, the local significance impact of the Proposal on vegetation types is ranked Low, excluding VT3, which is ranked Moderate. It must be noted that although the local significance ranking of VT3 has been ranked '2' due to the presence of suitable habitat for *Abutilon* aff. *hannii* and *Eragrostis crateriformis* (P3), no known locations of either of these two taxa are proposed to be impacted by clearing of the current footprint. • Five potentially locally significant vegetation types were identified in Woodman Environmental (2019). The majority of these VTs (VTs 2, 3, 4, and 9) were noted to have a high probability of occurrence in the wider region, either through their occurrence on relatively common geology, soil types and landforms or known occurrence in other studies. These VTs aren't known to

Element	Description – Flora and Vegetation
	represent vegetation that has potentially been identified as being regionally restricted by other studies and were not representative of listed TECs or PECs. • VTs 3 and 4 were identified as being comprised of vegetation associated with watercourses and associated floodplains which were able to be distinguished from adjacent vegetation; VT 8 was identified as being a claypan which is representative of a wetland type. Although VT 3 cannot be described as being representative of GDV, localised pockets of GDV may be present where *Eucalyptus camaldulensis* and *Sesbania cannabina* occur. Note, only one individual of *Eucalyptus camaldulensis* was recorded throughout the Proposal area. • All mapped locations of VT8 are outside the disturbance footprint and will be avoided, with no disturbance occurring to VT8 in the Proposal area (Figure 37). • VT4 is associated with sheetflow areas. It is expected that 15ha of VT4 will be disturbed as part of the Proposal. This represents 13.5% of VT4's mapped coverage in the survey area, and 4% of the total 379ha footprint. The proposal has also been modified to avoid disturbance to VT4 throughout the Proposal area (i.e. through repositioning roads and accommodation camp layout etc.)
Mitigation	Calidus has developed a series of management plans and procedures to mitigate potential impacts from the Proposal. Plans and procedures most relevant to the management of impacts to vegetation and flora are summarised below: • Dust management procedure (CRL-ENV-PRO-015-19) • Weed hygiene procedure (CRL-ENV-PRO-003-19) • Ground disturbance permit procedure (CRL-ENV-PRO-001-19) • Land rehabilitation procedure (CRL-ENV-PRO-016-19) The key management actions prescribed in these procedures are summarised below under the EPA mitigation hierarchy framework (avoid, minimise and rehabilitate).
avoid	• While there is limited ability to avoid the disturbance of vegetation overlying the orebodies, there is some flexibility in located associated infrastructure to avoid areas of higher values, within other design constraints (e.g. engineering and heritage requirements). • Avoid placing mine infrastructure in area identified as being of high conservation significance as far as practicable • Locate WRD and TSF to avoid significant vegetation as far as practicable
minimise	• All practical steps will be taken to minimise adverse impacts. WRD and TSF will be designed to accommodate the smallest practical footprint, as safely as possible. • Areas cleared for support infrastructure will be limited to the minimum required for satisfactory and safe establishment and use of the infrastructure. • Prepare and implement a ground-disturbance permitting procedure to ensure disturbance remains within authorised boundaries. • Include the following information in employee and contractor inductions: o Protection of flora and vegetation o Restriction of activities to within approval clearing boundaries o Identification and reporting of weeds o Hygiene procedures to minimise to introduction and spread of weeds • Make available maps of the approved disturbance envelopes to all persons involved in mine planning and initial ground-disturbance authorisation • Define clearing boundaries with on-ground markings (i.e. flagging) and as GPS coordinates in earth moving equipment. • Incorporate vegetation protection into design of mining facilities.

Element	Description – Flora and Vegetation
	• Incorporate vegetation protection specifications in all construction-related contracts and subcontracts. • Conduct weed control in areas to be disturbed that contain weeds. • Implement weed hygiene measures for mobilisation and demobilisation of mining equipment entering and leaving the area.
rehabilitate	• Progressive rehabilitation of disturbed areas will commence as soon as practicable and remaining disturbed areas will be rehabilitated upon mine closure. This measure will redress some of the impact to vegetation and flora. • The rehabilitation of the mined areas coupled with the careful placement of WRDs, TSF and infrastructure will reduce the impact to vegetation and flora of the area. • Rehabilitate disturbed area, as part of the MCP
Predicted Outcome	No Threatened species or ecological communities listed under the BC Act were recorded within the Proposal area. No DBCA listed Priority Ecological Communities occur within the Proposal area. The vegetation of the Proposal area is not considered to be strongly phreatophytic. Three Priority species (*Eragrostis crateriformis* P3; *Heliotropium murinum* P3; *Ptilotus mollis* P4) will be disturbed by the Proposal. These three species were all recorded in very high numbers throughout the Proposal area and have a high likelihood of occurrence on similar soil types and geologies outside the Proposal area (Woodman Environmental 2019a and 2019b). Similarly, all vegetation types that are within the proposed disturbance footprint are considered widespread or have a high probability of occurrence in the wider Pilbara IBRA region, either through their occurrence on relatively widespread geology, soil types and landforms or through their known occurrence in other studies (Woodman Environmental 2019b). Existing statutory controls for management of potential impacts to flora and vegetation resulting from dust, groundwater abstraction, hydrocarbon contamination and clearing, together with management controls to be prepared by Calidus, are sufficient to manage potential impacts to vegetation and flora. Flora and vegetation will not be significantly impacted by the Proposal and can effectively meet the EPA objective to “protect flora and vegetation so that biological diversity and ecological integrity are maintained.”

Figure 37: Significant flora taxa and potently regionally significant vegetation (avoided)
(Source: Woodman Environmental 2019b Figure 2; Appendix 7-2)



Source: DMIRS - Tenements, Woodman Env. Cons. - Flora, Vegetation
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_37, Rev: A

6.4 Social surroundings (Aboriginal heritage and culture)

<table>
<tr><th>Element</th><th>Description – Social Surroundings (Aboriginal heritage and culture)</th></tr>
<tr><td>EPA Objective</td><td>To protect social surroundings from significant harm</td></tr>
<tr><td>Policy and Guidance</td><td>• Environmental Factor Guideline – Social Surroundings (EPA 2016g).
• Aboriginal Heritage Due Diligence Guidelines (DAA 2013).</td></tr>
<tr><td>Supporting Studies</td><td>• SandS CRM (2019) Calidus Warrawoona Gold Project Archaeological Site Avoidance Survey. Archaeological Survey Report – Site Avoidance Level. Appendix 8-1
• SandS CRM (2018) Calidus Warrawoona Gold Project Ethnographic Site Avoidance Survey. Ethnographic Survey Report – Site Avoidance Level. Appendix 8-2</td></tr>
<tr><td>Existing Environment</td><td>Existing environment information is based on results and findings from supporting studies commissioned by Calidus, as summarised above.

Consultation with Traditional Owners has not identified any significant issues to date, with no previously recorded Aboriginal sites entered onto the DPLH Register of Aboriginal Sites for the Proposal area.

Archaeological survey

An Archaeological Site Avoidance Survey of the Proposal area, undertaken in conjunction with Njamal Peoples Trust and SandS CRM Archaeologists, recorded nine archaeological places within the survey area. These newly recorded archaeological places included quarries, rock art and grinding patches (Table 34).

Table 34 Archaeological site avoidance survey results

<table><tr><th>Site ID</th><th>Site Type</th><th>Significant</th><th>Size (Ha)</th></tr><tr><td>CALI_19_001</td><td>Quarry</td><td>Low</td><td>0.10</td></tr><tr><td>CALI_19_002</td><td>Rock Art</td><td>High</td><td>0.07</td></tr><tr><td>CALI_19_003</td><td>Rock Art</td><td>High</td><td>0.01</td></tr><tr><td>CALI_19_004</td><td>Rock Art</td><td>High</td><td>0.02</td></tr><tr><td>CALI_19_005</td><td>Rock Art/Grinding Patch</td><td>High</td><td>0.13</td></tr><tr><td>CALI_19_006</td><td>Grinding Patch</td><td>Medium</td><td>0.03</td></tr><tr><td>CALI_19_007</td><td>Grinding Patch</td><td>Medium</td><td>0.02</td></tr><tr><td>CALI_19_008</td><td>Quarry</td><td>Low</td><td>0.01</td></tr><tr><td>CALI_19_009</td><td>Rock Art</td><td>High</td><td>0.01</td></tr></table>
Ethnographic survey

An Ethnographic survey was undertaken (concurrently to the Archaeological survey) across the Proposal area, via helicopter with Njamal Peoples Trust and SandS CRM representatives. All Njamal participants confirmed the Proposal area did not contain any specific ethnographic sites or places.

Note, because of recorded engraving sites in the area (Sands CRM 2019), it was agreed to recommend that if any archaeological sites that may have ethnographic importance are identified during future archaeological surveys (such as engraving sites), senior Njamal representatives are afforded the opportunity to be consulted about the cultural importance of any such place.</td></tr>
<tr><td>Potential Impacts</td><td>• Impacts to Aboriginal heritage sites.</td></tr>
<tr><td>Assessment of Impacts</td><td>The Proposal has been modified to avoid disturbance to all recorded archeological places within the Proposal area, therefore ensuring there will be no impacts to these sites.

All potential impacts on Indigenous cultural heritage are most appropriately managed through the ground disturbance procedures.</td></tr>
</table>

Element	Description – Social Surroundings (Aboriginal heritage and culture)
Mitigation	Calidus has developed a series of procedures to mitigate potential impacts from the Proposal. Procedures most relevant to the management of impacts to Social Surrounds (Aboriginal heritage and culture) are summarised below: • Stakeholder engagement procedures and environmental policy • Ground disturbance permit procedure (CRL-ENV-PRO-001-19) The key management actions prescribed in these procedures are described below.
avoid	• Development envelope was refined to exclude potential sensitive site • The indicative disturbance footprint has been adjusted to avoid potential sensitive sites.
minimise	• Ensure all areas of proposed disturbance have surveyed for Aboriginal heritage (ethnographic and archaeological) prior to disturbance. • In the event that an Aboriginal heritage site cannot be avoided, Calidus will submit a Section 18 application and obtain consent from the Minister for Aboriginal Affairs under the AH Act prior to disturbance. • In the event that an item of indigenous heritage is identified during construction or operations, ground disturbance will cease and the item of interest will be left in-situ until such time that the area can be appropriately viewed. Approval for recommencement of ground disturbing activities will only occur after consultation with native title claimants or their representatives and the Department of Planning, Lands and Heritage (DPLH) as required.
Predicted Outcome	Although no direct impact will occur to heritage places as a result of this project, Calidus recognise the Traditional Owners' cultural association to country and general concerns regarding disturbance to the land. Through archaeological and ethnographic surveys and consultation with Traditional Owners, areas of significance to the Aboriginal cultural heritage have been identified with the Proposal area and disturbance to these areas will be avoided. All potential impacts on Aboriginal cultural heritage are most appropriately managed through the ground disturbance procedures. Management of indigenous cultural heritage is primarily driven by corporate-level policy and by meeting obligations and requirements under the AH Act. If required, any mitigation strategies for cultural management will be undertaken through consultation with Traditional Owners and the DPLH. Through the protection afforded by processes under the AH Act, the Proposal will meet the EPA objective "to protect social surroundings from significant harm".

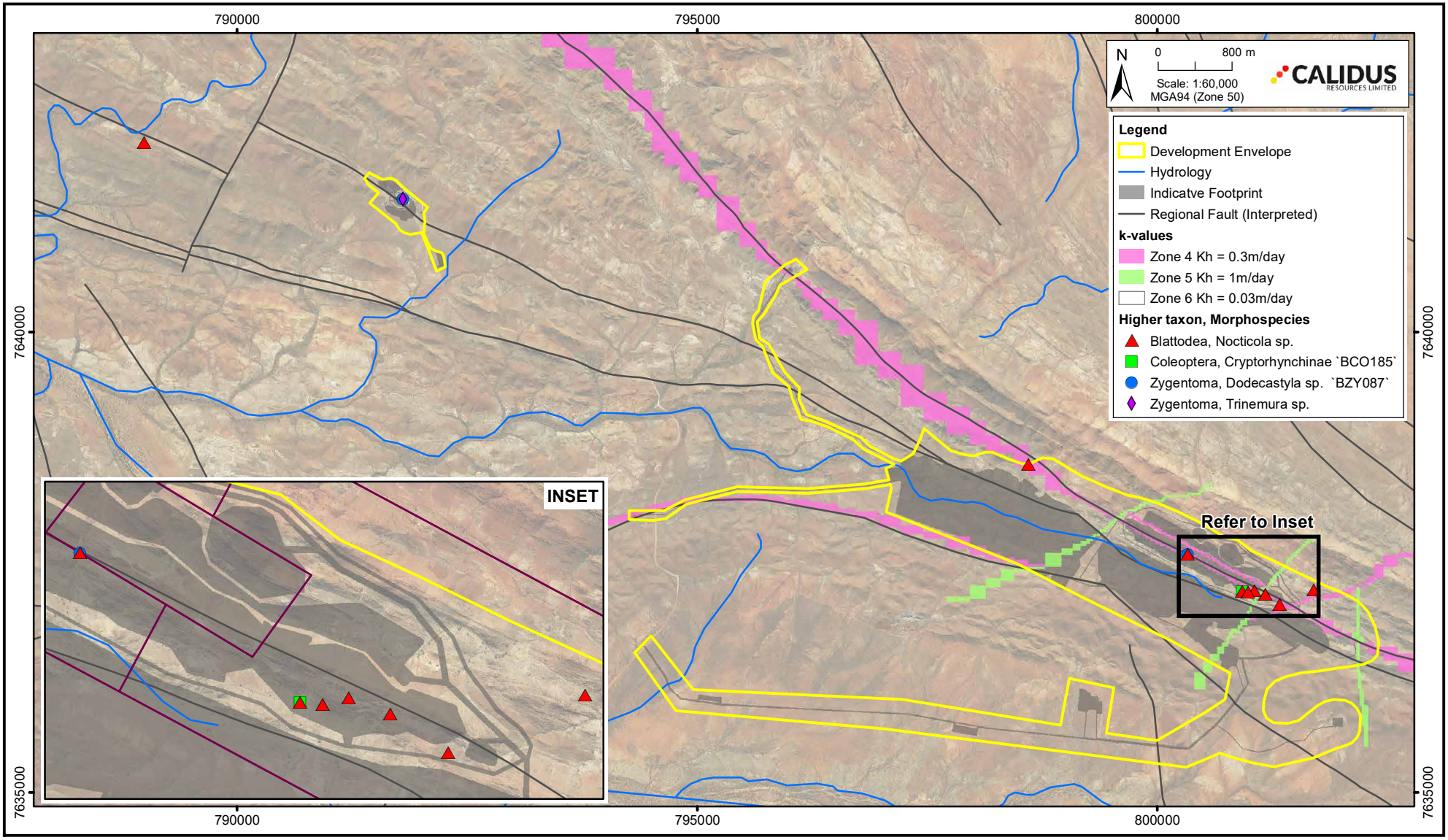
6.5 Subterranean fauna

Element	Description – Subterranean Fauna
EPA Objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained
Policy and Guidance	• Environmental Factor Guideline – Subterranean Fauna (EPA 2016h) • Technical Guidance – Subterranean Fauna survey (EPA 2016i) • Technical Guidance: Sampling Methods for Subterranean Fauna (EPA 2016j).
Supporting Studies	• Subterranean Fauna Survey. Biologic (2019e); Appendix 2-2 • Level 1 Vertebrate Fauna, Desktop SRE, Subterranean Assessment. Biologic (2017a) Appendix 1-1
Existing Environment	Existing environment information is based on results and findings from supporting studies commissioned by Calidus, as summarised above.

Element	Description – Subterranean Fauna
	Prior to Biologic (2019e), no previous subterranean fauna sampling has been undertaken within the Proposal area, with the nearest survey conducted 20km south at Corunna Downs. A Level 2 subterranean fauna assessment was undertaken within the Proposal area, which sampled 118 bores and holes, resulting in 1979 subterranean fauna specimens, comprising almost 99% stygofauna (1955 specimens) and 1% troglofauna (24 specimens). **Troglofauna** Relative to other subterranean fauna surveys within the wider area, the troglofauna species assemblage recorded within the Proposal area is considered depauperate (Biologic 2019e). *Blattodea* were the most abundant group, accounting for the majority of troglofauna recorded (75%, 19 specimens), followed by *Zygentoma* (3 specimens) with single records of *Pseudoscorpiones*, *Diptera* and *Coleoptera.* Of the six morphospecies recorded, one taxon is known to be widespread in the Pilbara and one taxon was recorded from multiple sites within the Proposal area. Two troglofauna taxa were recorded as singleton records (one individual from a single site). The remaining two groups represented indeterminate taxa that could not be resolved to species-level due to specimens being immature, in poor/damaged condition or the wrong sex for species- level identifications. Of these, one taxon was recorded from multiple locations within the Proposal area whereas the remaining taxon was a unique singleton record (Biologic 2019e). Overall, one taxon is widespread in the Pilbara, one taxon was recorded from multiple sites, and two taxa were recorded as singleton records (with the two remaining groups unable to be resolved to species-level) (Biologic 2019e). **Stygofauna** The stygofauna specimens resulted in 28 morphospecies and five indeterminate taxa, representing a rich stygofauna species assemblage compared to nearby surveys. Fourteen stygofauna taxa were widespread and known to occur throughout the wider catchment or regionally. Ten stygofauna taxa were recorded from multiple locations within the Proposal area, with known linear ranges ranging from 0.13km to 17 km. Three stygofauna taxa were singleton taxa or known only from a single site, whereas the remaining taxon represented a unique higher-level taxon that could not be identified to species level (Biologic 2019e). **Subterranean habitat** Overall, the current geological and hydrogeological information suggests that the potential habitats for troglofaunal and stygofaunal species found in the Proposal area is likely to extend beyond the pit boundaries, particularly at Klondyke pit to the north, north-west and south-east via shear zones and to the west via faults and fractures.
Assessment of Potential Impacts	A risk assessment for subterranean fauna was undertaken, based on current taxonomic and ecological information, available habitat information. One troglofaunal taxon and 3 stygofauna taxon were considered at 'Moderate' risk. No groups were 'High' risk, with all other groups receiving a 'Low' risk rating. Taxa are generally regarded as a moderate risk due to their high likelihood to represent short-range endemic stygobite species, as localised speciation and short-range endemism are common patterns within their taxonomic groups. The 'Moderate risk ranked subterranean fauna are listed below (Biologic 2019e): **Troglofauna** • *Cryptorhynchinae* sp. `BCO185`, **Stygofauna** • *Megastygonitocrella* sp. `BHA256` • *Pilbaranella* sp. `BSY042`, and • *Billibathynella* sp. `BSY043` A hydrogeological assessment of 'Moderate' risk groups was then undertaken to determine habitat connectivity, the results of which are detailed below (Biologic 2019e).

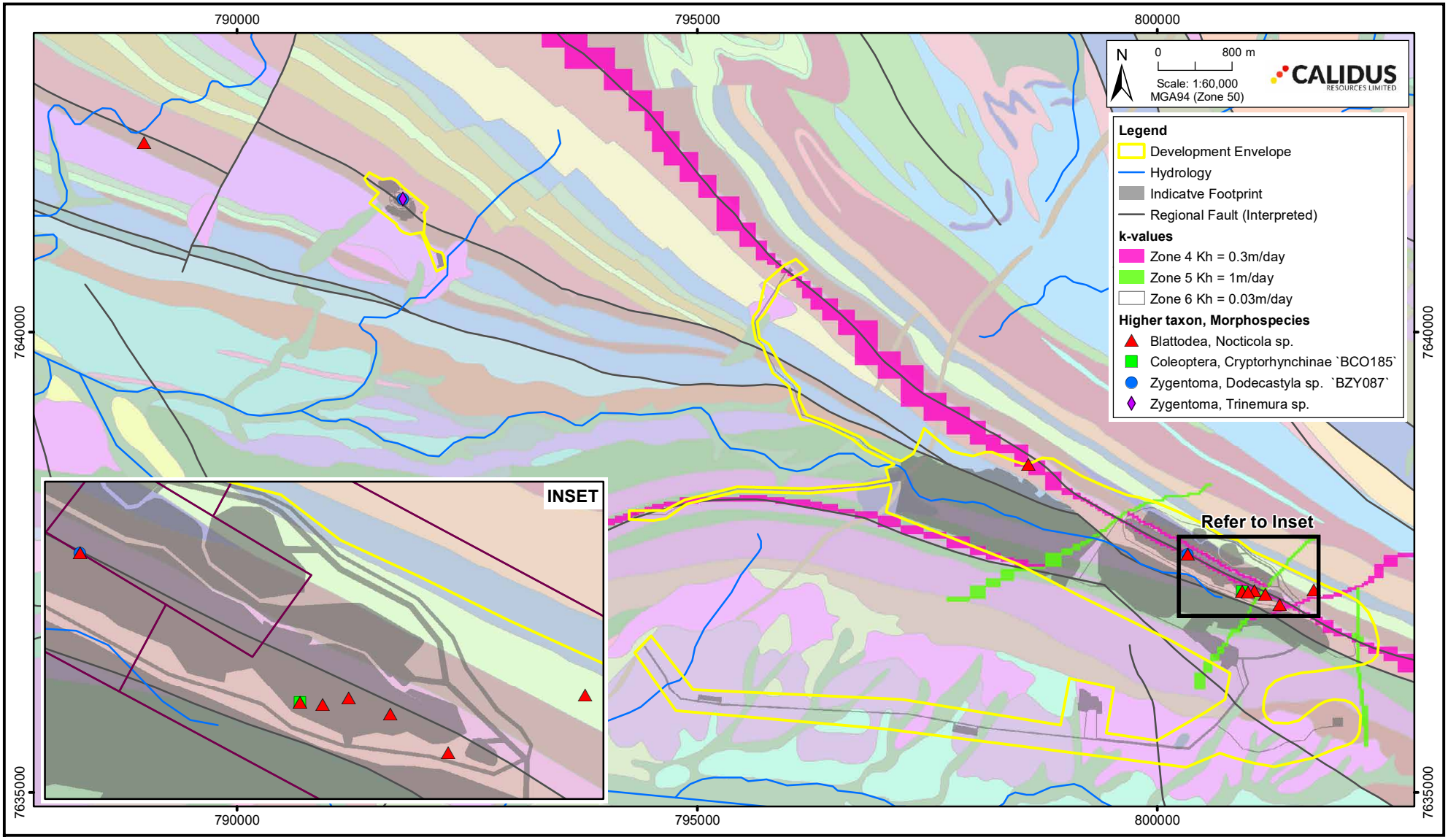
Element	Description – Subterranean Fauna
	Habitat connectivity, Klondyke Recent hydrological tests of bores in and around the proposed Klondyke pit show that the majority of the underlying geology at Klondyke is of low permeability (Groundwater Resource Management 2019b) (Figure 38). However, the Klondyke shear which strikes northwest through the centre of the deposit provides a zone of preferential flow and permeability (fractured rock habitats), which is the most likely habitat for troglofauna in the area of the deposit. The Klondyke shear zone runs for approximately 40km throughout and beyond the Klondyke deposit to the north, north-west and south-east (Figure 38; Figure 39). The Klondyke shear is paralleled by several other shears, including the St. George and Coronation shears (Figure 38). Hydrological testing showed that at least two vertical fracture zones and faults cross the Klondyke Shear within and near the deposit, though it is very likely that they are more numerous throughout the area (Groundwater Resource Management 2019b). Such fracture zones and faults support enhanced permeability (Groundwater Resource Management 2019b) and are likely to comprise highly suitable habitat for troglofauna (above water table). Therefore, it is likely that a network of habitable rock fractures may occur to the north, north-west and south-east of the proposed pit via the Klondyke shear, and into the west via transverse/ vertical fractures and faults. Potential connectivity between fractured rock habitats and superficial detrital habitats may also occur in the vicinity of weathered saprolite valley fill and alluvials near drainage lines (Biologic 2019e). **Habitat connectivity, Copenhagen** Due to a strong hydraulic gradient from the Warrawoona Ranges to the south-west, the groundwater table at Copenhagen, Fieldings Gully, and Coronation is very close to the surface. Consequently, potential troglofauna habitat at these deposits is limited to surface geologies <5mbgl. Similarly, to Klondyke, hydraulic testing showed the basement geology (basic and ultrabasic volcanic rocks) to be mostly impermeable, therefore shears/ fracture zones in the rocks and thin detrital layers are likely to be the most suitable habitat at Copenhagen, with near-surface habitats extensive along the Warrawoona Syncline. This is further supported by a recent soil and landforms report (Mine Earth 2019), which demonstrated that the surface soils between Copenhagen and Klondyke are chemically and physically consistent. Although current geological information is limited, it is likely that suitable habitat for the troglofauna species found within Copenhagen occurs beyond the pit boundaries (Biologic 2019e).
Mitigation	Calidus has developed a series of procedures to mitigate potential impacts from the Proposal. Procedures most relevant to the management of impacts to Subterranean Fauna are summarised below: • Ground Disturbance Permit Procedure, CRL-ENV-PRO-001-19 • Hydrocarbon Management Procedure, CRL-ENV-PRO-004-19 • Hydrocarbon (and chemical) Spill Management Procedure, CRL-ENV-PRO-005-19 • Groundwater Monitoring Procedure, CRL-ENV-PRO-021-19
minimise/ rehabilitate	• Licence all groundwater abstraction under the RIWI Act and manage in accordance with licence conditions.
Predicted Outcome	Habitat connectivity for subterranean invertebrate fauna throughout the surrounding aquifers and geologies is considered likely and not restricted to the Proposal area (Biologic 2019e). The current geological and hydrogeological information suggests that the potential habitats for subterranean invertebrate species found at both Klondyke and Copenhagen pits is likely to extend beyond the pit boundaries (Biologic 2019e). At Klondyke, habitat connectivity is expected to the north, north-west and south-east via shear zones and to the west via faults and fractures. Copenhagen subterranean habitat is also connected through surface detritals/colluvials. Proposed water abstraction and mine pit dewatering is not considered to pose a conservation risk to subterranean fauna, given the high likelihood that habitat extends beyond the modelled extent of drawdown (both lateral and vertical) as defined in Section 5 and Section 6.1. This Proposal is expected to meet the EPA's objective for subterranean fauna "to protect subterranean fauna so that biological diversity and ecological integrity are maintained."

Figure 38: Permeability modelling (K-zones) and subterranean habitat features (Source: Biologic 2019e; Appendix 2-2)



Source: GRM - k-values, Biologic - Subterranean Fauna
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_38, Rev: A

Figure 39: Locations of troglofauna taxa potentially at risk from proposed impacts (Source: Biologic 2019e; Appendix 2-2)



Source: GRM - k-values, Biologic - Subterranean Fauna, DMIRS - Geology
Drawn: CAD Resources (08 9246 3242), Date: Oct 2019, CAD Ref: a2738_F001_39, Rev: A

6.6 Air quality

Element	Description – Air Quality
EPA Objective	To maintain air quality and minimise emissions so that environmental values are protected.
Policy and Guidance	• Environmental Factor Guideline – Air Quality (EPA 2016k) • National Environment Protection (Ambient Air Quality) Measure (NEMP 2016).
Supporting Studies	• Warrawoona Gold Project – Assessment of Dust Emissions. Environmental Technologies and Analytics. Environmental Technologies and Analytics (2019); Appendix 3-6 • Hydro-Meteorological and Surface Water Management Study. Groundwater Resource Management (2019a); Appendix 4-1
Existing Environment	Existing environment information is based on results and findings from supporting studies commissioned by Calidus, as summarised above. An air emissions desktop assessment has been completed for the Proposal area, which included characterising the local climate and meteorology and potential atmospheric emissions for the Proposal, in support of the environmental regulatory approval (Environmental Technologies and Analytics 2019). It is expected that the Proposal will create dust emissions due to construction, blasting, haulage and general traffic activities, the impacts of which may not be confined to the development envelope. Mean annual wind roses show that easterly's and south-easterlies predominate in the morning, but by the afternoon north-westerly's and northerlies prevail. For the morning observation time it was noted that it was calm for about 7% of the year, while afternoons are nearly always windy with calm conditions noted only about 0.5% of the time (Groundwater Resource Management 2019a). Conventional dust management measures have been incorporated into the design of the Project. It is expected that, with the conventional measures in conjunction with the adopted exclusion zone and setback to sensitive roost locations, airborne dust emissions will be maintained within acceptable levels at sensitive receptor locations (Environmental Technologies and Analytics 2019).
Assessment of Potential Impacts	The Proposal; will at times generate dust emissions which may result in a temporary/short term impact, particularly during construction, blasting, haulage and general traffic activities. An assessment on air quality found that the Proposal, in isolation of other emissions, presents minimal impact on the air quality in the region.
Mitigation	Calidus has developed a series of procedures to mitigate potential impacts from the Proposal. Plans and procedures most relevant to the management of impacts to Air Quality are summarised below: • Blast Management Procedure, CLR-ENV-PRO-017-19 (Appendix 9-2) • Dust Management Procedure, CRL-ENV-PRO-015-19 • Significant Species Management Plan, CRL-ENV-PLN-006-19 (Appendix 9-1) • WRD and TSF Closure Procedure, CRL-ENV-PRO-023-19 (Appendix 9-7)
minimise	• Implement Blast Management Plan (CLR-ENV-PRO-017-19) • Areas subject to topsoil stripping will be minimised reducing the surface area exposed • Water trucks will be used to apply water to disturbed surfaces and unsealed road surfaces • Unsealed road surfaces will be maintained regularly to retain surface integrity • Vehicle speeds will be limited on unsealed roads to minimise wheel generated dust • Dust suppression water sprays will be installed and operating at the processing plant – primary crusher, conveyor to surge bin, surge bin to emergency conveyor, emergency conveyor to stockpile, surge bin to apron feeder, reclaim hopper to conveyor, and conveyor to SAG Mill.

Element	Description – Air Quality
Predicted Outcome	Dust generation is unavoidable during construction and operations, but it is not considered significant if industry standard controls are implemented. Conventional dust management measures have been incorporated into the design of the Proposal. It is expected that, with conventional dust management measures and the proposed mining exclusion zone and 200m buffer to sensitive roost locations, airborne dust emissions will be maintained within acceptable levels at sensitive receptor locations. As the Proposal will not significantly affect air quality and will implement measures to minimise impacts on environmental values, this Proposal is expected to meet the EPA's objective for air quality, "to maintain air quality and minimise emissions so that environmental values are protected."

7 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecologically communities and heritage places, defined in the EPBC Act as matters of national environmental significance. Under the EPBC Act, an action will require approval from the Minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

Four terrestrial fauna species confirmed within the Proposal area are listed as matters of national environmental significance:

- Northern Quoll
- Ghost Bat
- Pilbara Leaf-nosed Bat
- Pilbara Olive Python

An assessment has been made to determine if the Proposal is 'likely to have a significant impact' on each of these EPBC Act listed species. Based on DoEE (2013), if a Proposal is 'likely to have a significant impact' it is "*not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility*". The assessment criteria is based on the significant impact criteria for Endangered and Vulnerable species as described in DoEE (2013).

7.1 Endangered

The Northern Quoll is classified as Endangered under the EPBC Act. Referral guidelines (DoEE 2016) define populations important for the long-term survival of the species as;

- high density quoll populations, which occur in refuge-rich habitat critical to the survival of the species, including where cane toads are present
- occurring in habitat that is free of cane toads and unlikely to support cane toads upon arrival i.e. granite habitats in WA, populations surrounded by desert and without permanent water; or
- subject to ongoing conservation or research actions i.e. populations being monitored by government agencies or universities or subject to reintroductions or translocation.

An assessment of the significance of the Proposal on the Northern Quoll is presented in Table 35.

7.2 Vulnerable

The Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python are classified as Vulnerable under the EPBC Act and BC Act. An 'important population' of a Vulnerable species is defined by DoE (2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

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

Habitat critical to the survival of a species is defined by (DoE 2013b) as areas that are necessary:

- 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; and/or
- for the reintroduction of populations or recovery of the species or ecological community.

An assessment of the significance of the Proposal on the confirmed EPBC Act listed Vulnerable species (Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python) confirmed as occurring within the Proposal area is presented in Table 36.

Table 35 Significance of the Proposal to fauna considered Matters of National Environmental Significance (MNES) (confirmed Endangered species)

MNES Significant Impact Criteria	Likelihood of a significant Impact* (DoEE 2013 criteria)	Justification
Northern Quoll *Dasyurus hallucatus*		
Result in the loss of habitat critical to the survival of the northern quoll	Likely	Denning habitat for the Northern Quoll comprises rugged, rocky areas, often in close association with permanent water (Molloy 2015; Oakwood 2000). Although no permanent water is in close proximity, the denning habitat is consistent with Rocky Breakaway habitat type recorded in the Proposal area. Approximately 19ha of the Rocky Breakaway habitat type is present in the broader Proposal area (approximately 1% of the total area surveyed) (Biologic 2017a). The Medium/Minor Drainage Lines, Rounded Hills, and Hillcrest/Hillslope habitats are also considered important habitat due to the ability to provide foraging and dispersal habitat for the species. Approximately 1,107ha (61% of the area surveyed across the Proposal area). As the proposed development is likely to disturb denning habitat and important foraging and dispersal habitat, it is possible that the Proposal may have a significant impact on the species based on this criterion.
Decrease the size of a population important for the long-term survival of the northern quoll and therefore interfere with the recovery of the species	Likely	As defined by DoE (2016), the population existing across the Proposal area is considered to be a high density population, as numerous camera triggers of multiple individuals across multiple cameras and or traps has occurred over three consecutive years (Biologic 2019g). The continued annual presence of a similar number of animals in high densities as defined above (DoE 2016) defines the likely resident population as important for the long-term survival of the Northern Quoll. The Proposal will reduce the amount of local foraging and dispersal habitat, and potentially exacerbate threatening processes through indirect impacts such as introduced species, altered fire regimes, vehicle strike and altered hydrology, and therefore may impact the population through a loss of individuals. The Proposal is likely to have a significant impact on the species based on this criterion.

MNES Significant Impact Criteria	Likelihood of a significant Impact* (DoEE 2013 criteria)	Justification
Introduce inappropriate fire regimes or grazing activities (i.e. Increasing the risk of late dry season high intensity fires to the area) that substantially degrade habitat critical to the survival of the northern quoll or decrease the size of a population important for the long-term survival of the species.	Unlikely	The Proposal is unlikely to significantly increase the impact caused by grazing in the area or changed fire regimes and unlikely to cause significant impact to the species based on this criterion.
Fragment a population important for the long-term survival into two or more populations.	Unlikely	Infrastructure at the proposal area is unlikely to restrict interaction between individuals. The species is regarded as having good dispersal capabilities (Spencer 2013; Woolley 2015) and the Proposal area is surrounded by suitable dispersal habitat (drainage lines and the Warrawoona Ranges). The Project is unlikely to cause significant impact to the species based on this criterion.
Result in invasive species or increases of them that are harmful to the northern quoll becoming established in its habitat, namely cane toads, feral cats, red foxes or exotic grasses which increase fire risk.	Unlikely	Feral cats have been recorded in the Study Area (Biologic 2019a) and are likely to reside in Northern Quoll habitat. The Proposal, without effective management, may result in higher feral cat numbers. However, as this population is already established, the Proposal is unlikely to have a significant impact on the species based on this criterion.

* 'likely' is "*not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility*" (DoEE 2013).

Table 36 Significance of the Proposal to fauna considered Matters of National Environmental Significance (MNES) (confirmed Vulnerable species)

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Ghost Bat *Macroderma gigas*		
Lead to a long-term decrease in the size of an important population of a species	Likely	The Ghost Bat colony associated with the Warrawoona Range is considered an important population based on consistently high monitoring records and activity levels (Biologic 2017d, 2018, 2019f). A series of targeted bat surveys have placed the population at approximately 475 individuals (Biologic 2019f), which represents a large portion of the current known Pilbara population size of 1500-2000 individuals (Threatened Species Scientific Committee 2016a). Although adaptive management will monitor the Ghost Bat population in advance of any disturbance and adjust/refine the management measures accordingly, impacts to the size of the colony at Klondyke Queen are possible and remain a risk.
Reduce the area of occupancy of an important population	Unlikely	Mitigation measures for potential impacts are in place to ensure that the colony will persist at the Klondyke Queen roost. Displaced individuals roost at Bow Bells South (occasional diurnal roost), or further afield at Comet mine roost, 20km northwest and outside the Proposal area (Biologic 2019d). The Proposal is unlikely to have a significant impact on the species based on this criterion.
Fragment an existing important population into two or more populations	Unlikely	Genetic analysis suggest that there is a single, large, highly diverse genetic population of Ghost Bats in the Pilbara region with significant movement between caves (Biologic 2017b). Proposed mitigation and adaptive management measures during operations will ensure the local colony can persist within the Klondyke Queen roost. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Adversely affect habitat critical to the survival of a species	Likely	Impact on the Klondyke Queen roost will be managed through ongoing monitoring, adaptive management and mitigation, but remains at risk from possible indirect impacts. Blasting controls and limits on movements of heavy vehicles will reduce the risk of collapse. Cyanide reduction (detoxification) processes will maintain cyanide concentrations in tailings slurry at acceptably low levels (WAD cyanide discharge less than 30mg/L). Groundwater drawdown associated with the mine pit dewatering may alter humidity within the roost, however Ghost Bats are known to tolerate a broad range of humidity levels (Biologic 2019f; R. Bullen, Bat Call WA, pers. comm. 2019).

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Disrupt the breeding cycle of an important population	Unlikely	The colony is likely to persist within the Klondyke Queen mine (permanent maternity roost) and mitigation measures to manage impacts are in place or planned. Bow Bells South has not yet been confirmed as a breeding roost despite multiple surveys (Biologic 2017d, 2018, 2019f); however, there are breeding records at the nearby Comet mine (Armstrong and Anstee 2000), which is approximately 20km northwest and outside the Proposal area. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	The colony is likely to persist within the Klondyke Queen roost and it is unlikely that there will be a significant impact to foraging habitat. Rocky outcrop habitat types account for 18.6ha of the area surveyed at the Proposal area, of which only 0.8ha is within the proposed disturbance footprint (which represents 4.6% of this habitat types known extent across the Proposal area). Foraging habitat types associated with watercourses represents 55.5ha of the area surveyed, with 14.3ha (25.8%) of this surveyed habitat type in the disturbance footprint. The area surveyed also contains approximately 1,742ha of open grassland foraging habitat types, of which approximately 380ha is within the disturbance footprint (just 21.8% of its surveyed area). The species is also known to prefer foraging habitat outside of the Proposal area in the plains to the north and south of the Warrawoona Ranges (Biologic 2019d, 2019e). The Proposal is unlikely to have a significant impact on the species based on this criterion.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	The colony is likely to persist within the Klondyke Queen roost and no significant impacts from invasive species introduced by the mine's operations are foreseen. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Introduce disease that may cause the species to decline	Unlikely	The Proposal is not likely to introduce or increase transmission of any diseases relevant to this species. The Proposal is unlikely to have a significant impact on the species based on this criterion, and the colony is likely to persist within the Klondyke Queen roost.

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Interfere substantially with the recovery of the species.	Unlikely	Impact on the size of the Ghost Bat colony is unlikely. Fluctuations in population size occur presently and so natural fluctuations in population/colony size during mining operations may be expected. Any limited reduction during operations is expected to recover following completion of the operations. Any major reduction of the colony size during operations will initiate adaptive management procedures to further mitigate or remove impacts. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*		
Lead to a long-term decrease in the size of an important population of a species	Likely	The colony associated with the Warrawoona Range is part of a much broader and nationally significant Pilbara/upper Gascoyne interbreeding biological population comprising multiple colonies and genetically distinct from northern populations (Threatened Species Scientific Committee 2016b). The colony is likely to persist within the Bow Bells South mine, approximately 4km from the Klondyke mine, an important roost for the Pilbara Leaf-nosed Bat. Dewatering of roost sites presents the highest risk to the species due to their dependency on high humidity roosting conditions. Dewatering will not impact on the regionally significant colony at Bows Bell South roost, which is expected to maintain a significant saturated thickness (Groundwater Resource Management 2019b, Appendix 4-2). Although the risk of cyanide poisoning is low, the species potential dependency on local water resources during the height of the dry season may still present this impact source as a risk. The Proposal is considered likely to have a significant impact on the species based on this criterion.
Reduce the area of occupancy of an important population	Unlikely	Aside from roosting, Pilbara Leaf-nosed Bats use the Study Area as a flight path to preferred foraging grounds outside of the Warrawoona Ranges, occasionally also using areas such as the Copenhagen pit, proposed TSF area, and area north-west of Bow Bells for foraging (Biologic 2019d, 2019e). The colony is planned to persist within the Bow Bells South mine and mitigation measures for impacts are in place or planned. Therefore, the Proposal is unlikely to have a significant impact on the species based on this criterion.

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Fragment an existing important population into two or more populations	Unlikely	The Pilbara Leaf-nosed Bat in the Pilbara and upper Gascoyne represent one interbreeding biological population comprising multiple colonies (Armstrong, unpublished genetic data in Threatened Species Scientific Committee 2016b). This isolated population is of national significance. The colony is likely to persist within the Bow Bells South mine and mitigation measures for impacts are in place or planned. Therefore, the Proposal is unlikely to have a significant impact on the species based on this criterion.
Adversely affect habitat critical to the survival of a species	Likely	Both Bow Bells South and Klondyke Queen roost are classified as permanent diurnal roosts (Priority 1), and are considered "critical habitat for daily survival, occupied year-round and likely to be the focus for some part of the 9-month breeding cycle", as defined by Threatened Species Scientific Committee (2016b). The colony is likely to persist within the Bow Bells South mine, although Klondyke Queen may result lower humidity levels following dewatering, which may influence the habitat value of Klondyke Queen roost for this species. Priority 3 foraging habitat for Pilbara Leaf-nosed Bats identify with the Rocky outcrop habitat types at the Proposal area, which account for 18.6ha of the area surveyed, of which only 0.8ha is within the proposed disturbance footprint (which represents 4.6% of this habitat types known extent across the Proposal area). Foraging habitat types associated with watercourses represent 55.5ha of the area surveyed, with 14.3ha (25.8%) of this surveyed habitat type in the disturbance footprint. The area surveyed also contains approximately 1,742ha of open grassland foraging habitat types, of which approximately 380ha is within the disturbance footprint (just 21.8% of its surveyed area). The species is also known to prefer foraging habitat outside of the Proposal area, in the plains to the north and south of the Warrawoona Ranges (Biologic 2019d, 2019e). Appropriate management of the tailing pond containing cyanide is also planned, which will maintain a concentration of WAD cyanide discharge at less than 30mg/L, which is well below the mining industry water quality benchmark for the protection of wildlife (of 50mg/L) (Donato *et al.* 2007).
Disrupt the breeding cycle of an important population	Likely	Bow Bells South and Klondyke Queen are classified as permanent diurnal roosts (Biologic 2019f), with observations of pregnant bats exiting at the adit in January 2019 (R. Bullen, Bat Call WA, pers. comm. 2019 in Biologic 2019f). The colony is likely to persist within the Bow Bells South roost, 4km from the Klondyke mine. Abandonment of Klondyke Queen by Pilbara Leaf-nosed Bats may occur following dewatering activities. However, the colony currently utilises roosts both at Bow Bells South and Klondyke Queen, fluctuating between the two sites on a regular basis, indicating that Bow Bells South can (and already does) accommodate the Klondyke Queen colony (R. Bullen, Bat Call WA, pers. comm. October 17, 2019).

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	The colony is likely to persist within the Bow Bells South roost, and the disturbance footprint is a small portion of the overall foraging and roosting habitat available (as discussed above). The species also forage outside the Proposal area, preferring the plains to the north of the Warrawoona Ranges and the areas north-west of Bow Bells and Copenhagen (Biologic 2019d, 2019e). The Proposal is unlikely to have a significant impact on the species based on this criterion.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	The colony is likely to persist within the Bow Bells South mine and no significant impacts from invasive species introduced by the mine's operations are foreseen. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Introduce disease that may cause the species to decline	Unlikely	The Proposal is not likely to introduce or increase transmission of any diseases relevant to this species. The Proposal is unlikely to have a significant impact on the species based on this criterion, and the colony is likely to persist within the Bow Bells South roost.
Interfere substantially with the recovery of the species.	Unlikely	Potential impact on the size of the Pilbara Leaf-nosed Bat colony can be mitigated through the implementation of the Significant Species Management Plan (CRN-ENV-PLN-006-19, Appendix 9-1) but the fluctuation in population size of the colony during the mining operation cannot be foreseen. Any reduction during operations is expected to recover post closure. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Pilbara Olive Python *Liasis olivaceus barroni*		
Lead to a long-term decrease in the size of an important population of a species	Unlikely	Foraging and dispersal habitats are present in the Medium/Minor Drainage Lines and Rocky Breakaway habitat types of the Proposal area (68ha or 37% of the area surveyed) (Biologic 2017a), which is likely to be impacted during development, although some level of habitat disturbance appears to be tolerated. There is also a lack of permanent water features recorded in proximity to the Proposal area. Based on the lack of records (despite targeted surveys) and the quality and quantity of preferred habitat (relative to the surrounding region) the population of Pilbara Olive Pythons inhabiting the Proposal area is unlikely to represent a source population (therefore, not an 'important population'). For this reason, it is unlikely the Proposal will have a significant impact on the species based on this criterion.

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Reduce the area of occupancy of an important population	Unlikely	Of the 68ha of preferred Medium/Minor Drainage Lines and Rocky Breakaway habitat types for the species, the Proposal is likely to disturb approximately 15ha of this habitat type (just 22% of the habitat type surveyed within the Proposal area). The population occurring within the Proposal area is also unlikely to represent an important population (as discussed above) and thus the Proposal is unlikely to have a significant impact on the species based on this criterion.
Fragment an existing important population into two or more populations	Unlikely	The species is highly mobile and able to travel extensive distances (Pearson 2003; Tutt 2004). Drainage Lines and Rocky Breakaway habitat types are used as dispersal habitat types and are well represented outside the Proposal area throughout the Warrawoona Ranges, providing a thoroughfare for the species to disperse through the region. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Adversely affect habitat critical to the survival of a species	Unlikely	The Proposal will involve the removal of approximately 15ha of the Pilbara Olive Python's preferred habitat type, Medium/Minor Drainage Lines and Rocky Breakaways, which is just 22% of these habitat types surveyed within the Proposal area. Some level of habitat disturbance appears to be tolerated by the Pilbara Olive Python and the remaining habitat is unlikely to be adversely affected by the Proposal. The Proposal is not likely to have a significant impact on the species based on this criterion.
Disrupt the breeding cycle of an important population	Unlikely	Although preferred habitat will potentially be lost, following the initial ground disturbance activities, there are few threatening processes that will have an ongoing adverse impact on the breeding cycle of the population. The population does not meet the criteria of an important population and the Proposal is unlikely to cause significant impact to the species based on this criterion.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	The species is highly mobile and able to travel extensive distances (Pearson 2003; Tutt 2004). Drainage Lines and Rocky Breakaway habitat types are used as dispersal habitat types and are well represented outside the Proposal area throughout the Warrawoona Ranges, providing a thoroughfare for the species to disperse through the region. The Proposal is unlikely to have a significant impact on the species based on this criterion.

MNES Significant Impact Criteria	Likelihood of a significant impact* (DoEE 2013 criteria)	Comments/Assessment
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	Feral cats have been recorded across the Proposal area (Biologic 2019a) and are likely to reside in some preferred habitat of the Pilbara Olive Python. Predation by introduced species (cats, foxes, dogs) is identified as a major threat for the species more broadly, as well as predation from these species on the Pilbara Olive Python's food sources (Ellis 2013). Given a population of introduced species already resides in the Proposal area, the Proposal is unlikely to have a significant impact on the species based on this criterion. Management measures will be implemented to ensure that introduced animal density/abundance is not increased as a result of the Proposal.
Introduce disease that may cause the species to decline	Unlikely	The Proposal is unlikely to introduce or increase transmission of any diseases relevant to this species. The Proposal is unlikely to have a significant impact on the species based on this criterion.
Interfere substantially with the recovery of the species.	Unlikely	The Proposal is unlikely to interfere substantially with any conservation recovery initiative for the species. The Proposal is unlikely to significant impact the species based on this criterion.

* 'likely' is "*not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility*" (DoEE 2013).

8 HOLISTIC IMPACT ASSESSMENT

The Proposal is located in an historical mining belt, utilised for pastoral activities and mineral exploration. Baseline studies since 2016 have contributed significantly to the scientific understanding of the area and allowed Calidus to design the Proposal in a way that identifies, prevents and minimises adverse environmental impacts.

Calidus has undertaken substantial investigations, which have guided the assessment of potential risks to the environment from the Proposal. The investigations have relied on the technical skills and experience of over 25 specialised consultants, and covered a range of factors and aspects relevant to the Proposal, including terrestrial and subterranean fauna; flora and vegetation; air quality (dust); noise; vibration/blasting; geotechnical and geochemical analysis of soils and waste; hydrogeology and hydrology; and ethnographic and archaeological investigations.

The results of these investigations, consultations and risk assessments have all been taken into account in developing the Proposal and preparing this document.

Colonies of Ghost Bats and Pilbara Leaf-nosed Bats are highlighted in this document as at risk from the Proposal because roosts of regional significance occur within the Proposal area, albeit outside the indicative disturbance footprint.

Detailed assessment of the Proposal's impact on environmental factors, including relevant mitigation commitments and the predicted outcomes, are provided in Sections 5 and 6. A summary of the findings from each environmental factor assessed is also presented in the Executive Summary.

One 'key preliminary factor', terrestrial fauna, is considered most relevant to the Proposal. This factor is described in detail in Section 5.

Six 'other factors' are summarised in Section 6, and include: 1) inland waters; 2) flora and vegetation; 3) terrestrial environmental quality; 4) social surroundings (Aboriginal heritage and culture); 5) subterranean fauna; and 6) air quality. These other factors are considered unlikely to be significantly impacted by the Proposal and can be largely managed through secondary environmental approval processes and regulatory mechanisms to achieve an appropriate environmental outcome.

Consideration has also been given to the interaction between the assessed environmental factors. Many aspects of the Proposal have the potential to impact on multiple factors, and understanding this has enabled mitigation strategies to consider and manage multiple factors. Table 37 presents a holistic overview of all the potential impacts and mitigation measures that extend across multiple factors (including key and other factors) of the Proposal.

The Proposal will include a mining exclusion zone and 200m 'blasting' buffer to further protect important roosting sites, and has developed a series of adaptive management plans and procedures, specifically designed to reduce and mitigate impacts associated with the key environmental factors of the Proposal through monitoring outcomes. Plans and procedures include a Significant Species Management Plan (CRL-ENV-PLN-006-19; Appendix 9-1), Blasting Management Procedure (CRL-ENV-PRO-017-19; Appendix 9-2), Surface Water Monitoring Procedure (CRL-ENV-PRO-020-19; Appendix 9-3), Groundwater Monitoring Procedure (CRL-ENV-PRO-021-19; Appendix 9-4), TSF and Cyanide Management Procedure (CRL-ENV-PRO-019-19; Appendix 9-5), Metalliferous Drainage Management Procedure (CRL-ENV-PRO-022-19; Appendix 9-6), and WRD and TSF Closure Procedure (CRL-ENV-PRO-023-19, Appendix 9-7).

As part of an adaptive management approach, Calidus will continue to work closely with technical experts across key factors (i.e. bat and other fauna specialists, hydrologists, specialists in materials characterisation and metalliferous waste management) to better understand the issues and to refine/adapt management measures accordingly. Additional investigations proposed include:

- Ongoing monitoring of conservation significant fauna, including the Ghost Bat, Pilbara Leaf-nosed Bat, and the Northern Quoll and their habitat across the Proposal area to further understand population dynamics and habitat condition over time.
- Surface water monitoring to establish a baseline dataset to assist in the development of triggers and thresholds in surface water management.
- Further hydrogeological investigations in order to refine current flow models.
- Other investigations, as described in the Significant Species Management Plan (CRL-ENV-PLN-006-19)

Given the Proposal design considerations, the implementation of management measures outlined in this document and provisions under other regulatory mechanisms (such as the Mining Act, RIWI Act, AH Act and Part V of the EP Act), Calidus is of the view that the Proposal can be implemented consistent with EPA objectives, and without material risk to maters of national environmental significance.

Table 37 Holistic impact assessment summary

Proposal aspect (activities with the potential to cause harm)	POTENTIAL IMPACTS TO KEY AND OTHER FACTORS							
	Terrestrial Fauna	Inland Waters	Flora and Vegetation	Subterranean Fauna	Terrestrial Environmental Quality	Air Quality	Social Surroundings	Mitigation tools
Land clearing	No loss of any diurnal roosts. Loss of 5-night refuge sites within the mine pits. These sites are not diurnal roosts and not considered critical habitat. Removal of high value habitat for other species of conservation significance is low, with less than 1ha of proposed disturbance to rocky breakaways (important to the Northern Quoll and Pilbara Olive Python).	Very minor loss of Coongan River Catchment. The total area of catchment loss is approximately 6.8km^2, which represents an almost 0.1% loss to the total Coongan River catchment.	No TECs, PECs, Threatened Flora or vegetation of regional significance.	There are no high risk troglofaunal or subterranean fauna groups recorded in the Proposal area. Geological connectivity along the Warrawoona Range also ensures habitat linages.	Topsoil assessment has identified adequate topsoil resources (containing no problematic materials) from a range of soil types across the Proposal area. Topsoil stockpiles have been considered in disturbance footprint.	Dust generation is unavoidable but is not considered significant if industry standard controls are implemented. No sensitive receptors on the surface in close proximity to the Proposal.	The mine plan has been modified to avoid known archeological places within the Proposal area. No known heritage places will be disturbed.	Ground Disturbance Permitting procedures Significant Specie Management Plan Surface Water Monitoring Procedure
Mine pit dewatering	Reduction in bat roosting habitat quality/condition.	Mine pit dewatering will reduce local groundwater levels in the vicinity of Klondyke pit	No Groundwater Depending Vegetation/Ecosystems recorded in the Proposal area	Potential subterranean fauna habitats are likely to extend widely beyond the pit boundaries.	Mine dewatering will develop a strong local hydraulic gradient towards the Klondyke pit, such that any potential infiltration from the TSF and WRD will likely migrate towards it.	NA	NA	Significant Species Management Plan Groundwater Monitoring Procedure Metalliferous Drainage Management Procedure. Mine Closure Plan
Waste storage and handling (TSF, WRD, NAZ waste material)	Ingesting poor quality water or tailings slurry may harm individuals.	Loss of containment of NAZ waste streams into the environment	NA	Harmful waste material will be appropriately encapsulated in mine pits and within WRDs, to	Unsuccessful rehabilitation as a result of poor-quality waste material	NA	NA	Significant Species Management Plan Surface Water Monitoring Procedure

Proposal aspect (activities with the potential to cause harm)	POTENTIAL IMPACTS TO KEY AND OTHER FACTORS							
	Terrestrial Fauna	Inland Waters	Flora and Vegetation	Subterranean Fauna	Terrestrial Environmental Quality	Air Quality	Social Surroundings	Mitigation tools
		Increased risk of flooding upstream from valley filled TSF		avoid seepage and surface drainage				Groundwater Monitoring Procedure TSF and Cyanide Monitoring Procedure Metalliferous Drainage Management Procedure Landform Management Plan Mine Closure Plan
Mine pit lake	Poor water quality and potentially harmful water source	Poor water quality and surrounding groundwater resource	NA	Potential subterranean fauna habitats are likely to extend widely beyond the pit boundaries.	NA	NA	NA	Significant Species Management Plan Surface Water Monitoring Procedure Groundwater Monitoring Procedure Metalliferous Drainage Management Procedure WRD and TSF Closure Procedure Mine Closure Plan
Increased human presence (vehicle activity, waste generation, water storage etc.)	Death or injury from vehicle strike. Waste from camp attracts feral animals, (increasing competition and predation), native animals (altering feeding and foraging patterns) and increases human/animal interactions.	NA	Potential increase in weed abundance. Changes in fire regimes	NA	Potential soil contamination from hydrocarbon spills	Dust generation along road corridors	NA	Significant Species Management Plan Hydrocarbon Management Procedure Hydrocarbon (and chemical) Spill Management Procedure

Proposal aspect (activities with the potential to cause harm)	POTENTIAL IMPACTS TO KEY AND OTHER FACTORS							
	Terrestrial Fauna	Inland Waters	Flora and Vegetation	Subterranean Fauna	Terrestrial Environmental Quality	Air Quality	Social Surroundings	Mitigation tools
Blasting	Increased noise and vibration emissions on adjacent bat roosts.	NA	Dust deposition reducing the condition of vegetation	NA	NA	Dust generation surrounding the mine pit	NA	Blast Management Procedure Significant Species Management Plan

9 REFERENCES

Armstrong, K. (2001) The distribution and roost habitat of the Orange Leaf -nosed Bat, Rhinonicteris aurantius, in the Pilbara region of Western Australia. Wildlife Research **28**, 95–104.

Armstrong, K.N. and Anstee, S.D. (2000) The Ghost Bat in the Pilbara: 100 years on. Australian Mammalogy **22**, 93–101.

ATC Williams (2019) Tailings Storage Facility Design Report - Feasibility.

Beard, J.S. (1975) The vegetation survey of Western Australia. Vegetation.

Biologic (2017a) Pilbara Ghost Bat Genetic Project 2017 (Unpublished report prepared for the BHP Billiton Iron Ore Pty Ltd).

Biologic (2017b) Warrawoona Level 1 Vertebrate Fauna, and Desktop SRE and Subterranean Assessment. Report prepared for Calidus Resources Limited.

Biologic (2018a) Warrawoona Targeted Bat Assessment - September 2017. Report prepared for Calidus Resources Limited. February 2018.

Biologic (2018b) Warrawoona Targeted Bat Assessment - July 2018. Report prepared for Calidus Resources Limited. September 2018.

Biologic (2018c) Warrawoona Gold Project: VHF Bat Foraging Studies. Report prepared for Calidus Resources Limited. July 2018.

Biologic (2018d) Warrawoona Gold Project. SRE Invertebrate Fauna Survey. Calidus Resources Limited.

Biologic (2018e) Warrawoona Level 1 Fauna Assessment. Report prepared for Calidus Resources Limited. February 2018.

Biologic (2019a) Warrawoona Targeted Bat Assessment - April 2019. Report prepared for Calidus Resources Limited. May 2019.

Biologic (2019b) Warrawoona Gold Project: VHF Bat Foraging Studies. Report prepared for Calidus Resources Limited. March 2019.

Biologic (2019c) Warrawoona Gold Project: Habitat Assessment and Targeted Vertebrate Fauna Survey. Report prepared for Calidus Resources Limited, 22 February 2019.

Biologic (2019d) Warrawoona Gold Project: 2019 Significant Species Survey. June 2019. Prepared for Calidus.

Biologic (2019e) Warrawoona Gold Project: Conservation Significant Bat Species Impact Assessment (Impact assessment Report).

Biologic (2019f) Warrawoona Gold Project. Conservation Significant Vertebrate Fauna Impact Assessment.

Biologic (2019g) Warrawoona Gold Project: Subterranean Fauna Survey. Draft report in prep. for Calidus Resources.

Biologic (2019h) Warrawoona Gold Project: Conservation Significant Vertebrate Fauna Impact Assessment. Report to Calidus Resources.

Blast It Global (2018) Assessment of blasting on the Klondyke Queen. A roost site for Pilbara Leaf-nosed Bat and Ghost Bat. Report prepared for Calidus Resources. 4 July 2018.

Boles, W. (1999) Avian prey of the Australian Ghost Bat Macroderma gigas (Microchiroptera: Megadermatidae): prey characteristics and damage from predation. Australian Zoologist.

Braithwaite, R.W. and Griffiths, A.D. (1994) Demographic variation and range contraction in the northern quoll, *Dasyurus hallucatus* (Marsupialia: Dasyuridae). Wildlife Research **21**, 203–217.

Bullen, R.D. (2013) Pilbara leaf-nosed bat (Rhinonicteris aurantia); summary of current data on distribution, energetics, threats. Paper presented at the Pilbara leaf-nosed bat workshop. Kensington WA.

Burbidge, A.A. (2004) Threatened Animals of Western Australia. Department of Conservation and Land Management, Kensington, Western Australia.

Burbidge, A.A., McKenzie, N.L. and Fuller, P.J. (2008) Long-tailed Dunnart (*Sminthopsis longicaudata*)., in: Mammals of Australia. Reed New Holland., Sydney, New South Wales:, pp. 148–150.

Bush, B. and Maryan, B. (2011) Field Guide to Snakes of the Pilbara, Western Australia. Western Australian Museum, Perth, Western Australia.

Churchill, S.K. (1991) Distribution, abundance and roost selection of the Orange Horseshoe-bat, Rhinonycteris aurantius, a tropical cave-dweller. Wildlife Research. **18**, 343–353.

Churchill, S.K. (1994) Diet, prey selection and foraging behaviour of the Orange Horseshore-bat, Rhinonycteris aurantius. Wildlife Research. **21**, 115–130.

Churchill, S.K. (2008) Australian Bats., Second Edition ed. ed. Allen and Unwin, New South Wales, Crow's Nest.

Churchill, S.K., Helman, P.M. and Hall, L.S. (1988) Distribution, populations and status of the orange horseshoe bat, Rhinonicteris aurantius (Chiroptera: Hipposideridae). Australian Mammalogy **11**, 27–33.

DAA (2013) Aboriginal Heritage Due Diligence Guidelines. Department of Planning, Lands and Heritage (Department of Aboriginal Affairs).

Davis and Metcalf (2008) The Night Parrot (Pezoporus occidentalis) in northern Western Australia: a recent sighting from the Pilbara region. Emu **108**, 233–236.

Department of Parks and Wildlife (2017) Interim guideline for preliminary surveys of night parrot (*Pezoporus occidentalis*) in Western Australia.

Department of Sustainability, Environment, Water, Population and Communities (2011) Survey Guidelines for Australia's Threatened mammals. EPBC Act survey guidelines 6.5, EPBC Act survey guidelines 6.5. Australian Government, Canberra, ACT.

Department of the Environment (2016) EPBC Act referral guideline for the endangered Northern Quoll *Dasyurus hallucatus*. (EPBC Act Policy Statement). Commonwealth of Australia, Canberra, Australian Capital Territory.

DER (2014) Assessment and management of contaminated sites. Contaminated sites guidelines. Department of Environment Regulation. December 2014.

DEWHA (2010) Survey Guidelines for Australia's Threatened Bats;

DEWHA (2017) Survey guidelines for Australia's threatened birds: Guidelines for detecting birds listed as threatened under the EPBC Act.

DMP & EPA (2015) Guidelines for Preparing Mine Closure Plans: http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-121.pdf.

DoEE (2013) Matters of National Significance. Significant Guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999. Department of Environment and Energy. Australian Government.

DoIIS (2016) Preventing acid and metalliferous drainage – Leading practice sustainable development program for the mining industry. Commonwealth Department of Industry Innovation and Science.

Donato, D. (1999) Bird Usage Patterns on Northern Territory Mining Water Tailings and their Management to Reduce Mortalities. Department of Mines and Energy, Darwin NT.

Douglas, A.M. (1967) The natural history of the Ghost Bat Macroderma gigas (Microchiroptera, Megasermatidae). The Western Australian Naturalist, in Western Australia. **10**, 125–137.

DoW (2007) WQPN 83: Infrastructure corridors near sensitive water resources. Department of Water.

DoW (2009) WQPN 51: Industrial wastewater management and disposal. Department of Water.

DoW (2010) WQPN 52: Stormwater management at industrial sites. Department of Water.

DoW (2013a) Western Australian water in mining guideline, Report No 12, Department of Water.

DoW (2013b) WQPN 15: Extractive industries near sensitive water resources. Department of Water.

DPaW (2017) Department of Parks and Wildlife. Interim guideline for the preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia. Kensington, Western Australia.

DSEWPC (2011) Survey Guidelines for Australia's Threatened Reptiles (Department of Sustainability, Environment, Water, Population and Communities, 2011).

Dziminski, M. and Carpenter, F. (2017) The conservation and management of the bilby (Macrotis lagotis) in the Pilbara: Progress Report 2017. Perth, Western Australia:

Environmental Technologies and Analytics (2019) Warrawoona Gold Project - Assessment of Dust Emissions. Report prepared for Calidus Resources Limited. September 2019 (No. 1084).

EPA (2016a) Environmental Factor Guideline: Terrestrial Fauna.

EPA (2016b) Technical Guidance: Terrestrial fauna surveys.

EPA (2016c) Technical Guidance: Sampling methods for terrestrial vertebrate fauna.

EPA (2016d) Technical Guidance - Sampling of short range endemic invertebrate fauna.

EPA (2016e) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016.

EPA (2016f) Environmental Factor Guideline: Inland Waters.

EPA (2016g) Environmental Factor Guideline – Social Surroundings.

EPA (2016h) Environmental Factor Guideline – Subterranean Fauna.

EPA (2016i) Technical Guidance – Subterranean Fauna survey.

EPA (2016j) Technical Guidance: Sampling Methods for Subterranean Fauna.

EPA (2016k) Environmental Factor Guideline – Air Quality.

EPA (2018a) Instructions for the referral of a Proposal to the EPA under Section 38 of the Environmental Protection Act 1986.

EPA (2018b) Statement of Environmental Principles, Factors and Objectives.

GCA (2019a) Warrawoona Gold Project: Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management.

GCA (2019b) Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management.

Gibson, L.A. and McKenzie, N.L. (2009) Environmental associations of small ground -dwelling mammals in the Pilbara region, Western Australia. Records of the Western Australian Museum Supplement **78**, 91–122.

Groundwater Resource Management (2019a) Hydro-Meteorological and Surface Water Management Study. Warrawoona Gold Project. Pre-Feasibility Study. Prepared for Calidus Resources Ltd.

Groundwater Resource Management (2019b) Warrawoona Gold Project Pre-Feasibility Hydrogeological Investigations Report. Prepared for Calidus Resources Limited.

Hall, L., Richards, G., McKenzie, N. and Dunlop, N. (1997) The importance of abandoned mines as habitat for bats. In P. Hale & D. Lamb (Eds.), Conservation Outside Nature Reserves. St Lucia, Queensland: Centre for Conservation Biology, University of Queensland. 326–333.

Harvey, M.S. (2002) Short-range endemism amongst the Australian fauna: some examples from non-marine environments. Invertebrate Systematics **16**, 555–570.

Hill, B. and Ward, S. (2010) National recovery plan for the Northern Quoll *Dasyurus hallucatus*. Northern Territory Department of Natural Resources, Environment and the Arts.

Hutson, A.M., Mickelburgh, S.P. and Racet, P.A. (2001) Microchiropteran Bats: Global Status Survey and Conservation Action Plan.

ICMM (2019) Planning for integrated mine closure: toolkit. International council on mining and metals. International Council on Mining and Metals.

Ingleby, S. and Westoby, M. (1992) Habitat requirements of the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) in the Northern Territory and Western Australia. Wildlife Research **19**, 721–741.

Jackett, N., Greatwich, B., Swann, G. and Boyle, A. (2017) A nesting record and vocalisations of the Night Parrot Pezoporus occidentalis from the East Murchison, Western Australia. Australian Field Ornithology, 34, 144-150.

Johnstone, R.E. and Storr, G.M. (1998) Handbook of Western Australian birds. Volume I: Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth, W.A.

Körtner, G., Pavey, C.R. and Geiser, F. (2007) Spatial ecology of the mulgara in arid Australia: impact of fire history on home range size and burrow use. Journal of Zoology **273**, 350–357.

Lloyd George Acoustics (2019) Environmental Noise Assessment Warrawoona Gold Project, Marble Bar. Prepared for: Calidus Keras (Pilbara) Gold Pty Ltd.

Martin, D. (2012) Scientific Evaluation of Fauna Sensitivity to Blasting.

McGilp, J. (1931) Geopsittacus occidentalis, Night-Parrot. South Australian Ornithologist, 11, 68-70.

Mine Earth (2019) Warrawoona Gold Project: Soils and landform assessment.

Minerals Council of Australia (2016) Rush, Australia's 21st Century Gold Industry. A Minerals Council of Australia and Chamber of Minerals and Energy of Western Australia publication.

Minerals Council of Australia (2019) .

Murphy, S., Austin, J., Murphy, R., Silcock, J.L., Joseph, L., Garnett, S.T. and Burbidge, A.H. (2017) Observations on breeding Night Parrots (Pezoporus occidentalis) in western Queensland. Emu - Austral Ornithology, 117(2), 107-113. (https://doi.org/10.1080/01584197.2017.1292404).

Murphy, S., Silcock, J.L., Murphy, R., Reid, J. and Austin, J. (2017) Movements and habitat use of the night parrot Pezoporus occidentalis in south-western Queensland. Austral Ecology, 42(7), 858-868. doi:https://doi.org/10.1111/aec.12508.

National Committee on Soil and Terrain (2009) The Australian soil and land survey handbook. Third Edition. 10.1071/9780643097117. ISBN (PDF): 978-0-643-09711-7.

NEMP (2016) National Environment Protection (Ambient Air Quality) Measure.

NEPM (2013) National Environment Protection Assessment of Site Contamination) Measure. National Environment Protection Council.

Night Parrot Recovery Team (2017) Leading Night Parrot Conservation. Retrieved from https://nightparrot.com.au/.

North, A. (1898) List of birds collected by the Calvert Exploring Expedition in Western Australia. Transactions of the Royal Society of South Australia, 22, 125-192.

Olsen, P.D. and Olsen, J. (1986) Distribution, Status, Movements and Breeding of the Grey Falcon, *Falco hypoleucos*. Emu **86**, 47–51.

Palaszczuk, A. and Miles, S. (2017) New night parrot community discovered in central west Queensland. Available from: http://statements.qld.gov.au/Statement/2017/3/22/new-night-parrot-community-discovered-in-central-west-queensland.

Pavey, C.R., Nano, C.E., Cooper, S.J., Cole, J.R. and McDonald, P.J. (2012) Habitat use, population dynamics and species identification of mulgara, *Dasycercus blythi* and *D. cristicauda*, in a zone of sympatry in central Australia. Australian Journal of Zoology **59**, 156–169.

Pearson (1993) Distribution, status and conservation of Pythons in Western Australia, in: D. Lunney, D. Ayers (Eds.), Herpetology in Australia, a Diverse Discipline. Surrey Beatty & Sons, pp. 383–395.

Peter O'Bryan & Associates (2019) Warrawoona Project - Klondyke Deposit Geotechnical Review of Blasting Report.

Richards, G.C., Hand, S., Armstrong, K.N. and Hall, L.S. (2008) Ghost Bat. In S. Van Dyck & R. Strahan (Eds.)., Mammals of Australia 3rd Edition. ed. Sydney: Reed New Holland.

Sands CRM (2018) 2018 Calidus Warrawoona Gold Project Ethnographic Site Avoidance Survey.

Sands CRM (2019) Calidus Warrawoona Gold Project Archaeological Site Avoidance Survey. September 2019. Prepared for Calidus.

Southgate, R., Paltridge, R., Masters, P. and Carthew, S. (2007) Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert, Australia. Ecography, 30(6), 759-776. doi:10.1111/j.2007.0906-7590.04956.x.

Southgate, R. and Possingham, H. (1995) Modelling the reintroduction of the Greater Bilby Macrotis lagotis using the metapopulation model analysis of the likelihood of extinction (ALEX). Biological Conservation, 73, 151-160.

Southgate, R.I. (1990) Distribution and abundance of the greater bilby *Macrotis lagotis*., in: Seebeck, J., Brown, P., Wallis, R., Kemper, C. (Eds.), Bandicoots and Bilbies. Surrey Beatty & Sons, Sydney, pp. 293–302.

Specialised Zoological (2017a) Monitoring bats of conservation significance near Marble Bar, WA. November 2016. Report for Keras Resources PLC and Rapallo Pty Ltd. March 2017.

Specialised Zoological (2017b) Monitoring bats of conservation significance near Marble Bar, WA April 2017. Report for Keras Resources PLC and Rapallo Pty Ltd. 22 August 2017.

Start, A., Ansee, S. and Endersby, M. (2000) A review of the biology and conservation status of the Ngadji, Pseudomys chapmani Kitchener, 1980 (Rodentia: Muridae). CALMScience, 3(2), 125-147.

Thompson, G. and Thompson, S. (2007) Shape and Spatial Distribution of Mulgara (Dasycercus Cristicauda) Burrows, with Comments on Their Presence in a Burnt Habitat and a Translocation Protocol. Journal of the Royal Society of Western Australia, 90, 195-202.

Threatened Species Scientific Committee (2016a) Conservation Advice: Macroderma gigas, Ghost Bat. TSSC, Threatened Species Scientific Committee, Canberra, Australian Capital Territory.

Threatened Species Scientific Committee (2016b) Conservation Advice Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat. Produced by the Threatened Species Scientific Committee under the Environment Protection and Biodiversity Conservation Act 1999.

Threatened Species Scientific Committee (2016c) Conservation Advice Macroderma gigas, Ghost Bat. Produced by the Threatened Species Scientific Committee under the Environment Protection and Biodiversity Conservation Act 1999.

Tidemann, C.R., Priddel, D.M., Nelson, J.E. and Pettigrew, J.D. (1985) Foraging behaviour of the Australian ghost bat, Macroderma gigas (Microchiroptera: Megadermatidae). Australian journal of zoology **33**, 705–713.

Trajectory (2019) Metalliferous Drainage Management Procedure. Warrawoona Gold Project (CRL-ENV-PRO-022-19). 29 September 2019.

Van Dyck, S. and Strahan, R. (2008a) Mammals of Australia., Third Edition ed. ed. Australian Museum., Sydney, New South Wales.

Van Dyck, S. and Strahan, R. (2008b) The mammals of Australia. New Holland Publishers, Sydney.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004) Inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture and Food, Western Australia, Perth, W.A.

Whitlock, F. (1924) Journey to central Australia in search of the Night Parrot. Emu, 23, 248-281.

Wilson, H. (1937) Notes on the Night Parrot, with references to recent occurrences. 37, 79-87.

Woinarski, J.C.Z., Oakwood, M., Winter, J., Burnett, S., Milne, D., Foster, P., Myles, H. and Holmes, B. (2008) Surviving the toads: patterns of persistence of the northern quoll Dasyurus hallucatus in Queensland. Department of Natural Resources, Environment and the Arts, Darwin.

Woodman Environmental (2018) Warrawoona Gold Project Flora and Vegetation Survey. Report prepared for Calidus Resources Limited. October 2018.

Woodman Environmental (2019a) Warrawoona Gold Project Flora and Vegetation Survey. Report prepared for Calidus.

Woodman Environmental (2019b) Memo of recommendations for referral of Warrawoona Gold Project, assessment against Clearing Principles. Report prepared for Calidus. September 2019.

Woolley, P.A. (2006) Studies on the crest-tailed mulgara *Dasycercus cristicauda* and the brush-tailed mulgara *Dasycercus blythi* (Marsupialia: Dasyuridae). Australian Mammalogy **28**, 117–120.

Worthington-Wilmer, J., Moritz, C., Hall, L. and Troop, J. (1994) Extreme population structuring in the threatened ghost bat, Macroderma gigas: evidence from mitochondrial DNA. Proceeding of the Royal Society of London B. **257**, 193–198.

10 APPENDIX LIST

1 - Terrestrial Fauna		
Appendix 1-1	Level 1 Vertebrate Fauna, Desktop SRE and Subterranean Assessment	(Biologic 2017b)
Appendix 1-2	Targeted Bat Assessment, April 2019	(Biologic 2019a)
Appendix 1-3	VHF Bat Foraging Studies 2019	(Biologic 2019b)
Appendix 1-4	Significant Species Monitoring Survey Report (June 2019)	(Biologic 2019d)
2 - Invertebrate Fauna		
Appendix 2-1	Short Range Endemic (SRE) Invertebrate Fauna Survey	(Biologic 2018d)
Appendix 2-2	Subterranean Fauna Survey	(Biologic 2019e)
3 - Fauna Impact Assessment		
Appendix 3-1	Conservation Significant Bat Species Impact Assessment	(Biologic 2019f)
Appendix 3-2	Conservation Significant Vertebrate Fauna Impact Assessment	(Biologic 2019g)
Appendix 3-3	Assessment of Blasting at the Klondyke Queen for Pilbara Leaf-nosed Bat and Ghost Bat (including 2019 underground mining addendum)	(Blast It Global 2018)
Appendix 3-4	Warrawoona Project – Klondyke Deposit Geotechnical Review of Blasting Report	(Peter O'Bryan and Associates 2019)
Appendix 3-5	Environmental Noise Assessment: Warrawoona Gold Project, Marble Bar	(Lloyd George Acoustics 2019)
Appendix 3-6	Warrawoona Gold Project – Assessment of Dust Emissions. Environmental Technologies and Analytics	(Environmental Technologies and Analytics 2019)
4 - Hydrology and Hydrogeology		
Appendix 4-1	Hydro-Meteorological and Surface Water Management Study	(Groundwater Resource Management 2019a)
Appendix 4-2	Hydrogeological Investigations	(Groundwater Resource Management 2019b)
5 - Waste Characterisation and Management		
Appendix 5-1	Characterisation of Mine-Waste and Ore Samples: Implications for Mining-Stream Management	(GCA 2019a)
Appendix 5-2	Characterisation of Mine-Tailings Slurry Sample and Implications for Mining-Stream Management	(GCA 2019b)
Appendix 5-3	Tailings Storage Facility Design Report	(ATC Williams 2019)

6 - Soils and Landforms		
Appendix 6-1	Soils and landform assessment	(Mine Earth 2019)
7 - Flora and vegetation		
Appendix 7-1	Warrawoona Gold Project Flora and Vegetation Survey	(Woodman Environmental 2019a)
Appendix 7-2	Memo of recommendations for referral of Warrawoona Gold Project, assessment against Clearing Principles	(Woodman Environmental 2019b)
8 – Indigenous Cultural Heritage		
Appendix 8-1	2019 Calidus Warrawoona Gold Project - Archaeological Site Avoidance Survey	(SandS CRM 2019)
Appendix 8-2	2019 Calidus Warrawoona Gold Project – Ethnological Survey	(SandS CRM 2018)
9 - Management Plans and Procedures		
Appendix 9-1	Significant Species Management Plan	CRL-ENV-PLN-006-19
Appendix 9-2	Blast Management Procedure	CRL-ENV-PRO-017-19
Appendix 9-3	Surface Water Monitoring Procedure	CRL-ENV-PRO-020-19
Appendix 9-4	Groundwater Monitoring Procedure	CRL-ENV-PRO-021-19
Appendix 9-5	TSF and Cyanide Monitoring Procedure	CRL-ENV-PRO-019-19
Appendix 9-6	Metalliferous Drainage Management Procedure	CRL-ENV-PRO-022-19
Appendix 9-7	WRD and TSF Closure Procedure	CRL-ENV-PRO-023-19