EPBC Referral Preliminary Documentation

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Karratha - Tom Price Road Stage 4

EOS 1813

EPBC 2020/8725

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D21#299061

EXECUTIVE SUMMARY

Background

The Manuwarra Red Dog Highway (MRDH) (formerly known as the Karratha - Tom Price Road) is being constructed as part of the 'Roads 2020 regional road development strategy: Pilbara Region', developed by Main Roads Western Australia (Main Roads) together with local government authorities (Main Roads, 1997a), and the 'Pilbara Regional Transport Strategy' (Main Roads, 1997b), developed by the Department of Transport (DoT). These strategies recognised that there was a requirement for a more direct link between Karratha and inland communities, such as Tom Price and Paraburdoo. Once completed, the road will ultimately provide a sealed link between the coastal and inland communities of the central Pilbara that will best meet the needs of all stakeholders.

Stages 1 to 3 of the MRDH have been completed, with Stage 3 completed in 2020. Stage 4 of the MRDH (Karratha - Tom Price Road Stage 4, the 'Proposed Action') will complete a sealed link between Karratha and Tom Price (the 'Proposed Action'). The Proposed Action involving the construction and operation of approximately 112 km of new road from the southern end of the MRDH Stage 3 Road (Wallyinya Pool) to the Nanutarra Munjina Road, provides substantial social and economic benefits.

Main Roads referred the Proposed Action (as the Karratha - Tom Price Road Stage 4) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 9 July 2020 (EPBC 2020/8725). On 3 September 2020, a delegate of the Minister for the Environment decided that the Proposed Action is a controlled action and that it will be assessed by Preliminary Documentation. A request for additional information was provided by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (then called the Department of Agriculture, Water and the Environment (DAWE)) on 9 September 2020 (Appendix 1).

Description of the action

The Proposed Action is located in the Pilbara region of WA within the Shire of Ashburton and will be undertaken entirely within the 'development envelope' (i.e. the maximum area within which the Proposed Action footprint will be located). The northern end of the development envelope is located approximately 130 km north-north-west of Tom Price and approximately 120 km south east of Karratha. The southern end of the development envelope is located approximately 22 km north-north-west of Tom Price and 215 km south east of Karratha. The development envelope is located approximately 1,150 km from Perth at its closest point.

Description of protected matters relevant to the action

Matters of National Environmental Significance (MNES) listed under the EPBC Act that have the potential to be in the development envelope and/or immediate surrounds were identified by DCCEEW as including the following Threatened fauna species:

- Northern Quoll (*Dasyurus hallucatus*) (Endangered);
- Pilbara Leaf-Nosed Bat (*Rhinonicteris aurantia*) (Vulnerable);
- Ghost Bat (*Macroderma gigas*) (Vulnerable);
- Pilbara Olive Python (*Liasis olivaceus barroni*) (Vulnerable);

- Night Parrot (*Pezoporus occidentalis*) (Endangered); and
- Grey Falcon (*Falco hypoleucos*) (Vulnerable).

Although no flora or vegetation listed under the EPBC Act were identified as occurring within the development envelope and/or immediate surrounds by the desktop survey, flora and vegetation surveys undertaken by Biota (2021a) in April-May and October 2020 identified a single individual of the critically endangered fringed fire-bush (*Seringia exastia*) as being present within the development envelope.

This species has recently been combined with the common and widespread species *Seringia elliptica* due to newly discovered genetic similarity (Binks et al., 2020). Following the formalised combination of these two species, *Seringia exastia* represents a common, widespread species that would no longer be considered to be of conservation significance (Biota, 2021a). *Seringia exastia* is therefore expected to be de-listed in the near future and was considered by the Threatened Species Scientific Committee in 2020. Given that the outcomes of this meeting are still pending, at the time of preparation of this document, the species *Seringia exastia* is still listed as Critically Endangered under the EPBC Act. This status has been reflected within the impact assessment presented in this document.

No EPBC Listed threatened Ecological Communities (TECs) have been identified within the development envelope and/or immediate surrounds.

Assessment of impacts

Threatened flora

No significant impacts are expected to occur to the Threatened flora as a result of the Proposed Action.

Threatened fauna

Clearing for construction of the road directly impact on the following Threatened fauna habitat:

- Up to 178.3 ha of potential Northern Quoll foraging, dispersal and denning habitat. This includes up to 4.0 ha of habitat critical to Northern Quoll survival being rocky areas identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' comprising:
  - The mesas, caves, cliff and free faces habitat, a portion of these rocky areas identified by Biota (2021a) as core denning habitat
  - The rocky gullies habitat, also considered critical habitat, identified by Biota (2021a) as a foraging and dispersal resource for Northern Quolls.
- Up to 178.2 ha of potential Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat, none considered habitat critical to the survival of the species.
- Up to 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat, none considered habitat critical to the survival of the species.
- Up to 313.3 ha of potential Pilbara Olive Python foraging habitat, none considered habitat critical to the survival of the species.
- Up to 29.3 ha of potential Night Parrot foraging habitat, none considered habitat critical to the survival of the species.

- Up to 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat, none considered habitat critical to the survival of the species.

[Note: These estimated habitat impact areas include an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown].

Other aspects of the Proposed Action that have the potential to result in impacts to Threatened fauna include:

- disturbance or injury from construction equipment or construction activities;
- vehicle strike;
- collision with fencing;
- disturbance from artificial light;
- disturbance from noise and vibration;
- fragmentation of habitat and population isolation;
- Habitat degradation as a result of groundwater abstraction and dewatering;
- introduced species; and
- attraction to food waste at construction camps, illegal rubbish dumping and litter.

Significant residual impacts

The Proposed Action will result in the following significant residual impacts:

- clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll;
- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2001a).

The Proposed Action is not expected to result in significant residual impacts to any other Threatened flora or fauna including Pilbara Leaf-nosed Bat, Pilbara Olive Python, Night Parrot and Grey Falcon.

Avoidance and mitigation

The Proposed Action will avoid impacts on MNES where possible. Main Roads will implement standards and procedures, together with a project specific Fauna Action Management Plan (AMP) (Appendix 7) to mitigate and minimise the Proposed Action's potential direct and indirect impacts on MNES. This includes management (including corrective actions) and monitoring to achieve management targets.

Offsets

Main Roads propose to use the Pilbara Envronmental Offsets Fund to couterbalance the Proposed Action's significant residual impacts. Main Roads expects) to pay a rate per hectare of impact to

habitat critical to the survival of the Northern Quoll, important foraging and dispersal habitat for the Northern Quoll and foraging habitat of high importance to Ghost Bats. Based on the DCCEEW residual impact offset rate, contribution to the fund will be made for the following significant residual impacts:

- up to 4.0 ha habitat critical to the survival of the Northern Quoll; and
- Up to 48.4 ha of supporting habitat comprising:
    - 12.6 ha of habitat that represents supporting habitat for both Northern Quoll (foraging and dispersal) and Ghost Bat (foraging)
    - 29.7 ha of habitat that represents supporting habitat for Northern Quoll (foraging and dispersal) only
    - 6.1 ha of habitat that represents supporting habitat for Ghost Bat (foraging) only.

This equates to a contribution of $93,229.

Conclusion

Implementation of the Proposed Action:

- provides substantial social and economic benefits. A discussion on the scale of social and economic impacts to Yindjibarndi and Wintawari people heritage, historic heritage and amenity is provided in Section 5;
- has been developed in consideration of appropriate stakeholder consultation (Section 5.2);
- is consistent with the Objectives of the EPBC Act and principles of ecologically sustainable development (ESD) including the precautionary principle (Section 6); and
- is consistent with relevant Commonwealth Conservation Advice, Recovery Plans and Threat Abatement Plans.

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GLOSSARY

Term/Abbreviation/Acronym	Definition
AHIS	Aboriginal Heritage Inquiry System
AMP	Action Management Plan
ARUs	Acoustic Recording Units
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soils
BBI	Balla Balla Infrastructure
BC Act	*Biodiversity Conservation Act 2016*
CO_2	Carbon dioxide
CEMP	Construction Environmental Management Plan
CER	Consultative Environmental Review
CSES	Community and Stakeholder Engagement Strategy
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DoE	Department of Environment
DoT	Department of Transport
DoW	Department of Water
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
Development envelope	The maximum area within which the Proposed Action footprint will be located
Disturbance footprint	The location where the physical elements of the Proposed Action occur
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
FMG	Fortescue Metals Group
FMP	Fauna Management Plan
GSWOS	Groundwater and Surface Water Operating Strategy
ha	Hectares
IBRA	Interim Biogeographic Regionalisation for Australia
IRP	Impact Reconciliation Procedure

Term/Abbreviation/Acronym	Definition
ISCA v2.0 Technical Manual	Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability rating tool version 2.0 Technical Manual Planning
km	Kilometre
m	Metre
m^3	Meters cubed
KDCCI	Karratha and Districts Chamber of Commerce and Industry
MCA	Multi Criteria Analysis
MNES	Matters of National Environmental Significance
MOU	Memorandum of Understanding
MS 677	Ministerial Statement 677
MSE	Mechanically stabilised earth
MRDH	Manuwarra Red Dog Highway
MRWA or Main Roads	Main Roads Western Australia
PECs	Priority Ecological Communities
PD	Preliminary Documentation
PDC	Pilbara Development Commissions
PICCI	Pilbara Inland Chamber of Commerce and Industry
Proposed Action	Construction and operation of the MRDH Stage 4 Project
PMST	Protected Matters Search Tool
RIWI Act	*Rights in Water and Irrigation Act 1914*
Survey area	The area covered by the Biota 2021 survey
SPRAT	Species Profile and Threats Database
TECs	Threatened Ecological Communities
TSSC	Threatened Species Scientific Committee
WA	Western Australia
WGAC	Wintawari Guruma Aboriginal Corporation
WONS	Weed of National Significance
WQPNs	Water Quality Protection Notes
YAC	Yindjibarndi Aboriginal Corporation

Document Control

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1 INTRODUCTION

1.1 Background

The Manuwarra Red Dog Highway (MRDH) (formerly known as the Karratha - Tom Price Road) is being constructed as part of the 'Roads 2020 regional road development strategy: Pilbara Region', developed by Main Roads Western Australia (Main Roads) together with local government authorities (Main Roads, 1997a) and the 'Pilbara Regional Transport Strategy' (Main Roads, 1997b), developed by the Department of Transport (DoT). These strategies recognised that there was a requirement for a more direct link between Karratha and inland communities, such as Tom Price and Paraburdoo. Once completed, the road will ultimately provide a sealed link between the coastal and inland communities of the central Pilbara that will best meet the needs of all stakeholders.

Stage 1 of the MRDH is a sealed road that links Tom Price through to Nanutarra Munjina Road. Stages 2-3 of the MRDH are currently a sealed road linking the regional centre of Karratha through to Wallyinya Pool. Stage 4 (the 'Proposed Action') will complete the sealed link from Wallyinya Pool to Nanutarra Munjina Road. When completed the 269 km road will provide crucial connectivity between Tom Price and Karratha, as well as access to significant tourism destinations and mine sites in the region. While alternative sealed routes do currently exist, they compromise time efficiency, stretching over 550 km and adding at least another 3 hours to the journey. The lack of a safe and time efficient transport option adversely affects the local residents and businesses of Karratha, Tom Price, and Paraburdoo. Linking Karratha to Tom Price and the inland Pilbara Region via a sealed road will improve safety and transport network efficiency, and enable recreational, social and health benefits to be realised.

Stages 1 to 3 of the MRDH have been completed, with Stage 3 completed in 2020. The Proposed Action (Karratha - Tom Price Road Stage 4, referred herein as MRDH Stage 4) will complete the sealed link between Karratha and Tom Price and is the subject of this document (Figure 1). The Proposed Action involves the construction and operation of approximately 112 km of new road from the southern end of the MRDH Stage 3 Road (Wallyinya Pool) to the Nanutarra Munjina Road (Figure 2).

Works will include:

- clearing of vegetation and topsoil removal;
- blasting (required in areas of cut which cannot be excavated by standard earthmoving machinery);
- excavation of material pits to provide construction material;
- water abstraction;
- creation of temporary side-tracks and turnaround locations;
- road drainage;
- accommodation works (i.e. fencing) and potential relocation of services;
- site office and construction compound establishment;
- construction of the road formation, including application of asphalt and bitumen;

- haulage of construction materials and any excess materials generated on site;
- stockpiling and laydown areas (mulch, aggregate, material);
- landscaping and revegetation; and
- ongoing maintenance activities.

For the purposes of identification and assessment of alignment options for the Proposed Action, the route was divided into three sections based on topographical, geological and site conditions being the Coolawanyah Section, Hamersley Section Tom Price Section. These sections are further described in Section 1.3.6.

Main Roads referred the Proposed Action (as the Karratha - Tom Price Road Stage 4) under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) on 9 July 2020 (EPBC 2020/8725). On 3 September 2020, a delegate of the Minister for the Environment decided that the Proposed Action is a controlled action and that it will be assessed by Preliminary Documentation. A request for additional information was provided by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (then called the Department of Agriculture, Water and the Environment (DAWE)) on 9 September 2020 (Appendix 1).

It is noted that the referral submitted in July 2020 referred to the project including 107 km of new road construction. As detailed above, MRDH Stage 4 will required 112 km of new road. This increase from the amount stated in the referral is a result of modifications in the proposed design of the road including the additional road required for the interchange where Stage 4 meets Stage 3. Change to the design have been undertaken to enhance constructability and road safety as well as to avoid sensitive environmental receptors and heritage sites. The proposed new road construction remains within the development envelope presented in the referral and the assessment presented in this document has been undertaken over the entire area (112 km of new road construction). This includes the response to the Preliminary Documentation information request, and the in the determination of the proposed offsets.

1.2 Purpose of this document

This document has been prepared to address DCCEEW 's request for further information to support assessment of a controlled action by preliminary documentation (Appendix 1). The sections that address the specific content requested to be included is shown in Table 1-1.

Table 1-1 Additional information requirements reference table

SPECIFIC CONTENT TO BE INCLUDED	SECTION NUMBER
Description of the action	1.3
Description of the environment and Matters of National Environmental Significance (MNES)	1.4
Assessment of impacts	3
Avoidance and mitigation measures	4
Offsets	4
Economic and social matters	5
Ecologically sustainable development	6

1.3 Description of the action

The Proposed Action is located within the Pilbara region of WA and within the Shire of Ashburton and will be undertaken entirely within the development envelope. The northern end of the development envelope is located approximately 130 km north-north-west of Tom Price and approximately 120 km south east of Karratha. The southern end of the development envelope is located approximately 20 km north-north-west of Tom Price and 215 km south east of Karratha. The Proposed Action is located approximately 1,150 km from Perth at its closest point (Figure 2).

The Proposed Action includes construction and operation of Stage 4 of the MRDH. Stage 4 of MRDH comprises approximately 112 km of new road from the southern end of Stage 3 of the MRDH (Wallyinya Pool) to the Nanutarra - Munjina Road. The road will be a standard two-lane single carriageway with associated waterway crossings. The components of the Proposed Action are described in the sections below.

The development envelope for the Proposed Action is 7,142 ha. All disturbance including that for laydown areas, site offices, side tracks, turnaround locations and other construction activities will occur within the development envelope. The ground disturbance footprint within the development envelope is approximately 650 ha in area. Of this area, approximately 550 ha is permanent clearing (e.g. road, drainage infrastructure) and approximately 100 ha is temporary clearing which will be rehabilitated.

1.3.1 Layout plan

A layout plan for the Proposed Action is provided in Figure 2.

It should be noted that the design of the Proposed Action is currently in alignment definition phase and is undergoing planning, stakeholder consultation and investigations to further define the alignment. As such, the alignment shown in the layout plan is subject to change, however; it will remain within the development envelope and impacts such as disturbance to vegetation will be within the limits detailed in this document.

1.3.2 Pre-construction, construction and operational stages of the Proposed Action

1.3.2.1 Pre-construction

As mentioned, the Proposed Action is currently in the alignment definition phase which builds on the outcomes of the alignment route and corridor options assessment which was undertaken to finalise an approximately 400 m wide route corridor. Further details regarding the corridor options assessment are provided in Section 1.3.6.

As part of the alignment definition phase, the Phase 1 ‘base case’ concept design has been developed. The base case defines the road alignment along the centreline of the corridor alignment, the 400 – 500 m tie-in and realignment of Stage 3 at the northern extent, the 400-500 m tie-in and realignment of Stage 1 and the southern extent, and the Roebourne - Wittenoom

Road. The development of the base case addresses key constraints, such as the mitigation of impacts on other land users, environmental constraints and heritage constraints, including:

- the existing Rio Tinto Dampier to Paraburdoo rail line;
- existing infrastructure such as 220 kV Overhead Power Line cables, the existing Telstra fibre optic cable and existing high-pressure gas line;
- existing land uses such as the Coolawanyah and Hamersley pastoral leases, the Hamersley Homestead, crown reserves and mining tenements;
- numerous floodways and creek crossings;
- major watercourse crossings (Fortescue River and Weelamurra Creek);
- heritage constraints including Aboriginal heritage sites; and
- environmental constraints including:
  - State listed Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs); and
  - State and Commonwealth listed protected flora, fauna and fauna habitat.

The base case design was developed to minimise these impacts as far as practicable and this phase of the design ('alignment definition') will include value engineering that will optimise this design. During this phase, further definition to the design will be achieved including option assessment on waterway crossings (i.e. the requirement for bridge structures), balancing of cut and fill, consideration of stakeholder feedback and avoidance (where practicable) of environmental and heritage constraints.

The base case does not include definition of bridges or other structure designs. It is noted, however, that there are high water flows within the development envelope and surrounds and there will be a requirement for crossings of waterways, such as the Fortescue River, Weelamurra Creek and numerous creeks. While this will be further refined during alignment definition, these crossings are expected to be achieved primarily through the construction of floodways and culverts. It is noted that bridge structures may be required at locations such as the Fortescue River crossing and the Weelumurra Creek crossing due to constrained geometry and substantial flows.

It is expected that all rail crossings and road intersections will be at grade.

1.3.2.2 Construction

Construction will be undertaken using traditional earth-moving equipment and construction techniques. It is noted that blasting will likely be required in areas of cut which cannot be excavated by standard earthmoving machinery.

The road formation will be built using both imported fill and cut-to-fill materials from within the development envelope.

There is insufficient design detail at this stage to confirm the design and construction method for any bridges that may be included in the design. However, the design is expected to be industry standard, such as pre-cast concrete or steel, supported on piled foundations or spread footings with mechanically stabilised earth (MSE) walls at the abutments. A high-level construction methodology for bridges would typically comprise (noting this is subject to detailed design):

- piling works for foundation construction;
- construction of concrete pier columns;
- construction and installation of MSE walls at abutments;
- construction of concrete beams and slab; and
- completion of ancillary works, such as landscaping.

The key basic raw materials required for construction of the road include sand, limestone, clay, lateritic gravel, and crushed rock aggregate. This material will be sourced in accordance with Main Roads standard practice and processes.

Where practicable, the Proposed Action will seek to balance the “cut to fill” requirements during construction to minimise any net import or export of material from the project. This will minimise the requirement to import additional material, thus minimising costs and environment impacts (e.g. carbon dioxide emissions) associated with transport.

Laydown and stockpiling areas (and potential access tracks) for material and equipment will be required during construction, as will areas for facilities such as site offices etc. The location of these will be established by Main Roads. All such areas will be located within the development envelope. Clearing for the material pits, laydown areas, stockpiling and facilities is expected to result in up to approximately 100 ha of vegetation clearing, which will be rehabilitated as part of the Proposed Action.

Water required for construction will be sourced from new or existing bores. It is estimated that between 148,000 and 412,000 kL will be required. Any water abstraction required for construction will be undertaken to minimise drawdown and potential impacts on vegetation or fauna. Should new bores be required, a 26D licence to construct or alter a well will be submitted along with a 5C licence to extract water under the *Rights in Water and Irrigation Act* 1914. These licenses will set out the permissible well locations and quantities of water that can be abstracted which will provide assurance with respect to minimising impacts to groundwater levels in the area. A data review and gap analysis (Jacobs; 2020) informs the construction water strategy (see Appendix 2).

The location, source and potential yield of potential bores to be used are provided in Table 1-2.

Table 1-2 Potential Bore Locations

Bore Name	Coordinates		Airlift Yield (L/S)	Groundwater Source
	Easting	Northing		
2 Mile Bore	575041	7537929	Unknown	Wittenoom Formation
AB1	568526	7518148	Unknown	Fractured Rock
Cliff Well	574772	7507795	Unknown	Fractured Rock
Horseshoe Bore	571141	7512798	Unknown	Fractured Rock
PB1_RW	568956	7528760	Unknown	Fractured Rock
PB2_RW	568937	7528790	Unknown	Fractured Rock
RCB11	575610	7519757	4	Hamersley-Fractured Rock

RCB5	575555	7520217	3.5	Hamersley-Fractured Rock
RCB6	575405	7520080	1	Hamersley-Fractured Rock
RCB8	577248	7517933	Unknown	Hamersley-Fractured Rock
RCB9	575620	7520065	5	Hamersley-Fractured Rock
Ridge Bore	573273	7532041	Unknown	Wittenoom Formation
WARP13	561596	7586418	5	Hamersley - Millstream
WARP14	561612	7586396	5	Hamersley - Millstream
WARP15	558882	7591884	5	Hamersley - Millstream
WARP16	575637	7553517	10	Hamersley-Fractured Rock
WARP19	569370	7562877	18	Wittenoom-Wittenoom
WARP20	565419	7576297	10	Hamersley-Fortescue
WARP23	559025	7591828	5	Hamersley - Millstream
WARP24	547902	7602578	3.8	Hamersley - Millstream
WARP25	547957	7602561	2-7	Hamersley - Millstream
WARP5	575574	7543252	16	Hamersley-Fractured Rock
WB16KRP0003	570341	7571459	<1	Hamersley-Fortescue
WB18KRP0013	569931	7571206	45.7	Wittenoom-Wittenoom
WB18KRP0014	573598	7558815	6.25	Wittenoom-Wittenoom
Weelumurra Well	572527	7535249	Unknown	Wittenoom Formation
Xmas Bore	577458	7511977	Unknown	Fractured Rock

1.3.2.3 Operation

MRDH Stage 4 will operate as a two-lane single carriageway (one lane in each direction) road. Traffic modelling indicates a likely maximum of 635 vehicles per day will utilise the road, of which up to around 230 will be heavy vehicles. The road will be operated by Main Roads including standard management and maintenance practices. MRDH Stage 4 will be subject to normal routine, recurrent and periodic maintenance during its operation. The maintenance operations are confined to the road corridor and the road itself, typically including vegetation management, drainage, road markings, signs and the road pavement.

1.3.3 Description of the activities associated with the Proposed Action

Key activities of the Proposed Action that quantify the limits or context of the physical and operation elements are presented in Table 1-3.

Table 1-3 Key activities of the Proposed Action

ELEMENT	PROPOSED EXTENT
Physical Elements	
Road construction and	Clearing and disturbance of no more than 650 ha including approximately

associated infrastructure	550 ha of permanent clearing and 100 ha of temporary clearing that will be subject to rehabilitation.
Waterway crossings	Bridges, culverts and low-level floodways across watercourses, as determined by the conditions at each crossing (to be confirmed during the alignment definition phase).
Operational Element	
Operations	Operation of the new road including standard maintenance activities.

1.3.4 Anticipated timing

Construction of the MRDH Stage 4 is planned to commence in mid to late 2022 for a period of up to three years.

Once constructed and open for public use, operation of the MRDH Stage 4 will be ongoing. The completed road will be subject to normal routine, recurrent and periodic maintenance during operation.

1.3.5 Rehabilitation activities

Vegetation clearing for the purpose of material pits, laydown and stockpile areas, site offices and other temporary purposes will be rehabilitated using locally native species, which will be selected to reflect the surrounding vegetation and be characteristic of significant fauna habitat.

Revegetation along the development envelope will comply with *MRWA Vegetation Placement within the Road Reserve* Doc. No. 6707/022 (Main Roads, 2013, Appendix 3). This guide defines the recommended setbacks and clearance requirements that apply to all revegetation or landscaping associated with new road construction.

1.3.6 Feasible alternatives considered

1.3.6.1 'Do nothing' option

As discussed in Section 1.1, the proposed MRDH Stage 4 project will complete a sealed link between Karratha and Tom Price and will realise significant social and economic benefits. The 'do-nothing' option would result in these benefits not being realised and would significantly reduce the benefits of the already constructed MRDH Stages 1-3.

1.3.6.2 Alignment Development Process

Development of the alignment of the Proposed Action considered various alternate alignments which were each assessed during various stages against factors such as route length, earthwork and blasting requirements, tenure and existing infrastructure, cultural heritage, environmental features and hydrological risk. The stages of the route development were:

- Strategic assessment & initial feasibility study - The MRDH has been the subject of planning and strategic studies for over 20 years. In early planning phases, when the whole of the road link was being developed, strategic and feasibility studies compared broad route options and staging of the link between Karratha and Tom Price.
- Rapid corridor assessment - Due to concerns regarding floodplain management from the original planning study outcomes, Main Roads undertook a rapid assessment with the objective

to undertake a structured process to evaluate alignment options for the Karratha Tom Price Road Stage 4. This included the Hamersley Homestead appraisal which assessed the various route options with respect to potential impacts of cultural heritage and significant environmental sites near the Hamersley Homestead.

- Detailed corridor assessment - Main Roads undertook a detailed options assessment in late 2020 with the purpose of refining the preferred corridor options identified during the rapid assessment and finalising the MRDH Stage 4 road corridor within a single 400 m (minimum) wide road corridor (Cardno 2020b). The detailed assessment followed a structured process to evaluate the corridor options.
- Alignment definition – Main Roads then undertook an alignment definition to confirm the alignment of the Proposed Action based on cost estimates, site investigations, stakeholder inputs and constraints mapping.

For the purposes of identification and assessment of alignment options for the Proposed Action, the route was divided into three sections based on topographical, geological and site conditions as follows:

- Coolawanyah Section: Starting at the Roebourne Wittenoom Road, this section crosses the Fortescue River, traversing its associated floodplains and channels originating from the Chichester Range. The Coolawanyah Section is topographically flat.
- Hamersley Section: Traverses the Hamersley Ranges which are characterised by steep slopes and cliffs, crossing of Weelumurra Creek and its incised tributaries.
- Tom Price Section: Traverses a small portion of the Hamersley Ranges before crossing the southern Hamersley Plateau flats – an extensive floodplain with clay soils – and finishing at the Nanutarra - Munjina Road.

A summary of the identified corridor options, key assessment criteria and preferred options for each assessment stage for each of the three route sections in shown in Table 1-4.

Table 1-4 Summary of corridor options assessment

Phase	Corridor Options	Assessment Outcome	Preferred Option(s)
Coolawanyah Section			
Strategic assessment & initial feasibility study	Two options: 1. Adjacent to existing Rio Tinto rail 2. Existing local road network	Route adjacent to Rio Tinto Rail provides significant route length and earthwork requirement advantages.	Adjacent to existing Rio Tinto rail.
Rapid corridor assessment	Eastern and western side of the Rio Tinto rail alignment considered	Western side of the Rio Tinto rail provides advantages given it avoids impacts to the rail and has a reduced upstream hydrologic risk. No significant environmental differences between the two options were identified.	Western side of the Rio Tinto rail alignment.
Detailed	Detailed assessment not required as outcome of Rapid Assessment resulted in a single		

Phase	Corridor Options	Assessment Outcome	Preferred Option(s)
corridor assessment	preferred corridor alignment		
Outcome	Minimum 400 m wide corridor on the western side of the Rio Tinto main rail alignment.		
Hamersley Section			
Strategic assessment & initial feasibility study	Two options: 1. Adjacent to existing Rio Tinto rail 2. Existing local road network	Route adjacent to Rio Tinto Rail provides significant route length and earthwork requirement advantages.	Adjacent to existing Rio Tinto rail.
Rapid corridor assessment	15 road corridor options through the Hamersley Ranges	Route length, interference with an existing State agreement (mining lease) and upstream hydrological risk presented fatal flaws to eight options.	7 options identified for further assessment.
Detailed corridor assessment	Seven corridor options through the Hamersley Ranges	An assessment against technical risks, major watercourse and catchment crossings and earthworks requirements identified one clear preferred option. There were no significant differences in potential impacts to MNES identified across the options. The minimisation of major watercourse crossings was considered beneficial from an environmental and heritage perspective.	A single 400 m corridor identified.
Outcome	Minimum 400 m wide corridor through the Hamersley Ranges.		
Tom Price Section			
Strategic assessment & initial feasibility study	Two options: 1. Adjacent to existing Rio Tinto rail 2. Existing local road network	Route adjacent to Rio Tinto Rail provides significant route length and earthwork requirement advantages.	Adjacent to existing Rio Tinto rail.
Rapid corridor assessment	Eastern and western side of the Rio Tinto rail alignment considered	Western side of the Rio Tinto rail provides advantages given it avoids impacts to the rail and has a reduced upstream hydrologic risk. No significant environmental differences between the two options were identified.	Western side of the Rio Tinto rail alignment.
Rapid corridor assessment – Hamersley Homestead	Three options diverting around the Hamersley Homestead Community	Consultation with the Wintawari Guruma Aboriginal Corporation (WGAC) with respect to visual intrusion into and from the Hamersley Homestead indicated that the two options west of homestead are preferable.	Two options to the west of Hamersley Homestead

Phase	Corridor Options	Assessment Outcome	Preferred Option(s)
Detailed corridor assessment	Two options diverting around the west of Hamersley Homestead and the western side of Rio Tinto mainline rail alignment	An assessment against technical risks, major watercourse and catchment crossings and earthworks requirements identified one clear preferred option. There were no significant differences in potential impacts to MNES identified across the options. The minimisation of major watercourse crossings was considered beneficial from and environmental and heritage perspective.	A single 400 m corridor identified.
Outcome	Minimum 400 m wide corridor through the Hamersley Ranges.		

1.4 Description of the environment and matters of national environmental significance

1.5 Description of protected matters within the Proposed Action Area

This Preliminary Documentation describes the following MNES listed under the EPBC Act that are, or have the potential to be, in the development envelope and surrounds:

EPBC Act Listed species

- Northern Quoll (*Dasyurus hallucatus*) (Endangered);
- Pilbara Leaf-Nosed Bat (*Rhinonicteris aurantia*) (Vulnerable);
- Ghost Bat (*Macroderma gigas*) (Vulnerable);
- Pilbara Olive Python (*Liasis olivaceus barroni*) (Vulnerable);
- Night Parrot (*Pezoporus occidentalis*) (Endangered);
- Grey Falcon (*Falco hypoleucos*) (Vulnerable); and
- Fringed fire-bush (*Seringia exastia*) (Critically Endangered).

1.6 Technical reports

Studies and surveys used to inform the impact assessment of the Proposed Action are listed in Table 1-5. Appendix 3 presents the biological survey report used to inform this documentation. The biological survey incorporated a desktop review over a study area comprising an 18 km buffer from the development envelope.

Table 1-5 Studies and surveys relevant to the Proposed Action

SURVEY / REPORT NAME	LOCATION / EXTENT IN SURVEY AREA	METHODOLOGY
Surveys undertaken for the Proposed Action prior to referral		
Vegetation and Flora		
Ecologia Environment, 2018. Karratha-Tom Price Road and Pannawonica-Millstream Road Weed Survey. Perth, Western Australia.	The northern portion of the development envelope.	A review of weed species occurring near the study area was undertaken using NatureMap and the EPBC Protected Matters Search Tool. This was followed by weed mapping undertaken over two separate field surveys.
Fauna		
GHD Pty Ltd, 2017. Karratha Tom Price Road (K-TP3 and K-TP4a to Rio Access) Northern Quoll Reconnaissance Survey	The northern portion of the development envelope for the Proposed Action.	A desktop and targeted field survey for the Northern Quoll.

Other		
Main Roads Western Australia, 2003. Karratha – Tom Price Road, Karratha to Nanutarra-Munjina Rd Section. Consultative Environmental Review (Assessment No. 1244). Volume 1	Entire MRDH route	Desktop and field studies.
Further surveys undertaken for Proposed Action following referral to provide supplementary information		
Vegetation, Flora and Fauna		
Biota Environmental Sciences 2021. Manuwarra Red Dog Highway State 4 Biological Survey. Perth, Western Australia	The development envelope which will accommodate all physical components of the Proposed Action. Size: 7,142 ha	Detailed and targeted flora and vegetation survey. Basic and targeted fauna survey

1.7 Existing environment

1.7.1 Existing land use

The tenure in and around the development envelope is a combination of crown land, pastoral leases and mining tenements. Land use in the wider Pilbara region includes mining and petroleum operations, pastoralism, tourism and recreation, and conservation. Existing land-uses within and adjacent to the development envelope for the Proposed Action include pastoral activities, crown reserves, mineral exploration, utilities, unsealed roads and mining railways.

The development envelope is situated partially within the Coolawanyah and Hamersley Pastoral Leases, with the remainder of the land designated as Unallocated Crown Land. A number of mining tenements also overlap the development envelope. Pastoral Leases and Mining Tenements are shown in Figure 3.

The majority of the proposed road alignment is located approximately 100 m from the existing Rio Tinto Dampier to Paraburdoo rail line.

The following Crown Reserves are within or near to the development envelope (Figure 4):

- 38991 - the Millstream Water Reserve, managed by the WA Department of Water and Environmental Regulation (DWER) and Water Corporation;
- 40743 - owned by Australian Telecommunications Commission (Telstra) and is for a repeater station;
- 39013 - owned by Telstra and is for a repeater station; and
- 27915 - owned by the WA Department of Primary Industries and Regional Development (DPIRD) and is for a Resting Place.

Of these, reserves 38991 and 27915 overlap the development envelope.

There are no formally recognised conservation lands within the development envelope. The nearest conservation estates are Karijini National Park (located approximately 18 km south-east of the

development envelope) and the Millstream – Chichester National Park (located approximately 14 km north of the northern extent of the development envelope) (Figure 4).

Native Title exists across the development envelope with the Ngarluma and Yindjibarndi People having Native Title rights in the northern portion of the development envelope and the Wintawari Guruma People having Native Title rights in the southern portion (Figure 5).

1.7.2 Topography

The topography within and adjacent to the development envelope is heavily governed by the underlying geology, the majority of which is extremely ancient and very hard. The landforms that MRDH Stage 4 would be located on can be divided into broad units, defined as follows:

- foothills and ranges of the Chichester and Hamersley Ranges, which rise to approximately 350 m and 580 m respectively in the development envelope and consist of highly dissected, weathered plateau remnants;
- Fortescue River valley which is a wide, relatively flat valley incorporating numerous creeks and drainage lines as part of the Fortescue River system; and
- eastern outwash plain of the Hamersley Range, which is dominated by very low alluvial ridges with scattered outcrops.

1.7.3 Groundwater

The Millstream wellfield is located approximately 100 km south of Karratha, with production wells between 31 km and 35 km north west of the development envelope. Along with water from the Harding Dam Catchment Area and the Bungaroo Creek Water Reserve, the Millstream wellfield supplies the West Pilbara Water Supply Scheme. This scheme supplies water to Karratha, Dampier, Roebourne, Wickham, Point Samson, Cape Lambert and the Burrup Peninsula (DWER, 2018).

The Millstream wellfield and surrounding area is encompassed by the Millstream Water Reserve (West Pilbara) Public Drinking Water Resource Area (Millstream Water Reserve) and associated Priority 1 and Priority 2 Groundwater Protection Areas. The development envelope is located partially within both of these priority drinking water areas (Figure 6).

The Millstream area is a complex system of permanent pools and wetlands, which is predominantly fed by groundwater discharge from the Millstream Dolomite, along with seasonal flows in the Fortescue River. Groundwater flow is generally towards the north in this aquifer (SKM, 2009). The bores comprising the Millstream wellfield are situated in the Millstream Dolomite, which is an unconfined and highly transmissive aquifer, making the wellfield vulnerable to contamination from inappropriate land uses (DWER, 2018).

Groundwater aquifers within the Pilbara region are primarily recharged through large rainfall events via infiltration through streambeds (CSIRO, 2015). Significant groundwater supplies can be found with relative ease in the alluvium and colluvium found in the low-lying areas of the coastal plain, Fortescue River valley and the upper reaches of Weelumurra Creek to the south of Hamersley Station. There are forty-eight known groundwater bores licenced to six different users within the Millstream Water Reserve (DWER, 2018). Information from the then Water and Rivers Commission (now DWER) indicates that depths to water in these bores range from around four to 37 m below ground level.

The WA Department of Water (DoW) (2016) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the Development Envelope lies within this area. DoW (2016) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year.

1.7.4 Surface water

A hydrological risk assessment was undertaken by Cardno (2022), which provides an understanding of the surface water regime throughout the Development Envelope; identifies and describes the hydrological risk factors associated with the Proposed Action; and proposes design criteria to be adopted in managing major waterways. WSP Golder (2022) reviewed this assessment and prepared a Hydrological Risk Assessment for MRDH (Stage 4) (see Appendix 5).

Watercourses that cross the development envelope include (Cardno, 2022):

- Fortescue River and associated tributaries – intersects the northern part of the development envelope;
- Weelumurra Creek (an ephemeral creek) – intersects the northern to central part of the development envelope; and
- Caves Creek - intersects the southern part of the development envelope (no crossing required).

In addition, minor creek crossings include Cowcumba Creek / Tunkawanna Creek, Ballyeerina Creek (crosses twice, north and south) and Barnett Creek.

There are also a large number of ephemeral drainage lines throughout the development envelope, which are generally tributaries of one of the above-named watercourses.

Between the Chichester and Hamersley Ranges all surface drainage is directed to the Fortescue River across a wide plain. Flows tend westwards across the proposed road alignment. At the southern end of the plain, the braided channels of Weelumurra Creek run parallel to the road before joining the Fortescue River.

Through the Hamersley Ranges, the rugged topography leads to small catchments drained by numerous, small channels. All drainage feeds into Weelumurra Creek, which runs along the proposed alignment.

South of the Hamersley Ranges, the country is flat to undulating. Drainage may occur in the form of sheet flow in places, parallel to the proposed road alignment.

No wetlands of international importance (declared Ramsar Wetlands) are located within or near to the development envelope.

1.7.5 Vegetation and flora

The development envelope sits within the Pilbara Bioregion and the Chichester, Fortescue and Hamersley subregions as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) Version 7 (DAWE, 2021a)

Field survey assessment

An overview of the vegetation types (Biota 2021a) within the development envelope is provided in Table 1-7 and shown in Figure 6. Vegetation condition in the development envelope and disturbance footprint (Figure 9) ranged from ‘Excellent’ to ‘Poor’ as shown in Table 1-6.

Table 1-6 Vegetation Condition

Vegetation condition	Extent in development envelope (ha)	Extent in disturbance footprint (ha)
Excellent	3,560.0	292.3
Very Good to Excellent –	735.6	65.0
Very Good	2,253.	174.9
Good to Very Good	60.6	7.0
Good	117.7	4.0
Good to Poor	0.6	0
Poor	8.1	0
Completely degraded	101.0	0
Cleared	307.5	8.1

Groundwater dependent vegetation

Eucalyptus and Melaleuca species that depend on groundwater have been identified by Biota (2021a) as being present in and around the development envelope. This vegetation is restricted to the major drainage lines (Fortescue River, Weelumurra Creek and its tributaries; and Barnett Creek (Biota, 2021a)). *Melaleuca argentea* which is present along Weelumurra Creek and its tributaries as well as in a small area of the Hamersley section is highly dependent on groundwater, while *Eucalyptus camaldulensis, Eucalyptus victrix, Melaleuca glomerata* have a low to moderate dependency on groundwater (Rio Tinto, 2018).

Table 1-7 Vegetation types and extent within the development envelope (Biota, 2021a)

ID	VEGETATION TYPE	VEGETATION TYPE DESCRIPTION	EXTENT OF VEGETATION TYPE WITHIN THE DISTURBANCE FOOTPRINT (HA)
H1	Vegetation of Stony Hillslopes, Hillcrests and Foothills	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.	Excellent - 288.2 Good – 0.8
H2		*Corymbia hamersleyana* scattered low trees over *Acacia inaequilatera* scattered tall shrubs over *Triodia wiseana* open hummock grassland.	Excellent - 19.3
H3		*Eucalyptus leucophloia* subsp. *leucophloia*, (*Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland.	Excellent – 407.6 Very Good – 3.9968×10^{-6}
H4		*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses.	Excellent – 8.4
C1	Vegetation of Cracking Clays	*Eriachne benthamii*, *Eragrostis xerophila*, *Astrebla elymoides* very open tussock grassland over *Cynodon convergens* very open bunch grassland.	Excellent – 12.7 Very Good – 109.4
C2		*Acacia xiphophylla* low woodland over *Triodia epactia* very open hummock grassland over *Eragrostis xerophila* scattered tussock grasses.	Excellent – 1.7 Very Good – 205.0
C3		Mixed *Astrebla* tussock grassland over *Urochloa occidentalis* var. *occidentalis* bunch grassland. This vegetation type forms part of the Brockman Iron cracking clay communities of the Hamersley Range PEC.	Very Good – 88.1
C4		*Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 72.7

ID	VEGETATION TYPE	VEGETATION TYPE DESCRIPTION	EXTENT OF VEGETATION TYPE WITHIN THE DISTURBANCE FOOTPRINT (HA)
C5		*Eucalyptus victrix* scattered low trees over *Eriachne benthamii*, (*Themeda* sp Hamersley Station (M.E. Trudgen 11431)) very open tussock grassland over mixed open herbland. This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 4.4
M1	Mulga Vegetation	*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses.	Excellent to Very Good – 166.7 Good – 3.1
M2		*Acacia ?macraneura*, *A. aptaneura* over *Triopia epactia* scattered hummock grasses.	Excellent to Very Good – 492.0 Good – 0.5
M3		*Acacia aneura*/*aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.	Very Good – 74.9
M4		*Acacia aptaneura*, *A ?macraneura* (*Hakea lorea* subsp. *lorea*) low open woodland over mixed tussock grasses, bunch grasses and herbs.	Very Good – 47.8
P1	Vegetation of Stony Plains and Sloping Plains	*Corymbia deserticola* subsp. *deserticola*, *C. hamerslayana*, *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Triodia wiseana* open hummock grassland.	Excellent – 333.4 Very Good – 0.4
P2		*Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.	Excellent – 913.7 Very Good – 101.0 Good – 8.6
P3		*Hakea lorea* subsp. *lorea* low open woodland over shrubs over *Triodia epactia* very open hummock grassland with *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) very open tussock grassland.	Very Good to Good – 38.7 Good – 15.0
P4		*Corymbia hamersleyana* scattered low trees over *Triodia epactia*, (*T. wiseana*) open hummock grassland and *Eulalia aurea* scattered tussock grasses.	Excellent – 3.4 Very Good – 11.1

ID	VEGETATION TYPE	VEGETATION TYPE DESCRIPTION	EXTENT OF VEGETATION TYPE WITHIN THE DISTURBANCE FOOTPRINT (HA)
P5		*Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open hummock grassland with mixed tussock grasses.	Excellent – 24.0 Very Good – 85.1
P6		*Hakea lorea* subsp. *lorea* low open woodland over **Vachellia farnesiana* scattered shrubs over *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland. This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 11.8 Good – 26.4
P7		*Triodia wiseana* hummock grassland with *Eriachne flaccida* scattered tussock grasses.	Excellent – 42.4 Good – 0.8
P8		**Vachellia farnesiana* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland over mixed annual grassland and herbland.	Very Good – 81.5
D1	Vegetation of Drainage Lines	*Eucalyptus victrix* (*E.camaldulensis* subsp. *refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.	Excellent – 156.5 Very Good – 328.7 Good – 15.1
D2		*Eucalyptus camaldulensis* subsp. *refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.	Very Good – 6.6 Good – 14.6
D3		*Eucalyptus victrix* low open woodland over **Vachellia farnesiana* scattered tall shrubs over mixed tussock grasses and bunch grasses.	Very Good – 17.5 Good – 1.0
F1	Vegetation of Floodplains	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T.epactia*) open hummock grassland with mixed tussock grasses.	Excellent – 783.7 Very Good – 712.9 Good to Poor – 0.6
F2		*Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.	Excellent – 356.0

ID	VEGETATION TYPE	VEGETATION TYPE DESCRIPTION	EXTENT OF VEGETATION TYPE WITHIN THE DISTURBANCE FOOTPRINT (HA)
			Excellent to Very Good – 5.9 Very Good – 74.4 Good – 0.4
F3		*Corymbia hamersleyana* low open woodland over mixed Acacia open shrubland over *Triodia epactia* very open hummock grassland with *Chrysopogon fallax* very open tussock grassland.	Excellent – 48.5 Very Good – 166.3 Poor – 4.0
F4		*Acacia citrinoviridis* low woodland over *Triodia epactia* open hummock grassland and *Chrysopogon fallax* scattered tussock grasses.	Very Good – 40.8 Good – 17.8
F5		*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.	Excellent – 167.7 Excellent to Very Good – 71.0 Very Good – 13.2 Very Good to Good – 11.9 Good – 13.5 Poor – 4.0
Cleared	Other Mapping Units	Cleared	Cleared - 307.5 Disturbed – 101.1

1.7.6 Threatened Ecological Communities

A search of the DCCEEWPMST did not identify any TECs listed under the EPBC Act as occurring within the development envelope and/or immediate surrounds (Biota, 2021a).

During the field survey, no TECs listed under the EPBC Act were identified within the survey area by Biota (2021a).

1.7.7 Threatened Flora

A search of the DCCEEWPMST which encompassed the development envelope and immediate surrounds did not identify any flora species listed under the EPBC Act as potentially occurring within this area (Biota, 2021a).

A detailed and targeted flora survey was undertaken by Biota over three field trips between April 2020 and March 2021 (Biota, 2021a). The survey used both quadrats and relevés, as well as targeted searches for conservation significant flora and weeds along traverses (Biota, 2021a).

The scope and approach of the flora survey was undertaken in accordance with the following policies:

- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016a); and
- Environmental Factor Guideline – Flora and Vegetation (EPA, 2016b).

Survey limitations were assessed in the Biota (2021a) report (provided in Appendix 4) and no significant limitations were identified. Given the above, the surveys undertaken are considered adequate for the purpose of this impact assessment including with respect to survey extent, effort and timing.

Within the survey area, a total of 557 native vascular flora species from 190 genera and 56 families were recorded.

One species currently listed as Critically Endangered under the EPBC Act (and Critically Endangered under the BC Act), *Seringia exastia*, was recorded in the foothills in the south-central section of the survey area (Biota, 2021; record shown in Figure 10). This species has recently been combined with the common and widespread species *Seringia elliptica* due to newly discovered genetic similarity (Binks et al., 2020). Following the formalised combination of these two species, *Seringia exastia* represents a common, widespread species that would no longer be considered to be of conservation significance (Biota, 2021a). The Threatened conservation status cannot be removed from *Seringia exastia* until the Threatened Species Scientific Committee (TSSC) reviews recommended changes to the Threatened Flora List and the revised list is then signed by the WA Minister for the Environment. *Seringia exastia* is, therefore, expected to be de-listed in the near future. At the time of preparation of this document however, the species *Seringia exastia* is still listed as Critically Endangered under the EPBC Act. This status has been reflected within the impact assessment presented in this document.

The Fringed Fire-bush is an erect and compact, multi-stemmed shrub that can grow up to 0.9 m high (DAWE, 2021e). The leaves are grey-green and oblong and inflorescences contain 7-9 flowers, which are purple and flower from April to December (TSSC, 2009). It has been suggested that the species consists of one or a few large clones of self-sterile individuals that reproduce vegetatively by underground suckers (Trudgen, 1998).

The species grows in pindan heathland, most commonly occurring on almost flat land (DAWE, 2021e). Associated vegetation includes Feathertop Spinifex (*Triodia schinzii*), Soap Wattle (*Acacia* colei), Bloodwood (*Eucalyptus dampieri*) and several other common species with a variety of intermediate sized shrubs (Broome Botanical Society, 1995; DAWE, 2021e).

The Fringed Fire-bush is endemic to WA, occurring in the Dampierland IBRA Bioregion and the Rangelands Natural Resource Management Region, with several sub-populations in Broome (DAWE, 2021e). There are 291 records of the newly combined species (*Seringia elliptica* and *Seringia exastia* combined as described above) recorded in Florabase. (Western Australian Herbarium, 2021).

The total population size is not conclusively known. The main threat to the Fringed Fire-bush is road maintenance works and competition from weeds (Broome Botanical Society, 1995; DAWE, 2021e).

A single plant of this species was identified within the development envelope. The location of the recorded specimen is approximately 115 m from the centre line of the current alignment and outside the disturbance footprint (Figure 10). The closest record of the species (prior to its record during the Biota (2021a) survey) is 14 km from the development envelope.

As only a single record was identified within the development envelope and given that this species has recently been combined with the common and widespread species, *Seringia elliptica*, this occurrence is not considered to indicate the presence of suitable, high quality habitat that may support this species.

1.7.8 Introduced and invasive flora species

The Biota (2021a) field survey recorded 15 introduced flora species within the survey area (Figure 11):

- Kapok Bush (*Aerva javanica*);
- Bipinnate Beggartick (*Bidens bipinnata*);
- Buffel Grass (*Cenchrus ciliaris*);
- Birdwood Grass (*Cenchrus setiger*);
- Feathertop Rhodes Grass (*Cynodon dactylon*);
- Native Thornapple (*Datura leichhardtii subsp. leichhardtii*);
- Awnless Barnyard Grass (*Echinochloa colona*);
- Speedy Weed (*Flaveria trinervia*);
- Spiked Malvastrum (*Malvastrum americanum*);
- Djanggara (*Portulaca pilosa*);
- Ruby Dock (*Rumex vesicarius*);
- Whorled Pigeon Grass (*Setaria verticillata*);
- Common Sowthistle (*Sonchus oleraceus*);
- Caltrop (*Tribulus terrestris*); and
- Mimosa Bush (*Vachellia farnesiana*).

No WONS or declared pests for the Pilbara region under the WA *Biosecurity and Management Act* 2007 (DPIRD, 2020; Biota, 2021) were recorded. However, Buffel Grass, Birdwood Grass, Mimosa Bush and Ruby Dock were present and are all considered to be serious environmental weeds in WA (CALM, 1999a). It is noted that much of the Proposed Action is on pastoral leases, so many weeds (especially Buffel Grass) would have been introduced for stock grazing.

1.7.9 Fauna

1.7.9.1 Overview

A desktop study and multiple field surveys were conducted by Biota in 2020 (Biota, 2021a). Field surveys were undertaken in April, May and October 2020 (Biota, 2021a).

The desktop study was undertaken to identify features of significance known from the study area. This involved the collation of previous biological surveys overlapping the study area and the outputs of various database searches. The results of the desktop study were used as the basis for compiling lists of fauna species of significance potentially occurring in the survey area. In reviewing previous surveys carried out nearby, the potential presence of habitat types associated with significant species were identified and used to tailor the design and timing of the field survey.

Basic and targeted fauna surveys of the survey area was undertaken to verify the accuracy of the desktop study, broadly characterise the fauna assemblage and collect data on species of significance. This involved describing and mapping fauna habitats and selective low-intensity sampling.

The scope and approach of the fauna surveys (Biota, 2021a) was consistent with the following policies:

- Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016a);
- Technical Guidance – Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA, 2020);
- Survey Guidelines for Australia's Threatened Birds (DEWHA, 2010); and
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011).

Survey limitations were assessed in the Biota (2021a) report (Appendix 4) and no significant limitations were identified. Given the above, the surveys undertaken are considered adequate for the purpose of this impact assessment including with respect to survey extent, effort and timing.

The desktop assessment (Biota 2021a) identified a total of 305 vertebrate fauna species with the potential to occur in the survey area. It is noted that there are several bird species which may occur within the development envelope and/or immediate surrounds due to their migratory natures. These species are primarily expected to occur transitionally through the development envelope and would not be dependent upon the habitats present.

Thirty-one of the species in the potential assemblage are listed as conservation significant. A further 23 avifauna species are listed as 'Marine' under the EPBC Act, despite these species not using marine habitats. In fact, fewer than half of the 293 taxa listed by the EPBC Act as Marine gain all or most of their food at sea (Garnett 2013). As the survey area does not encompass any marine habitats, these taxa were not considered further in the assessment.

The consolidated potential species list is provided in the Biota (2021a) report (Appendix 4).

During the Biota (2021a) field survey, a total of 110 native vertebrate fauna species were recorded within the survey area. In addition, secondary evidence (long extinct nest relics) of the Lesser Stick-nest Rat (extinct on the mainland) was recorded. The Lesser Stick-nest Rat was not included in the species list and total counts for the field survey due to its extinct status.

Three EPBC Act listed fauna species (two mammal species and one bird species), were recorded in the survey area:

- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara form) – Vulnerable (Figure 14));
- Ghost Bat (*Macroderma gigas*) – Vulnerable (Figure 15); and
- Grey Falcon (Falco hypoleucos) – Vulnerable (Figure 18).

Two of the above species, the Pilbara Leaf-nosed Bat and the Grey Falcon, were recorded with certainty from the survey area through call recordings and sighting respectively. Secondary evidence of the Ghost Bat also confirmed their presence (remains and scats were identified inside a cave within the survey area).

Twelve fauna habitat types were identified in the development envelope. The habitats aligned broadly with the landforms, with some isolated habitats that support specific fauna assemblages. Additional information on fauna is provided in Appendix 4 (Biota, 2021a). Most of the fauna species of significance recorded from the survey area, or likely to occur, would be associated with the rocky habitats of the Hamersley Range which would be considered to have the highest local significance.

Figure 12 shows each of the fauna habitat types mapped by Biota (2021a). Table 1-8 describes each of the fauna habitats.

1.7.9.2 EPBC Act listed fauna occurrence likelihood assessment

Based on the survey findings, previous records from the study area, and an assessment of habitat within the survey area, six EPBC Act listed threatened species were recorded, are considered likely to occur in or near or may occur in the development envelope. These species are:

Recorded:

- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara form) - Vulnerable;
- Ghost Bat (*Macroderma gigas)* - Vulnerable; and
- Grey Falcon (*Falco hypoleucos)* - Vulnerable.

Likely to occur:

- Northern Quoll (Dasyurus hallucatus) – Endangered;
- Pacific Swift (Apus pacificus) – Migratory/marine; and
- Pilbara Olive Python (Liasis olivaceus barroni) – Vulnerable.

May occur:

- Night Parrot (Pezoporus occidentalis) – Critically Endangered.

The Fork-tailed Swift was not recorded during the survey but occurs widely over the Pilbara, including the Hamersley Range. The species is thought to be exclusively aerial and is likely to occur as a sporadic visitor to airspace over all parts of the survey area, particularly in association with

thunderstorms and low-pressure systems (Biota, 2021a). Given this, it is considered unlikely that the species will interact with the Proposed Action and is therefore not considered further in this assessment.

1.7.9.3 EPBC Act listed fauna habitat

Table 1-8 shows the habitat types found in the development envelope, which EPBC Act listed fauna likely to occur in the area is associated with each habitat type and the extent of each habitat type in the development envelope and disturbance footprint. These fauna habitat associations for each species are shown in Figure 13 to Figure 18.

The estimated extent of available habitat within the Pilbara region for each of the above species has been estimated based on identifying land systems within the species distribution (areas where it is considered the species is likely to may or occur based on spatial data from DCCEEW) that contain habitats similar to those identified by Biota (2021a) in the development envelope. While this approach may not provide the full extent of suitable habitat for each species as there are likely to be habitats not present within the development envelope that are also suitable, it does provide context with respect extent of the habitat within the disturbance footprint and development envelope in comparison with the regionally available habitat. The extent of habitat for each species within the disturbance footprint and the Pilbara region is provided in Table 1-9.

An assessment of the quality of the habitat that is present within the development envelope for each species has been undertaken in accordance with the guidance provided in the DCCEEW "*How to use the offset assessment guide*". The guidance sets out the three components that contribute to the calculation of habitat quality. These components then contribute to the final habitat quality score (DSEWPaC, 2012c).

An assessment of the quality of the habitat that is present in and around the development envelope for each relevant species is presented in Appendix 6.

Table 1-8 Fauna habitats in the development envelope and MNES fauna associations (Biota, 2021a)

HABITAT	DESCRIPTION	EPBC ACT LISTED FAUNA ASSOCIATION WITH HABITAT	EXTENT OF HABITAT WITHIN THE DISTURBANCE FOOTPRINT (HA)*	EXTENT OF HABITAT WITHIN THE DEVELOPMENT ENVELOPE (HA)
MG - Grove Mulga	Bands of *Acacia aneura* woodland over mixed shrubs over *Triodia melvillei/Triodia epactia* and annual herbs, alternating with bare ground.	Supporting habitat: • Grey Falcon (foraging)	69.7	666.2
MWP - Mulga woodland plain	*Acacia aneura* open woodland plains over scattered shrubs over. *Triodia spp* open hummock grassland.	Supporting habitat: • Grey Falcon (foraging)	16.1	122.5
ASCC - *Acacia xiphophylla* shrublands over cracking clay.	*Acacia xiphopyllya* low woodland over *Triodia epactia* open hummock grassland with cracking clay substrate.	Supporting habitat: • Grey Falcon (foraging)	10.4	328.9
ASM - Mixed Acacia shrublands	*Corymbia* trees with mixed *Acacia* shrublands over *Triodia epactia* and stony substrates.	Supporting habitat: • Grey Falcon (foraging)	157.5	1,659.2
GPCC - Grassland plains with cracking clay	Themeda grassland in the south and in the north, *Astrebla* grasslands, both with crackling clay substrates	Supporting habitat: • Grey Falcon (foraging) • Night Parrot (foraging)	29.3	203.4
CP - Floodplain	*Corymbia hamersleyana*/ *Eucalyptus victrix* low open woodland over mixed *Acacia* shublands over scattered *Triodia* hummock grasses and mixed tussock grasses.	Supporting habitat: • Ghost Bat (foraging) • Pilbara Olive Python (foraging) • Grey Falcon (foraging)	135	1,778.6

HABITAT	DESCRIPTION	EPBC ACT LISTED FAUNA ASSOCIATION WITH HABITAT	EXTENT OF HABITAT WITHIN THE DISTURBANCE FOOTPRINT (HA)*	EXTENT OF HABITAT WITHIN THE DEVELOPMENT ENVELOPE (HA)
HS - Mesas, caves, cliffs and free faces	*Eucalyptus leucophloia* over mixed acacia scattered-open shrubland over *Triodia wiseana/ Trioia epactia* hummock grassland.	Habitat considered to be critical to the survival of the species (Hill and Ward 2010) for: • Northern Quoll (denning) Supporting habitat: • Pilbara Leaf-nosed Bat (potential roosting habitat, foraging) • Ghost Bat (roosting, foraging) • Pilbara Olive Python (foraging) • Grey Falcon (foraging)	0.14	8.4
RHS – Rocky hills and slopes with low open spinifex and scattered trees	*Eucalyptus leucophloia* over mixed acacia scattered-open shrubland over *Triodia wiseana/Triodia epactia* hummock grassland.	Supporting habitat: • Northern Quoll (foraging, dispersal) • Pilbara Leaf-nosed Bat (foraging) • Ghost Bat (foraging) • Pilbara Olive Python (foraging) • Grey Falcon (foraging)	88.7	702.1
MDE – Eucalyptus fringed major drainage lines and associated tributaries	*Open Eucalyptus victrix/Eucalyptus camualdulensis*	Supporting habitat: • Pilbara Leaf-nosed Bat (foraging) • Pilbara Olive Python (foraging) • Grey Falcon (nesting, foraging) • Northern Quoll (foraging, dispersal)	85.5	1,233.1

HABITAT	DESCRIPTION	EPBC ACT LISTED FAUNA ASSOCIATION WITH HABITAT	EXTENT OF HABITAT WITHIN THE DISTURBANCE FOOTPRINT (HA)*	EXTENT OF HABITAT WITHIN THE DEVELOPMENT ENVELOPE (HA)
		• Ghost Bat (foraging, drinking)		
MDM - Melaleuca forest/major drainage lines	*Melaleuca argentea* and *Mel glomerate* over *Acacia bivenosa* and *Cyperus vaginatus*, with ephemeral pools.	Supporting habitat: • Pilbara Leaf-nosed Bat (foraging, flyway, drinking) • Grey Falcon (nesting, foraging) • Northern Quoll (foraging, dispersal) • Ghost Bat (foraging, flyway, drinking) • Pilbara Olive Python (foraging)	0.03	21.2
RG - Rocky gullies	*Eucalyptus leucophloia* and *Corymbia ferritcola* over mixed *Acacia spp.* (including A. *bivenosa*) over *Triodia epactia* open hummock grassland.	Habitat considered to be habitat critical to the survival of the species (Hill and Ward 2010): • Northern Quoll (foraging and dispersal) Supporting habitat: • Northern Quoll (foraging, dispersal) • Pilbara Leaf-nosed Bat (foraging) • Ghost Bat (foraging) • Pilbara Olive Python (foraging) • Grey Falcon (foraging)	3.75	13.7

HABITAT	DESCRIPTION	EPBC ACT LISTED FAUNA ASSOCIATION WITH HABITAT	EXTENT OF HABITAT WITHIN THE DISTURBANCE FOOTPRINT (HA)*	EXTENT OF HABITAT WITHIN THE DEVELOPMENT ENVELOPE (HA)
MMW - Man-made water bodies	*Dams etc*	Supporting habitat: • Ghost Bat (drinking) • Grey Falcon (drinking, foraging)	0.14	2.3

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Table 1-9 Threatened fauna habitat extent

SPECIES / HABITAT TYPE	HABITAT EXTENT WITHIN DISTURBANCE FOOTPRINT (HA)*	ESTIMATED HABITAT EXTENT IN PILBARA REGION (HA)
Northern Quoll – habitat critical to the survival of a species	4.0	8,786,246
Northern Quoll – supporting habitat	174.3	
Pilbara Leaf-Nosed Bat – supporting habitat	178.2	8,176,685
Ghost Bat – supporting habitat	313.4	9,304,536
Pilbara Olive Python – supporting habitat	313.3	8,741,003
Night Parrot – supporting habitat	29.3	669,982
Grey Falcon – supporting habitat	596.1	17,823,126[1]

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

1.7.9.4 Introduced fauna species

Eleven introduced fauna species potentially occur or have been previously recorded within the development envelope and/or immediate surrounds (Biota, 2021a).

The Domestic Cat and European Cattle were identified during the field survey. One naturalised exotic species Dog/Dingo (*Canis familiaris familiaris and/or C. f. dingo*) was also identified during the survey (Biota, 2021a).

1.7.10 EPBC Act listed Threatened fauna

1.7.10.1 Northern Quoll (*Dasyurus hallucatus*)

Species background information

The Northern Quoll is listed as Endangered under the EPBC Act (DAWE, 2021b). It is a small omnivorous marsupial with white spots against a dark brown body and with a long tail. It is predominantly nocturnal and solitary.

Abundance and distribution

The abundance of the Northern Quoll has declined since European settlement with the species contracting to a small number of geographic regions across northern Australia. While there are no overall assessments of the Northern Quoll population size available, the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' identifies a number of important populations for this species, including the populations in the Pilbara region of WA where there Proposed Action is

[1] Spatial data not available. Supporting habitat likely extends throughout the entire Pilbara region of 17,823,126 ha

located (Hill and Ward, 2010).

The Northern Quoll occurs in Queensland, the Northern Territory (NT) and WA. The Northern Quoll previously occurred across most of the northern third of Australia, but its range has significantly declined over the past century. The species is now restricted to six areas within Australia, two of which are in the northwest Kimberley and Pilbara region of WA (Braithwaite and Griffiths, 1994).

Analyses indicate genetic disjunction between populations across Australia, including between the populations in the Pilbara and Kimberley (Hill and Ward, 2010). Henderson (2015) found the species mean home range was 58 ha for males and 13 ha for females, during a study into the effects of mining infrastructure on Northern Quoll movement and habitat.

In the Pilbara, the distributional boundaries of Northern Quoll are delineated in the north, east and south by the Great Sandy Desert, Gibson Desert and Little Sandy Deserts. The distribution of Northern Quolls in the Pilbara is fragmented, and the species is mostly confined to ironstone formations (such as those found in the Hamersley section of the Proposed Action), some river systems and the Burrup Peninsula and adjacent offshore islands. Records from the Pilbara bioregion are scattered across the four subregions (Hamersley, Fortescue Plains, Chichester and Roebourne Plains), with records extending as far west as the Little Sandy Desert (How et al. 2009) and as far south as Karijini National Park (shown in Figure 19).

Habitat preferences

Northern Quolls do not have highly specific habitat requirements and occur in a variety of habitats across their range (Hill and Ward, 2010). They are most abundant in rocky terrain, which has been shown to support higher population densities and longer-lived individuals (Burnett, 1997; Oakwood, 2000). The species utilises a range of micro-habitats for foraging and denning, such as gorges, breakaways and hills, and also occurs near creek lines and drainage lines, where adjacent plains and vegetated areas provide habitats for foraging and dispersal of young.

Northern Quoll dens are often made in rock crevices, with surrounding vegetated habitats used for foraging and dispersal. Den sites may also include tree holes, logs, termite mounds, and goanna burrows, but these are used less often than rocky habitats (van Dyck and Strahan, 2008). Within the Pilbara, Northern Quolls records are often from rocky mesa habitats situated near dense vegetation along drainage areas (Biota, 2021a) and from the boulder tors (hills) of the Abydos-Woodstock Plain (How et al., 1991). Suitable Northern Quoll habitats are common within the Pilbara region (estimated extent >8.7 million ha), with vast amounts being vested in National Parks in the region, including the adjacent Millstream-Chichester National Park.

Breeding parameters

In the Pilbara region, Northern Quolls have one breeding season per year from April to September. After 21 to 26 days of gestation, females give birth to an average of up to eight young (DAWE, 2021b). The young are carried in the pouch for up to nine weeks, then deposited in dens. Only two or three survive to full independence at six months of age (van Dyck and Strahan, 2008). By 11 months of age Northern Quolls are sexually mature. Males generally die-off after mating and females only live for two years (Oakwood, 2000).

Key Threats

The key threats to northern quolls as identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' are (Hill and Ward, 2010):

- lethal toxic ingestion caused by cane toads;
- predation by feral predators;

- inappropriate fire regimes;
- habitat degradation;
- habitat destruction;
- weeds;
- disease;
- hunting; and
- population isolation.

Of these threats, predation by feral predators, habitat degradation, habitat destruction and weeds are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

While there are no records of Northern Quoll within 1 km of the development envelope, the species has been recorded previously on numerous occasions in close proximity to the development envelope. Naturemap has 152 records within 18 km of the development envelope, the closest being 4.8 km from the development envelope and the most recent being from 2018 (Biota, 2020a). There are also records within 4.1 km of the development area (Ecologica, 2014a) and within 2.1 km of the development envelope (Ecologica, 2012). Figure 19 shows the locations Northern Quolls have been recorded within the Pilbara, including those in proximity to the development envelope. The areas of higher record density are likely due to higher survey effort associated with development projects, particularly mining projects.

Given the extent of high-quality habitat present (particularly along major drainage lines and surrounding rocky areas) and the locations of previous recorded sightings, it is considered highly probable that a population of Northern Quoll exists in the habitat surrounding the development envelope, though this population is likely to occur at low density.

Species presence within development envelope

Distribution modelling of the Northern Quoll shows the Proposed Action is located within an area where the species is known or likely to occur; particularly in the Hamersley Range where approximately 40 km (200 ha) of the Proposed Action is located. The Hamersley Range is, therefore, considered to provide suitable habitat for the species.
Motion cameras were deployed at 27 locations during the surveys undertaken by Biota (2021a) which included 95 camera trap nights. No observations or secondary evidence of the Northern Quoll were recorded during the Biota (2021a) survey.

The species has been recorded previously within proximity to the development envelope and there is suitable habitat that the species may utilise within the development envelope and surrounding areas, particularly along drainage lines and surrounding rocky areas within the Hamersley Ranges.

Habitat that is representative of habitat critical to the survival of the Northern Quoll (or 'critical habitat' as defined in the recovery plan) is present in the Hamersley section of the development envelope in the form of rocky areas that may be used for denning and transitory (dispersal) habitat. The latter is characterised by creeklines used for foraging and/or transitioning through the landscape.

Based on the above, Northern Quoll are likely to occur in the development envelope, although with

a low population density (Biota, 2021a).

Species habitat extent

The Proposed Action will result in the loss of up to 178.3 ha of potential Northern Quoll denning, foraging and dispersal habitat, including up to 4.0 ha considered to be habitat critical to the survival of this species. Suitable supporting habitat and habitat critical to the survival of the Northern Quoll is shown in Figure 13 and detailed in Table 1-10.

Table 1-10 Extent of suitable Northern Quoll habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTRUBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
Habitat critical to the survival of the Northern Quoll			
HS - Mesas, caves, cliffs and free faces	Critical to the survival of the species – denning	0.14	8.4
RG - Rocky gullies	Critical to the survival of the species – foraging and dispersal	3.8	13.7
Sub-total		4.0	22.1
Supporting habitat			
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging, dispersal	88.7	702.1
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – foraging, dispersal	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – foraging, dispersal	0.03	21.2
Sub-total		174.3	1,956.4
Total		178.3	1,978.5

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Northern Quoll habitat present in the development envelope represents denning, foraging and dispersal habitat for the species. Of the suitable habitats present the mesas, caves, cliffs and free faces and rocky gullies habitat types are suitable for denning. These represent only a small proportion of the suitable habitat present (1.1%). Given this, Northern Quolls present in the development envelope are most likely using the area primarily for foraging and dispersal. Any individual Northern Quolls that use the denning habitat in the Development Envelope may have some level of reliance on those habitats, but Northern Quolls are unlikely to be restricted to the habitat present in the Development Envelope.

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated as '8' for denning and '7' for foraging based on Excellent condition denning and foraging habitat being present, with the species not confirmed but likely part of population in the locality (Biota, 2021b).

Habitat critical to the survival of the Northern Quoll is defined as habitat within the modelled distribution of the species which provides shelter for breeding, refuge from fire / or predation and potential poisoning from Cane Toads (DoE, 2016). Habitat critical to the survival usually occurs in the form of (DoE, 206; Hill and Ward, 2010):

- rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creek lines;
- structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs; and
- offshore islands where the northern quoll is known to exist.

Dispersal and foraging habitat associated with or connecting populations considered 'important for the long-term survival of the northern quoll' (high density populations within habitat critical to the survival of the species, populations in habitats free of cane toads and populations subject to ongoing conservation or research actions) is also considered habitat critical to the survival of the northern quoll (DoE, 2016).

Northern Quoll dens are often made in rock crevices, with surrounding vegetated habitats used for foraging and dispersal. Den sites may also include tree holes, logs, termite mounds, and goanna burrows, however these are used less often than rocky habitats.

The following habitat types are rocky habitats within the development envelope considered to represent habitat critical to the survival of the Northern Quoll (Biota, 2021b):

- Mesas, caves, cliffs and free faces; and
- Rocky gullies.

There is a total of 4.0 ha of habitat critical to the survival of the Northern Quoll within the disturbance footprint (Table 1-9).

The referral guideline for the Northern Quoll (DoE, 2016) identifies foraging or dispersal habitat to be any land comprising predominantly native vegetation in the immediate area (i.e. within 1 km) of shelter habitat. Given this, Northern Quoll habitat within 1 km of the habitat identified as habitat critical to the survival of the Northern Quoll is considered to be important habitat for the species. There is 42.3 ha of this habitat within the indicative disturbance footprint.

1.7.10.2 Pilbara leaf-nosed bat (*Rhinonicteris aurantia*)

Species background information

The Pilbara Leaf-nosed Bat is listed as Vulnerable under the EPBC Act (DAWE, 2021c). It is a sub-population of the orange leaf-nosed bat (DAWE, 2021c). It is insectivorous and of moderate size, with short fur, small ears and a fleshy diamond-shaped nose-leaf surrounding the nostrils.

Abundance and distribution

The Pilbara Leaf-nosed Bat is found in the Pilbara, Ashburton and the Kimberley regions of WA, as well as in Queensland and the NT (DAWE, 2021c). The species is endemic to the Pilbara and Ashburton regions. The Pilbara Leaf-nosed Bat occurs over an approximate area of 120 million ha

in the Pilbara bioregion, extending southwards into the northern half of the Gascoyne bioregion (DAWE, 2021c).

The species occurs in three sub-populations (eastern Pilbara, Hamersley Range and upper Gascoyne) which are separated by flat areas, such as the Fortescue and Ashburton valleys (Armstrong 2003). The Pilbara Leaf-nosed Bat represents one interbreeding biological population comprising multiple colonies and is considered to be an "important" population (TSSC, 2016a). The Pilbara population is also considered a separate conservation unit on the basis of taxonomy.

Population size is difficult to estimate for this species, as not all roost sites are known and counts of colony size is challenging (DAWE, 2021c).

It is estimated there are between 10 and 35 caves in the Pilbara and upper Gascoyne regions providing roost habitat and, in some cases, breeding sites (Cramer et al., 2016; TSSC, 2016a). Previous surveys indicate that colonies in large underground mines range from 'several dozen' up to a 'few hundred' individuals, whereas colonies in caves are generally smaller (DAWE, 2021c).

Habitat Preferences

The Pilbara Leaf-nosed Bat is a poor thermoregulator, exhibiting evaporative water loss of more than double that of other bats (Churchill, 2008). Therefore, it has an obligate reliance on deep caves and underground mines, especially in the Pilbara (Armstrong, 2001). Its persistence in the Pilbara depends heavily on the presence of physiologically benign, humid and temperature-stable caves and dis-used mines, which it uses as roosts. These sites provide the necessary narrow temperature and humidity conditions for the species, which range from 28 to 32 ºC and 96 to 100 per cent relative humidity (Churchill, 2008).

The species is generally encountered in rocky areas that provide opportunity for roosting in caves or disused underground mines (Armstrong, 2001). The species forages in *Triodia* hummock grassland, sparse tree and shrub savannah and riparian vegetation along drainage lines (Duncan et al., 1999). Other foraging habitat used by the species includes gorges with pools, gullies, rocky outcrops, major watercourses and open grassland and woodland (TSSC, 2016a).

It is estimated that >8.1 million ha of suitable habitat for the Pilbara Leaf-nosed Bat exists in the Pilbara region (Section 1.7.9.3).

Breeding Parameters

Little is known about the breeding of the Pilbara Leaf-nosed Bat, however, studies have been undertaken on the Orange Leaf-nosed Bat in the NT (Churchill, 1995). They typically breed once a year in July, with gestation lasting approximately 150 days. Young are independent by the following February, approximately eight months after mating. Life expectancy is approximately 10 years. This cycle is assumed to be similar in the Pilbara Leaf-nosed Bat sub-species (DAWE, 2021c).

Threats

Threats to the Pilbara Leaf-nosed Bat include forced exodus of roost sites, interruption of breeding activity, underground mine collapse or flooding, mine development, blasting in adjacent mine pits and underground workings, human disturbance to roosts, roadkill, site rehabilitation of disused mine shafts and natural predators (DAWE, 2021c).

Of these threats, interruption of breeding activity, blasting, human disturbance of roosts and roadkill are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

The modelled distribution of the Pilbara Leaf-nosed Bat shows the development envelope is in an area where the species is known or likely to occur. The distribution map within the conservation advice for the species indicates that the area surrounding the development envelope is an area where diurnal roosts and foraging habitat is likely to occur (TSSC, 2016a).

A review of DBCA records for the species suggests the Pilbara Leaf-nosed Bat is known to occur within the Hamersley Ranges, with records adjacent to and both west and east of the development envelope. Biota (2021a) found that the species has been recorded frequently within the study area (18 km buffer from development envelope), with the nearest record 0.27 km from the development envelope.

As noted above, no caves suitable for roosting (considered habitat critical to the survival of the species; TSSC, 2016a) were recorded in the development envelope. However, the species typically has a dry season foraging range of 15 to 20 km from its primary roost and does forage at greater distances if suitable water sources are available (Bullen, 2013). Accordingly, while no caves suitable for roosting were recorded in the development envelope, the call recordings suggest that there is likely one or more unknown roosts in the vicinity of the development envelope.

This shows that a population of Pilbara Leaf-nosed Bats utilise the development envelope and surrounding areas as supporting habitat, and that there are likely active roost caves within 15 to 20 km of the development envelope.

Species presence within development envelope

Bat sampling using ultrasonic sound recorders (USRs) was undertaken at 22 sites for a period of one to three nights at each site during the Biota (2021a) survey.

Pilbara Leaf-Nosed Bat calls were recorded at two locations within the development envelope (Figure 14), as follows:

- call recordings on two occasions (on consecutive evenings) in *Eucalyptus* fringed major drainage lines and associated tributaries habitat towards the northern end of the development envelope; and
- call recording on one occasion in Mulga Grove habitat towards the southern end of the development envelope.

The distribution map within the conservation advice for this species indicates that the development envelope lies in an area where diurnal roosts and foraging habitat is likely to occur (TSSC, 2016a). These calls were recorded in habitat types considered to be supporting habitat utilised for foraging. However, no caves suitable for roosting were identified during the field survey (Biota, 2021a).

Species habitat extent

Table 1-11 identifies the suitable Pilbara Leaf-Nosed Bat habitat that is present in the development envelope. The distribution of these habitats is shown in Figure 14.

Table 1-11 Extent of suitable Pilbara Leaf-nosed Bat habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTURBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
HS - Mesas, caves, cliffs and free faces	Supporting habitat - potential roosting, foraging	0.14	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat - foraging	88.7	702.1
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat - foraging	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat - foraging, flyway, drinking	0.03	21.2
RG - Rocky gullies	Supporting habitat - foraging	3.8	13.7
Total		178.2	1,978.5

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated '7' for roosting and '8' for foraging.

No roosting sites were identified during the field survey (Biota, 2021a). Excellent condition foraging habitat is present, however, it is likely that the individuals recorded during the field survey are from a roost outside of the survey area. Extensive suitable foraging habitat is available within an approximately 20 km radius of the development envelope (Biota, 2021b).

The conservation advice for the Pilbara Leaf-nosed Bat identifies permanent diurnal roosts, non-permanent breeding roosts and transitory diurnal roosts as habitat critical to the survival of the Pilbara Leaf-nosed bats. Nocturnal refuges are not considered habitat critical to the survival of the species but are considered important for local persistence in the area (TSSC, 2016a). Caves and complex mines deep enough to create this environment are uncommon in the Pilbara (van Dyck and Strahan, 2008). The Hamersley Range is regarded as suitable habitat for the species, with many records throughout the area. Approximately 40 km (200 ha) of the Proposed Action is located within the Hamersley Ranges.

As no suitable roosting caves have been identified within the development envelope, no habitat critical to the survival of the species (as defined above; TSSC, 2016a) has been identified within the development envelope.

The conservation advice also identifies foraging habitat as important for sustaining populations including gorges with pools, gullies, rocky outcrops, major watercourses, and open grassland and woodlands (TSSC, 2016a). As such, the following habitat types that occur in the development

envelope are considered supporting habitat for the Pilbara Leaf-nosed Bat:[2]

- Mesas, caves, cliffs and free faces (Priority 3 - foraging habitat).
- Rocky hills and slopes with low open spinifex and scattered trees (Priority 5 - foraging habitat);
- Rocky gullies (Priority 5 - foraging habitat);
- *Eucalyptus* fringed major drainage lines and associated tributaries (Priority 4 - foraging habitat); and
- *Melaleuca* forest/major drainage lines (Priority 4 - foraging habitat).

1.7.10.3 Ghost Bat (*Macroderma gigas*)

Species background information

The Ghost Bat is listed as Vulnerable under the EPBC Act (TSSC, 2016b). The Ghost Bat is the largest bat of sub-order Microchiroptera in Australia and is primarily insectivorous, however; it will also feed on other bats, small mammals, birds, frogs and reptiles (Milne et al., 2016; TSSC, 2016b). The bat's fur is light to dark grey and it has long ears, large eyes, a simple nose-leaf and no tail (van Dyck and Strahan, 2008). The species uses several roosts per night and often returns to the same daytime roost.

Abundance and distribution

Ghost Bats are restricted to the tropical north of Australia (Churchill, 2008). Populations display genetic variation as they are geographically isolated from each other, with Pilbara populations also being isolated from those in the Kimberley and NT (Armstrong and Wilmer, 2004). As such, the Pilbara population is considered to be an important population as it is necessary for maintaining genetic diversity.

The estimated population size in Australia is fewer than 10,000 mature individuals with estimates continuing to decline (Woinarski et al., 2014). Of the existing population, it is estimated that 1,300 to 2,000 ghost bats are within the Pilbara and 3,000 to 4,000 are within the Kimberley (TSSC, 2016b).

Habitat preferences

Ghost Bats occur over a range of landforms and inhabit areas with suitable caves for roost sites (Churchill, 2008). Roost sites include deep natural caves, rock crevices and disused mine adits that have a stable temperature and moderate to high relative humidity (TSSC, 2016b). In the Hamersley Range, preferred roosting habitat appears to be caves beneath bluffs of low rounded hills composed of Marra Mamba geology and larger hills of Brockman Iron Formation (Armstrong and Anstee, 2000). Breeding caves require high humidity, greater than 80%, and often have narrow entrances opening into larger chambers (Armstrong and Anstee, 2000). The species may also forage over large areas, depending on the productivity of the landscape (Churchill, 1998).

Ghost Bats are known to require a number of suitable caves throughout their home ranges, due to both temporal factors (i.e. night/feeding roosts for feeding throughout the duration of the night, as well as day roosts for resting) and seasonal factors (use of certain caves as maternity roosts, depending on the right environmental conditions). The presence of day roosts and/or maternity

[2] Priority 3, 4 and 5 refers to protection priorities for Pilbara Leaf-nosed habitat as defined in the conservation advice for the species (TSSC, 2016a).

roosts in an area is the most important indicator of suitable habitat for Ghost Bats, and these caves are generally the primary focus of conservation and/or monitoring (TSSC, 2016b).

The occurrence of pools of water is a critical component of the Ghost Bat foraging habitat (Armstrong, 2001). There is no documented information on the importance of surface drinking water for the Ghost Bat; however, anecdotal accounts from field observations suggest that this species requires surface water for drinking, and water sources in proximity to day roost caves are therefore likely to be important (Armstrong, 2013).

Data are not available on the maximum distance that Ghost Bats will fly from its day roost cave before it needs to drink water; however, based on a foraging range of 10 km from a roost, the species is likely to require at least one drinking water source within this range. Water sources closer to the roost may be more critical than water sources further away. Surface water pools that provide drinking and feeding habitat for the Ghost Bat may be derived from surface runoff or spring seepage following rainfall, or may be groundwater-fed.

It is estimated that >9.3 million ha of suitable habitat for the Ghost Bat exists in the Pilbara region (Section 1.7.9.3).

Breeding parameters

Little is known about the breeding of ghost bats. Females aggregate in maternity roosts and breed at an age of two to three years (Milne et al., 2016). Mating generally occurs in May and gestation time is assumed to be 8 months. Ghost Bats have a life expectancy of about 20 years (Hoyle et al., 2001; Woinarski et al., 2014).

Threats

Threats to the Ghost Bat include habitat loss (including destruction of roost sites), disturbance of breeding sites, modification of foraging habitat, collision with fences, collapse or rework of disused mines, contamination by mining residue at roost sites, disease, poisoning by cane toads and competition for prey with introduced species. (TSSC, 2016b).

Of these threats, habitat and roost sites loss, disturbance of breeding sties, modification of foraging habitat, collisions with fences and competition with introduced species are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

Two caves with evidence of Ghost Bat use have been identified in within 125 m of the development envelope (in addition to the one cave located within the development envelope discussed below) during the Biota (2021a) survey. These caves were found in close proximity to each other (Figure 15) with Ghost Bat scat recorded at both caves, and one identified as a possible maternity roost cave.

This, together with the extensive suitable foraging habitat and historical records shows that a population of Ghost Bats use the area.

Species presence within development envelope

The Proposed Action occurs within the modelled distribution of the Ghost Bat and the species is known to occur.

DBCA records for the species show the Ghost Bat occurs within the Hamersley Ranges with records adjacent to and both west and east of the development envelope.

Bat sampling using USRs was undertaken at 22 sites for a period of one to three nights at each site

during the Biota (2021a) survey. No records of Ghost Bats were identified using the USRs.

One cave containing ghost bat scat and ghost bat remains was identified within the development envelope. This cave is located approximately 300 m from the indicative disturbance footprint in the Rocky hills and slopes with low open spinifex and scattered trees (RHS) habitat type (Figure 15).

In addition, Ghost Bats caves were reported in two locations in the Hamersley section of the Biota survey area (approximately 125 m outside of the development envelope) in the Rocky hills and slopes with low open spinifex and scattered trees habitat type (Figure 15). One of these caves has been identified as a potential maternity roost cave (Biota, 2021a).

Species habitat extent

Table 1-12 identifies the suitable Ghost Bat habitat that is present in the development envelope. The distribution of these habitats is shown in Figure 15.

Table 1-12 Extent of suitable Ghost Bat habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTRUBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
CP - Floodplains	Supporting habitat – foraging	135.0	1,778.6
HS - Mesas, caves, cliffs and free faces	Supporting habitat – potential roosting, foraging	0.14	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging	88.7	702.1
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – foraging, drinking	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – foraging, flyway, drinking	0.03	21.2
RG - Rocky gullies	Supporting habitat – foraging	3.8	13.7
MMW - Man-made water bodies	Supporting habitat –drinking	0.14	2.3
Total		313.4	3,882.7

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated as '10' for roosting and '9' for foraging based on the confirmed roost sites and a possible maternity roost being present

approximately 125 m outside of the development envelope, with excellent condition foraging habitat in proximity to the roosts (Biota, 2021b).

The conservation advice for the Ghost Bat notes that the species' persistence in the arid Pilbara depends on the physiologically benign day roosts found deep underground in humid, temperature-stable caves. The cave with evidence of Ghost Bat usage identified within the Development Envelope and the two caves located in close proximity to the development envelope area represent habitat of high importance to the Ghosts Bats in the area, with the local population likely reliant on the caves. The conservation advice for Ghost Bats suggests that suitable habitat within 5 km of diurnal roost sites provide good foraging opportunities for the species(TSSC, 2016b). Given this, the Ghost Bat habitat within 5 km of the possible maternity roost is likely of higher importance to Ghost Bats.

The remaining Ghost Bat habitat in the area is likely used as foraging, flyway and drinking habitat. Given these habitats are widely represented in the region, it is unlikely that Ghosts Bats would be restricted to or reliant on these habitats.

1.7.10.4 Pilbara Olive Python (*Liasis olivaceus barroni*)

Species background information

The Pilbara Olive Python is listed as Vulnerable under the EPBC Act (TSSC, 2008). It is a subspecies of the Olive Python (TSSC, 2008). It is a dull olive-brown to pale fawn or rich brown colour with a white belly (TSSC, 2008). It is on average 2.5 m in length; however, individuals can grow up to 4 m (Cogger, 2000). They are adept at swimming and hunt in waterholes or along tracks. Their diet consists of wallabies, euros, fruit bats, ducks, corellas, spinifex pigeons and coucals (Pearson, 2006).

Abundance and distribution

The Pilbara Olive Python is a distinct subspecies of the Olive Python found across northern Australia. The subspecies has a known distribution coinciding roughly with the Pilbara bioregion, such as the Hamersley Range and Islands of the Dampier Archipelago. Twenty-one important populations are known to occur in four distinct areas: Pannawonica, Millstream, Tom Price and the Burrup Peninsula (DSEWPaC, 2012c). Given the proximity of the Proposed Action to the Tom Price and Millstream areas, it is considered likely that Pilbara Olive Pythons located in or near to the development envelope are part of an important population of the species.

It is difficult to estimate the population size of the Pilbara Olive Python due to its cryptic nature and lack of reliable trapping or census techniques (TSSC, 2008). Pearson (2006) stated that there are sizeable numbers of the species in isolated populations which are restricted from threatening processes.

Habitat preferences

The Pilbara Olive Python prefers escarpments, gorges, rocky outcrops and water holes in the ranges of the Pilbara region (Pearson, 1993; Wilson and Swan, 2003). The snake finds shelter in caves, under boulders, in water and trees overhanging water (Bush and Maryan, 2011). Radio-telemetry has shown that individuals are usually in close proximity to water and rock outcrops that attract suitable sized prey species (TSSC, 2008). It should be noted though that while the species is often associated with ephemeral or permanent water, individuals have large home ranges (between 88 ha and 449 ha) and may be recorded in rocky habitats some distance from these features (Biota, 2021a).

It is estimated that >8.7 million ha of suitable habitat for the Pilbara Olive Python exists in the

Pilbara region (Section 1.7.9.3).

Breeding parameters

The Pilbara Olive Python breeding season occurs from June to August. Males travel up to 4 km in search of females. They then move to shelter to breed and remain there for up to three weeks. Females lay eggs in October which later hatch in January (DAWE, 2021d).

Threats

Threats to the Pilbara Olive Python include major fire events, predation by feral cats and foxes, predation of food sources by foxes, destruction of habitat from mining infrastructure development, tourists using waterholes (Pearson, 2006).

Of these threats, predation and competition with introduced species and destruction of habitat are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

No evidence of Pilbara Olive Pythons was observed during the Biota (2021a) survey. However, there is excellent quality habitat for the species in the development envelope and surrounding areas, and nearby historical records suggest that the species is likely to be present in the area.

Known important populations of the Pilbara Olive Python in the vicinity of the development envelope exist in the Tom Price and Millstream areas (DSEWPaC, 2012).

Species presence within development envelope

The development envelope is within the modelled distribution for the species and the species is known or likely to occur with records throughout the Hamersley Ranges. The Biota (2021a) survey did not record any evidence of Pilbara Olive Pythons. However, the species has been recorded in the surrounding area previously, with the closest record of Pilbara Olive Python to the development envelope approximately 4 km west, where the alignment deviates around Hamersley Homestead. This suggests that the species is likely to be present in the development envelope.

Species habitat extent

The Biota (2021a) survey identified suitable habitat for the Pilbara Olive Python within the development envelope, particularly along major drainage lines and associated rocky areas (Biota, 2021a). The potential Pilbara Olive Python habitat listed in Table 1-13 is present in the development envelope. The distribution of these habitats is shown in Figure 16.

Table 1-13 Extent of suitable Pilbara Olive Python habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTURBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
CP - Floodplains	Supporting habitat - foraging	135.0	1,778.6
HS - Mesas, caves, cliffs and free faces	Supporting habitat - foraging	0.14	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered	Supporting habitat - foraging	88.7	702.1

trees			
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat - foraging	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat - foraging	0.03	21.2
RG - Rocky gullies	Supporting habitat - foraging	3.8	13.7
Total		313.3	3,757.1

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated '7' based on the excellent condition foraging habitat present with the species not confirmed but likely part of population in the locality (Biota, 2021b).

The conservation advice for the Pilbara Olive Python does not identify habitat critical to the survival of the species. Given the species habitat preference the habitats shown above are considered supporting habitat for the species. None of these habitats are likely to be habitats critical to the survival of the species (DoE, 2013). As these habitats are common and widespread in the region it is unlikely that the species is restricted to the habitat within the Development Envelope. Pilbara Olive Python individuals have large home ranges (between 88 ha and 449 ha), therefore they are unlikely to be dependent on the habitat to be cleared (Biota, 2021).

1.7.10.5 Night Parrot (*Pezoporus occidentalis)*

Species background information

Night Parrot is listed as Endangered under the EPBC Act (TSSC, 2016c). The species is a highly elusive, nocturnal ground dwelling parrot that grows up to 25 cm long (TSSC, 2016c). Adults are mostly bright green with black and yellow markings. They are found in the arid and semi-arid zones of Australia

Abundance and distribution

The current distribution of the night parrot is unknown; however, they are found in the semi-arid and arid areas of inland Australia (Murphy et al., 2017a; 2017b). Populations are known from Murchison and north-eastern desert regions in WA and from western Queensland (Biota, 2021a). Despite numerous unverified sightings, several dedicated searches and public campaigns there have been only two areas (western Queensland and the Pilbara in WA) where reliable records indicate that populations may persist. The species is nocturnal and is thought to be nomadic with a large home range (TSSC, 2016c).

Habitat preferences

Historically, the Night Parrot has been known to inhabit a wide variety of habitats, however most habitat records are of *Triodia* (Spinifex) grasslands and/or Chenopod shrublands in the arid and semi-arid zones. *Astrebla* spp. (Mitchell Grass), shrubby samphire and chenopod associations,

scattered trees and shrubs, *Acacia aneura* (Mulga) woodland, treeless areas and bare gibber (desert pavement) are also associated with sightings of the species (Higgins and Davies, 1996, Garnett et al., 2011).

It is estimated that >0.6 million ha of suitable habitat for the Night Parrot exists in the Pilbara region (Section 1.7.9.3).

Breeding parameters

Nesting sites are reported within dense vegetation, primarily old and large spinifex clumps (TSSC, 2016c). The breeding parameters of Night Parrots are largely unknown. It is believed to take place after heavy rainfall, with unverified reports of breeding activity in April, July and August (NSW Government, 2017a). It is estimated that the lifespan is 10 years.

Threats

There are no known threats to the Night Parrot however the conservation advice lists threats that are considered realistic threats in absence of direct evidence. These include inappropriate fire regimes, soil disturbance from grazing by domestic or feral herbivores, predation by feral cats and foxes, competition for food by livestock or feral herbivores, disease, collision with fencing and loss or degradation of habitat (DBCA, 2017; TSSC, 2016c).

Of these threats, fencing, predation and competition with introduced species and destruction of habitat are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

There are no DBCA records for this species within 50 km of the development envelope. No evidence of the Night Parrot was found within the survey area over seven nights of survey effort by Biota (2021a), or during previous surveys for the Proposed Action.

The closest confirmed recording of the Night Parrot is on the edge of the Fortescue Marsh, recorded during surveys for the Cloudbreak Mine development. Assessment in relation to the Cloudbreak Mine found that the habitats on the edge of the Fortescue March may be disproportionately important to Night Parrots as they offer protection from fire and have increased groundwater availability (Map IT, 2012). No habitats similar to this habitat are present in the development envelope for the Proposed Action. The Grassland plains with cracking clay habitat within the development envelope may provide adequate habitat for Night Parrot foraging.

It is highly unlikely that an important Night Parrot population is present in the vicinity of the development envelope.

Species presence within development envelope

The Proposed Action occurs within the modelled distribution of the Night Parrot in an area where habitat may be present (TSSC, 2016c).

Two nights of survey using auditory acoustic recording units (ARUs) within Floodplain habitat (Coolawanyah section), and five nights within Grassland plains with cracking clay habitat type (Tom Price section), were undertaken in April 2020. No Night Parrots were detected during the survey. The Night Parrot was also not recorded in surveys of areas nearby previously undertaken by Biota (2021a). However, the floodplains and the grassland plains with cracking clay habitat within the development envelope may provide habitat for Night Parrot foraging. It is considered, therefore that while this species 'May occur' within the development envelope due to the presence of suitable habitat, it is considered highly unlikely that an important Night Parrot population is

present in the development envelope.

Species habitat extent

Table 1-14 shows the potential Night Parrot habitat is present in the development envelope. The distribution of these habitats is shown in Figure 17.

Table 1-14 Extent of suitable Night Parrot habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTURBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
GPCC - Grassland plains with cracking clay	Supporting habitat - foraging	29.3	203.4

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated as '3' based on there being no evidence that the species occurs in the development envelope or in close proximity and the presence of suitable foraging habitat in Poor-Good condition (Biota, 2021b)

The conservation advice for the Night Parrot does not identify habitat critical to the survival of the species. Given the species habitat preference, the Grassland plains with cracking clay habitat is considered supporting habitat for the Night Parrot.

1.7.10.6 Grey Falcon (*Falco hypoleucos*)

Species background information

The Grey Falcon is listed as Vulnerable under the EPBC Act (TSSC, 2020). It is the rarest of the falcon species found in Australia and consists of a single population (TSSC, 2020). It is a medium-sized, pale falcon with a heavy thick chest, long wings and dark wing tips (TSSC, 2020). It primarily preys on birds, reptiles and mammals (NSW Government, 2017b).

Abundance and distribution

The Grey Falcon is sparsely distributed across arid and semi-arid inland Australia where rainfall is less than 500 mm annually, including the Murray-Darling Basin, Eyre Basin, central Australia and WA (Marchant and Higgins, 1993). It is commonly located on wooded plains and along major river courses (Johnstone et al., 2013).

The estimated number of mature individuals is less than 1,000 (BirdLife International, 2019; Garnett et al., 2011; Schoenjahn, 2018).

Habitat preferences

Grey Falcons typically nest in the tallest trees along watercourses, particularly river red gum (*Eucalyptus camaldulensis*), though they have also been known to nest in communications towers (Marchant and Higgins, 1993). It is known to frequent timbered lowland plains, particularly *Acacia* shrublands that are crossed by tree-lined watercourses, tussock grassland and open woodland, and

has been observed hunting in treeless areas (Garnett et al., 2011; Schoenjahn, 2018).

Breeding parameters

Breeding commonly occurs in tall trees such a river red gums, or on man-made structures from June to November (TSSC, 2020). Clutch size can vary from one to four eggs, which are laid in the old nests of other birds (TSSC, 2020). The young Grey Falcons stay with their parents for at least 12 months after fledging.

Threats

Threats to the Grey Falcon include grazing and clearing of arid and semi-arid rangelands, the small population size, nest shortage, collision with traffic, collision with fences, increased temperatures in arid and semi-arid Australia, predation by cats, secondary poisoning through mouse and locust control programs and taking of eggs and young for collections and falconry (NSW Government, 2017b; TSSC, 2020). Notably, the conservation advice for the Grey Falcon recognises that the threats listed within this advice are 'based on general considerations and extrapolations from better studied species and are, therefore, speculative' (TSSC, 2020).

Of these threats, collision with traffic, collision with fences and predation by introduced species are relevant to the Proposed Action.

Known populations in the vicinity of the development envelope

The Grey Falcon was recorded in flight, likely foraging during the Biota survey and has been recorded previously in close proximity to the development envelope (Biota, 2021a). This, together with the known distribution of the species and the presence of suitable habitat suggests that a population of Grey Falcon is present in the area surrounding the development envelope.

Species presence within development envelope

One Grey Falcon was observed once in flight during the Biota (2021a) survey, likely foraging. This observation was within the Rocky hills and slopes with low open spinifex and scattered tree habitat type. The location of the observation is shown on Figure 18.

The Grey Falcon occurring in the development envelope is not believed to represent an 'important population' on the basis that the Pilbara is believed to represent a "refugia to which the species may withdraw, and which provide foci for recolonization when conditions improve" (Olsen & Olsen, 1986).

Species habitat extent

The Grey Falcon may use all habitat types present in the development envelope although they are primarily associated with the Floodplains, *Eucalyptus* fringed major drainage lines and associated tributaries, *Melaleuca* forest/major drainage lines, and Man-made water bodies habitat types. Table 1-15 presents the potential Grey Falcon habitat that is present in the development envelope. The distribution of these habitats is shown in Figure 18.

Table 1-15 Extent of suitable Night Parrot habitat within the disturbance footprint and development envelope

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT IN DISTURBANCE FOOTPRINT* (HA)	EXTENT IN DEVELOPMENT ENVELOPE (HA)
MG - Grove Mulga	Supporting habitat - foraging	69.7	666.2
MWP - Mulga Woodland Plain	Supporting habitat - foraging	16.1	122.5
ASCC - Acacia xiphophylla shrublands over cracking clay	Supporting habitat - foraging	10.4	328.9
ASM - Mixed Acacia shrublands	Supporting habitat - foraging	157.5	1,659.2
GPCC - Grassland plains with cracking clay	Supporting habitat - foraging	29.3	203.7
CP - Floodplains	Supporting habitat - foraging	135	1,778.6
HS - Mesas, caves, cliffs and free faces	Supporting habitat - foraging	0.14	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat - foraging	88.7	702.1
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – nesting, foraging	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – nesting, foraging	0.03	21.2
RG - Rocky gullies	Supporting habitat - foraging	3.8	13.7
MMW - Man-made water bodies	Supporting habitat – foraging, drinking	0.14	2.3
Total		596.1	6739.9

*Extent based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Species habitat quality and importance

The Biota (2021b) habitat quality assessment is provided in Appendix 6. The overall habitat quality score for habitat within the development envelope was rated as '6' based on the confirmed record and excellent condition foraging habitat being present, but noting that the species occurs widely in similar habitats which are extensive in the locality (Biota, 2021b).

The conservation advice for the Grey Falcon does not identify habitat critical to the survival of the species. All habitats in and around the development envelope are likely to be used for foraging, at

least on occasion, with waterholes or other features attracting aggregations of birds likely to be particularly attractive (Biota, 2021a). Given this preference and that the species nests in tall trees along watercourses, the habitats shown above are considered supporting habitat for the species. This is further supported by the conservation advice for the species which lists the conservation of known nesting trees as a conservation and management priority (TSSC, 2020).

2 ASSESSMENT OF IMPACTS

This section assesses the potential direct and indirect impacts on protected matters that are likely to be present within the development envelope and surrounds.

Each protected matter is assessed consistent with the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* which identifies 'significant impact criteria' to assist in determining whether the environmental impacts of a Proposal are likely to be significant (DoE, 2013). Conservation advice, recovery plans, and other relevant guidance have been applied as relevant to specific protected matters.

The following aspects associated with the Proposed Action have the potential to result in impacts to MNES.

Habitat Loss

Clearing for road construction will impact on the following fauna habitat:

- Up to 178.3 ha of potential Northern Quoll foraging, dispersal and denning habitat. This includes up to 4.0 ha of habitat critical to Northern Quoll survival being rocky areas identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' comprising:
  - The (HS): mesas, caves, cliff and free faces habitat, a portion of these rocky areas identified by Biota (2021a) as core denning habitat
  - The (RG) Rocky gullies habitat, also considered critical habitat, identified by Biota (2021a) as a foraging and dispersal resource for Northern Quolls.
- Up to 178.2 ha of potential Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat, none considered habitat critical to the survival of the species.
- Up to 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat, none considered habitat critical to the survival of the species.
- Up to 313.3 ha of potential Pilbara Olive Python foraging habitat, none considered habitat critical to the survival of the species.
- Up to 29.3 ha of potential Night Parrot foraging habitat, none considered habitat critical to the survival of the species.
- Up to 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat, none considered habitat critical to the survival of the species.

[Note: These estimated habitat impact areas include an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown].

The Proposed Action requires approximately 100 ha of temporary clearing for construction activities such as site offices, laydown and access. This temporary clearing will be located outside fauna habitat areas where practicable and rehabilitated as part of the Proposed Action.

The Proposed Action's detailed design will minimise habitat impacts, including those for construction activities through:

- avoidance of fauna habitat where possible;
- the use of steepened batters, where safe to do so, to reduce the width of the clearing footprint; and

- the installation of safety barriers, where practicable, to reduce the width of the clearing footprint.

Interaction with construction activities

Injury or mortality of fauna individuals may potentially occur during the construction of the Proposed Action as a result of interaction with the construction activities including equipment, clearing and blasting.

Vehicle strike

Injury or mortality of fauna individuals is a potential impact of the Proposed Action as a result of the permanent risk of vehicle strike during operation of the Proposed Action.

Collision with fencing

It is possible that fencing will be installed at select areas along the new road for the protection of road users or for other health, safety and environment reasons. It is, therefore, possible that fauna individuals (such as bats and birds) may collide with this fencing. Collision with fences has the potential to result in injury or mortality of fauna individuals. Barbed wire will not be used in fencing.

Disturbance from artificial light

While there is no permanent lighting associated with the Proposed Action, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long periods of time and will be moved along the construction area as dictated by the construction schedule. Fauna may be attracted to areas where prey such as insects are attracted to the light emissions. Light emissions may also cause other behaviour responses such as changing the timing of bats entering and existing caves.

Disturbance from noise and vibration

Increased noise and vibration will occur temporarily as a result of construction activities (including blasting) but will decrease in the operational phase of the road, though it will remain slightly higher than background levels in close vicinity of the new road. Noise is an environmental stressor and can potentially affect fauna in a number of ways including alienation from noisy habitats, hearing loss, or reduction in foraging success due to masking (i.e. interference with the perception of sounds of interest).

Fragmentation of habitat and population isolation

Clearing and the construction of the road can result in the fragmentation of small pockets of suitable fauna habitat. As discussed in Section 2.2, the road will not provide a barrier to the movement of fauna.

Habitat degradation as a result of groundwater abstraction and dewatering

Abstraction of water for use during construction and during potential dewatering as part of the construction of waterway crossings has the potential to result in temporary localised drawdown in groundwater levels. If this draw down was of sufficient magnitude and duration to impact

vegetation dependent on groundwater, this could result in indirect impacts to MNES that utilise this vegetation.

Introduced species

There is the potential for a range of feral and weed species to be introduced and/or attracted to the area as a result of construction and operational activities, such as the clearing activities, increased traffic movements and waste. The presence of introduced predators may be exacerbated by the Proposed Action as a result of the creation of new pathways for pest animals and potential attraction of animals to waste. The presence of roadkill also has the potential to attract feral fauna into the area, particularly those using roadkill as food sources.

Dust generation

Potential impacts to Fringed Fire-Bush from the generation of dust during construction activities.

Attraction to food waste at construction camps, illegal rubbish dumping and litter

Dumping or inappropriate disposal of waste of during construction (e.g. at the construction camps) and operations (such as at rest areas) may attract fauna which can potentially make individuals more susceptible to vehicle strike, predation from feral predators and illness due to inappropriate food intake.

Indirect impacts as a result of change to surface water flow

Changes to surface water flows due to the physical presence of the road may result in shadowing (where water level is reduced or surf ace water absent as a result of infrastructure interrupting flow), flooding and waterlogging. The extent of impact in an area will generally depend on terrain slopes in the area and the angle of the road compared to the terrain. In gently sloping areas the impact of the road could potentially be substantial as it has the potential to obstruct considerable flow if it is perpendicular to the natural flow direction.

Changes to surface flow may result in impacts to flora and vegetation as well as backwater impacts on existing infrastructure (such as the Rio Tinto rail line, the proposed FMG rail line and access roads), and the serviceability and resilience of the new road itself.

A hydrological risk assessment was undertaken by Cardno (2022), which provides an understanding of the surface water regime throughout the Development Envelope; identifies and describes the hydrological risk factors associated with the Proposed Action; and proposes design criteria to be adopted in managing major waterways. WSP Golder (2022) reviewed this assessment and prepared a Hydrological Risk Assessment for MRDH (Stage 4) (see Appendix 5).

The Cardno (2022) assessment determined key design criteria for the future detailed design. The relevant design criteria in relation to the environmental impact assessment are:

- allowance for climate change and future changes in rainfall regimes;
- all impacts to third party infrastructure are to be avoided and detailed investigation must be conducted at relevant locations to determine if an increase in backwater is acceptable to the asset owner; and
- impacts on sensitive environmental and heritage receptors is to be evaluated for high probability events together with key stakeholders in all locations.

Adoption of these design criteria will ensure that the Proposed Action is designed and constructed in a manner that results in surface water flow paths and velocities being maintained. WSP Golder (2022, Appendix 5) undertook a hydrological risk assessment of MRDH Stage 4 and found that with implementation of the design elements recommended by Cardno (2022), changes to surface flows are unlikely to impact on ecosystems or environmental receptors.

Given this, it is not expected that surface water flows will be altered such that significant impacts to MNES occur. As such, potential impacts from changes to surface water flow are not discussed further.

2.1 Threatened flora

2.1.1 Fringed Fire-bush (*Seringia exastia*) – Critically Endangered

An overview of the ecology, abundance, distribution of the fringed fire-bush, which is listed as critically endangered under the EPBC Act is provided in Section 1.7.7.

One individual Fringed Fire-bush was recorded within the development envelope on the foothills in the south-central section of the survey area (Biota, 2021a) (Figure 10).

The location of the recorded specimen was approximately 115 m from the centre line of the proposed road alignment and outside of the disturbance footprint. As noted in Section 1.7.7, due to newly discovered genetic similarity by Binks et al (2020), *Seringia elliptica* has been combined with *Seringia exastia* with *Seringia exastia* now representing a common, widespread species that is no longer considered to be of significance (Biota, 2021a). The species is expected to be de-listed from the EPBC threatened species list after TSSC review of the Threatened Flora List. At the time of preparation of this document however, the species *Seringia exastia* is still listed as Critically Endangered under the EPBC Act. This status has been reflected within the impact assessment presented in this document.

2.1.1.1 Direct impacts

As this species does not fall within the disturbance footprint, no direct impacts to this species are anticipated as a result of the Proposed Action. A 50 m 'No Go' exclusion zone will be implemented around the location and marked on all relevant maps to minimise the potential inadvertent disturbance of the plant.

2.1.1.2 Indirect impacts

Potential indirect impacts to flora include:

- the introduction of new or spread of existing weed species as a result of vehicle movements and earthmoving activities; and
- potential impacts from the generation of dust during construction activities.

Introduction or spread of weed species

One of the main threats to the Fringed Fire-Bush is competition from weeds (Broome Botanical Society, 1995; DAWE, 2021e). Given the mitigation measures proposed to avoid the introduction of new or spread of existing weeds (Section 3), and the relatively high background level of weeds in the area, the proposed action is not expected to result in a significant increase in weeds in the area.

As such, no significant impacts to Fringed Fire-Bush are expected to occur as a result of the introduction or spread of weeds as a result of the Proposed Action.

Dust generation

Potential impacts to Fringed Fire-Bush from the generation of dust are considered negligible as dust generation due to the Proposed Action will only occur during construction and will occur over 100 m away from the single known plant in the development envelope for a short period of time. In the longer term, a reduction in dust generation is predicted due to the reduced ongoing vehicle travel on dirt roads once the Proposed Action is operational.

2.1.1.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Fringed Fire-Bush against the MNES significant impact criteria is provided in Table 2-1. This assessment uses the significant impact criteria for critically endangered species (DoE, 2013).

Table 2-1 Assessment of the potential impact of the Proposed Action on the Fringed Fire-Bush

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE FRINGED FIRE-BUSH
'lead to a long-term decrease in the size of a population'	Not Significant No direct impact is predicted to occur to the single plant of this species located within the development envelope. Indirect impacts are predicted to be negligible. Given this, the Proposed Action is not predicted to lead to a long-term decrease in the size of a population of Fringed Fire-Bush.
'reduce the area of occupancy of the species'	Not Significant The combined species has a wide distribution including throughout much of the Pilbara regions (Florabase, 2021). Given this, the clearing of 650 ha for the Proposed Action is not expected to reduce the area of occupancy of the species.
'fragment an existing population into two or more populations	Not Significant A single plant of the species has been identified within the development envelope. Given this, the Proposed Action will not fragment a population of Fringed Fire-Bush into two or more populations.
'adversely affect habitat critical to the survival of a species'	Not Significant No habitat critical to the survival of the Fringed Fire-Bush has been identified within the development envelope.
'disrupt the breeding cycle of a population'	Not Significant The closest previous record of the species is approximately 14 km from the development envelope. Given the single plant identified in the development envelope will not be disturbed, the Proposed Action will not disrupt the breeding cycle of a population of Fringed Fire-Bush.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to	Not Significant The combined species has a wide distribution including throughout much of the Pilbara region (Florabase, 2021). Given this, the Proposed Action is not expected to 'modify, destroy, remove, isolate or decrease the availability or

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE FRINGED FIRE-BUSH
the extent that the species is likely to decline'	quality of habitat' to the extent that the species is likely to decline.
'result in invasive species that are harmful to a species becoming established in the species habitat'	Not Significant Given the mitigation measures proposed to avoid the introduction of new or spread of existing weeds (Section 3), and the relatively high background level of weeds in the area, the proposed action is not expected to result in invasive species that are harmful to a species becoming established in the species habitat'
'introduce disease that may cause the species to decline'	Not Significant There is no credible impact pathway that could result in the introduction of a disease that may cause a decline in the Fringed Fire-Bush.
'interfere with the recovery of the species'	Not Significant No significant impacts are expected to occur to the Fringed Fire-Bush with the single plant identified within the development envelope to be protected using a 50 m no-go zone.

2.2 Threatened Fauna

The Commonwealth Significant Impact Guidelines 1.1 adopts criteria for assessment of impact to threatened species relating to 'populations' and/or 'important populations' (DotE 2013). However, these terms have not been defined for Threatened Fauna, specifically for mammals, reptiles and birds. For birds it is particularly difficult due to the mobile and widely-distributed nature of these species. For Threatened fauna, it is more appropriate to consider significance in terms of impacts on habitat rather than a resident population and this approach is adopted for the following sections on assessments of impacts of the Proposed Action.

The habitat of Threatened fauna has then been assessed based on Biota (2021a) and Biota (2021b) (Appendix 4 and Appendix 6).

2.2.1 Northern Quoll (*Dasyurus hallucatus*) – (Endangered)

Potential direct impacts that may occur to Northern Quoll as a result of the Proposed Action are:

- habitat loss;
- interaction with construction activities;
- vehicle strike during operations resulting in increased fauna injury or mortality; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Northern Quoll as a result of the Proposed Action include:

- fragmentation of habitat or due to clearing and the presence of the road;

- introduced species resulting in increased predation or competition for resources;
- habitat degradation resulting from weed invasion; and
- attraction to food waste at construction camps, illegal rubbish dumping and litter.

2.2.1.1 Direct Impacts

Loss of habitat

Up to 178.3 ha of potential Northern Quoll foraging, dispersal and denning habitat will be cleared for the Proposed Action (Section 1.7.10). This includes potential clearing of up to 4.0 ha of habitat considered to be habitat critical to the survival of the Northern Quoll according to the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)', as they may be used as denning and/or refuge sites (Hill and Ward 2010).

The 4.0 ha of critical habitat is comprised of:

- The mesas, caves, cliff and free faces habitat, a portion of these rocky areas identified by Biota (2021a) as core denning habitat; and
- The rocky gullies habitat, also considered critical habitat, identified by Biota (2021a) as a foraging and dispersal resource for Northern Quolls.

The referral guideline for the Northern Quoll (DoE, 2016) identifies foraging or dispersal habitat to be any land comprising predominantly native vegetation in the immediate area (i.e. within 1 km) of shelter habitat. Given this, Northern Quoll habitat within 1 km of the habitat identified as critical to the survival of the Northern Quoll is considered to be important habitat for the species. There is 42.3 ha of this habitat within the indicative disturbance footprint.

The field survey (Biota, 2021a) identified five habitat types that the Northern Quoll may utilise (shown in Figure 13). A breakdown of the area proposed to be cleared per habitat type is provided in Table 2-2. The Northern Quoll habitat loss for the Proposed Action represents less than 0.022% of the similar habitat available in the Pilbara region. It is also noted that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area. Habitat quality for habitat critical to the Northern Quoll was rated as '8' and supporting habitat types (foraging) were rated as '7' as described in Appendix 6 (Biota, 2021b).

Table 2-2 Extent of Northern Quoll habitat clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
HS – Mesas, caves, cliffs and free faces	Critical to the survival of the species – denning	0.14	8.4
RG - Rocky gullies	Critical to the survival of the species – foraging and dispersal	3.8	13.7
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging, dispersal	88.7	702.1

MDE – *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – foraging, dispersal	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – foraging, dispersal	0.03	21.2
	Total	178.3	1,978.5

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

Habitat degradation and habitat destruction are identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' as key threats to the species (Hill and Ward, 2010).It is likely that the clearing of 4.0 ha of habitat critical to the survival of the Northern Quoll will result in a significant residual impact on local Northern Quoll populations.

FMG (2018) identified 8,224 ha of potential Northern Quoll denning habitat in the region of which 299.3 ha (3.63%) was planned to be removed for the Solomon and Eliana mines and associated rail line. Based on this, the Proposed Action will result in the removal of a further 0.05% of the total denning habitat in the region as mapped by FMG (2018). This means that over 96% of the suitable denning habitat mapped by FMG (2018) would remain. Given this, the loss of 4.0 ha is unlikely to be significant given the availability of locally available denning habitat.

The remaining Northern Quoll habitat that will be cleared as a result of the Proposed Action represents 174.5 ha of supporting foraging and dispersal habitat. Of this habitat, 42.3 ha is foraging and dispersal habitat within 1 km of habitat critical to the survival of the Northern Quoll and is important dispersal habitat for the species (DoE, 2016). The loss of this 42.3 ha of important foraging and dispersal habitat is likely to result in a significant residual impact on local Northern Quoll populations. The loss of the 132.2 ha of this habitat type that is more than 1 km from habitat critical to the survival of the Northern Quoll is not likely to represent a significant residual impact. This habitat type is common within the Pilbara region (estimated extent >8.7 million ha) with vast amounts being vested in National Parks in the region, including the Millstream-Chichester National Park adjacent to the Proposed Action. Northern Quoll are not restricted to the foraging and dispersal habitat within the disturbance footprint and are unlikely to be reliant on it or significantly impacted by its loss.

Overall, the loss is a very small proportion of the available denning, foraging and dispersal habitat for Northern Quolls. It is not predicted that this clearing will result in a decline in population of Northern Quolls or interfere with the species recovery.

Interaction with construction activities

Injury or mortality of Northern Quoll individuals may potentially occur during the construction of the Proposed Action as a result of interaction with the construction activities including equipment and vehicle movements, clearing and blasting.

The risk of such impacts occurring are higher during construction in and near the denning habitat during mating season. This risk will be mitigated by limiting clearing of this habitat to between 1 April and 30 September to prevent coinciding with Northern Quoll when they have large pouch or denned young. Further, prior to clearing any Northern Quoll denning habitat, pre-clearance surveys will be undertaken to confirm no Northern Quolls are present in the area. Mitigation and

management measures are described in Section 3 and the Fauna Action Management Plan (Appendix 6).

Given the proposed mitigation measures and the low density of Northern Quolls expected in the area of the development envelope, impacts are expected to be minimal and limited to temporary avoidance behaviour in a small number of Norther Quolls. This avoidance behaviour will further reduce the risk of more serious impacts such as injury or mortality occurring.

Vehicle strike (operational traffic)

Once construction is complete and the road opened to traffic, there will be a permanent risk of vehicle strikes involving Northern Quoll leading to injury or mortality of individual quolls. Traffic modelling for the Proposed Action indicates traffic volumes will be low with a likely maximum of 635 vehicles per day, of which up to around 230 will be heavy vehicles. Lower volumes of traffic are expected at night which reduces the risks to Northern Quoll given it is a nocturnal species. Given this low expected traffic volume and low density of Northern Quolls in the area, impacts to Northern Quolls as a result of vehicle strike are not expected. In the unlikely event that they do occur, they will be limited to a small number of individuals. These impacts may occur throughout the operational life of the road.

Disturbance from light, noise and vibration

While there is no permanent lighting associated with the Proposed Action, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long periods of time and will be moved along the construction area as dictated by the construction schedule.

These temporary light emissions have the potential to result in behavioural responses in Northern Quolls. These impacts are expected to be limited to temporary avoidance of the illuminated areas previously used for foraging or changes to prey item (insects) aggregation resulting in changes to foraging behaviour. Given the temporary and localised nature of the light emissions and resultant minor behavioural changes, these impacts are not expected to be significant in consideration of the low densities of Northern Quoll likely to exist in the development envelope.

Increased noise and vibration will occur temporarily as a result of construction activities (including blasting) but will decrease in the operational phase of the road, though it will remain slightly higher than background levels in close vicinity of the new road.

Noise is an environmental stressor and can potentially affect wild animals including the Northern Quoll in a number of ways such as: alienation from noisy habitats, hearing loss, increased rates of predation (e.g. by feral species) or reduction in foraging success due to masking (i.e. interference with the perception of sounds of interest). However, there is a lack of research into the impact of noise on native fauna in the Pilbara in general, and on the Northern Quoll in particular.

Low level noise emissions and vibration from equipment during construction have the potential to result in behavioural responses in exposed Northern Quolls. These impacts are expected to be limited to temporary avoidance of the area by a small number of individuals.

Noise and vibration from limited blasting activities have the potential to cause injury (hearing loss) to individuals close to the blast point. This risk of this occurring is considered low however, as individual will likely have displayed avoidance behaviour due to construction activities and as such

would be unlikely to be in the development envelope or in adjacent areas such as denning areas close to the disturbance footprint.

Low level traffic noise may cause minor avoidance behaviour in a small number of individual Northern Quolls in close vicinity of the road during operations. However, the large home range of Northern Quolls means that traffic noise will impact on a small portion of Northern Quoll home ranges. Given the low number of Northern Quolls expected in these locations (if any) and the expected low traffic volume using the road daily, this impact is not expected to be significant.

2.2.1.2 Indirect impacts

Fragmentation of habitat and population isolation

It is unlikely that the Proposed Action will result in a significant indirect impact to Northern Quolls due to fragmentation. Habitat degradation and population isolation are identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' as key threats to the species (Hill and Ward, 2010).

The construction of the road may result in the fragmentation of small pockets of suitable Northern Quoll habitat in the vicinity of the action, particularly in areas where isolated pockets of Rocky hills and slopes with low open spinifex and scattered trees (RHS) and Rocky gullies (RG) habitat will be created between the disturbance footprint and the existing rail line. However, as Northern Quoll will be able to cross the road (with the exception of some small stretches that access maybe restricted due to steep slope created where material had to be cut to construct the road), these habitats will still be available for use as refuge and foraging habitat. As this fragmentation will not result in the isolation of habitat or known Northern Quoll populations, it is not expected to result in a decline in Northern Quoll populations or significantly impact the recovery of the species.

Introduced species

Feral species

Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' (Hill and Ward 2010). Feral predators such as foxes that prey on food sources that the Northern Quoll relies upon are also a threat (Hill and Ward 2010).

Feral predators are widespread throughout the Pilbara and recorded in the Development Envelope (Biota 2021). Given the proposed mitigation measures (Section 3), existing disturbance (such as existing rail lines) and multiple existing transport corridors in the region, it considered unlikely that the Proposed Action will result in an increase in feral predators such that Northern Quoll populations are likely to decline.

Cane toads are not present within the Pilbara however the Proposed Action has the potential to increase access to such species if they are introduced in future.

Weeds

The presence of weeds may be exacerbated by the Proposed Action as a result of clearing and introduction or spread of weeds. Any exacerbation of weeds as a result of the Proposed Action is not predicted to be significant however, due to the planned mitigation measures and the existing background level of weeds in the area. It is also noted that weeds of particular concern for the Northern Quoll such as Gamba Grass and Mission Grass (due to their large biomass and rigidity

potentially inhibiting movement and foraging) are not found within the development envelope. As such, impacts to Northern Quolls as a result of the exacerbated presence of weed species due to the Proposed Action are not expected to occur.

Attraction to food waste at construction camps, illegal rubbish dumping and litter

Northern Quolls are scavengers and as such may be attracted to waste (particularly meat) that is dumped or inappropriately disposed of during construction (e.g. at the construction camps) and operations (such as at rest areas). This attraction may potentially make Northern Quoll individuals more susceptible to vehicle strike, predation from feral predators and illness due to inappropriate food intake.

Given the mitigation measures that will be in place during construction (food waste will not be dumped, waste will be appropriately segregated and contained, including use of lids that cannot be removed by quolls), the low traffic volume expected and the lack of evidence of significant numbers of Northern Quolls being present in the area, there is a high level of confidence that impacts to Northern Quolls as a result of illegal dumping and littering will be negligible.

2.2.1.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Northern Quoll against the MNES significant impact criteria is provided in Table 2-3. This assessment uses the significant impact criteria for endangered species (DoE, 2013).

Table 2-3 Assessment of the potential impact of the Proposed Action on the Northern Quoll species

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NORTHERN QUOLL
'lead to a long-term decrease in the size of a population'	Not Significant As described in Section 2.2.1.1, it is likely that the clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll and up to 42.3 ha of foraging and dispersal habitat within 1 km of habitat critical to the survival of the Northern Quoll will result in a significant impact on local Northern Quoll populations. In addition, up to a further 132.2 ha of supporting foraging and dispersal habitat will be cleared. Given the relatively small amount of critical habitat, important foraging and dispersal habitat and other suitable Northern Quoll habitat to be cleared compared to the regionally available suitable habitat (>8.7 million ha), it is not predicted that this clearing will result in a decline in population of Northern Quolls or interfere with the species recovery. Other direct impacts to Northern Quoll may occur as a result of interaction with construction equipment and vehicle strike during operation of the Proposed Action. These impacts are expected to be limited to a small number of individuals due to a low density of Northern Quoll in the Proposed Action area and low volumes of traffic during and post construction. As described in Section 2.2.1.2, indirect impacts are expected to be limited to temporary behavioural (avoidance) behaviour in a small number of individuals. Given this, it is considered highly unlikely that the Proposed Action will result in a long-term decrease in size of a population of the Northern Quoll.

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NORTHERN QUOLL
'reduce the area of occupancy of the species'	Not Significant As described in Section 2.2.1.1, the Proposed Action will result in the clearing of up to 178.3 ha of potential Northern Quoll habitat, of which 4.0 ha has been identified has habitat critical to the survival of the species and 42.3 ha has been identified as important foraging and dispersal habitat. This clearing represents a very small percentage of the estimated >8.7 million ha of similar suitable Northern Quoll habitat present in the Pilbara region. As described in Section 2.2.1.1, the location of the action is not known as an area of high Northern Quoll population density and there were no observations or secondary evidence of the Northern Quoll recorded during the field survey undertaken by Biota (2021a). Given this, the relatively small amount of potential Northern Quoll habitat to be cleared (compared to the regionally available habitat), it is not considered likely that the area of occupancy of the Northern Quoll will be reduced.
'fragment an existing population into two or more populations	Not Significant Given the narrow width of the road, and the low traffic volume expected, the road will not provide a barrier that cannot be crossed by fauna (with the exception of some small stretches that access maybe restricted due to steep slope created where material had to be cut to construct the road). As such, it is not predicted that the Proposed Action will result in the fragmentation of an existing population of Northern Quoll into two or more populations.
'adversely affect habitat critical to the survival of a species'	Significant Rocky areas are identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' (Hill and Ward 2010) as habitat critical to the survival of the species as they are used as denning and refuge sites. Habitats within the development envelope that have been identified as being critical to the survival of the Northern Quoll are described in Section 1.7.10.1 and shown in Figure 13. The Proposed Action will result in the clearing of up to 4.0 ha of potential habitat critical to the survival of the Northern Quoll. The loss of up to 4.0 ha of habitat critical to the survival of the Northern Quoll is likely to have a significant impact on local Northern Quoll populations. FMG (2018) identified 8,224 ha of potential Northern Quoll denning habitat in the region of which 299.3 ha (3.63%) was planned to be removed for the Solomon and Eliana mines and associated rail line. Based on this, the Proposed Action will result in the removal of a further 0.05% of the total denning habitat in the region as mapped by FMG (2018). This means that over 96% of the suitable denning habitat mapped by FMG (2018) would remain. Given this, the loss of 4.0 ha is unlikely to be significant given the availability of locally available denning habitat and suitable habitat for the species more broadly in the Pilbara (estimated >8.7 million ha of suitable habitat is present in the Pilbara region).
'disrupt the breeding cycle of a population'	Not Significant As described above, the loss of up to 4.0 ha of habitat critical to the survival of the Northern Quoll and up to 42.3 ha of important foraging and dispersal habitat is unlikely to disrupt the breeding cycle of a population given that no

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NORTHERN QUOLL
	signs of Northern Quoll were recorded and given the availability of suitable habitat for the species more broadly in the Pilbara. Other direct impacts are expected to be limited to potential injury or mortality to a small number of individuals, while indirect impacts will be limited to temporary behaviour changes such as avoidance. It is also noted that clearing and construction activities will be managed to minimise potential impacts during Northern Quoll breeding periods. As described in Section 2.2.1.2, the Proposed Action is not predicted to isolate a Northern Quoll habitat of a population of Northern Quolls. This potential loss of a small number of individuals and temporary behavioural impacts are considered unlikely to disrupt the breeding cycle of the Northern Quoll population.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant As described in Section 2.2.1.1, it is likely that the clearing of 4.0 ha of habitat considered to be habitat critical to the survival of the Northern Quoll and 42.3 ha of important foraging and dispersal habitat will result in a significant residual impact on local Northern Quoll populations. In addition, up to a further 132.2 ha of supporting foraging and dispersal habitat will be cleared. Given the relatively small amount of habitat to be cleared compared to the regionally available suitable habitat (>8.7 million ha), it is not predicted that this clearing will result in a decline in population of Northern Quolls or interfere with the species recovery. Given this, it is not predicted that the Proposed Action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the Northern Quoll species is likely to decline.
'result in invasive species that are harmful to a species becoming established in the species habitat'	Not Significant Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' (Hill and Ward 2010). The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase existing impacts given habitats are already bisected by the adjacent freight rail. Cane toads are also identified as a major threat in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' (Hill and Ward 2010). Cane toads are not present within the Pilbara however the Proposed Action has the potential to increase access to such species if they are introduced in future.
'introduce disease that may cause the species to decline'	Not Significant The 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' references the potential for disease to impact Northern Quolls but does not raise any specific diseases as being of particular threat. There is no credible impact pathway associated with the Proposed Action that could result in the introduction of a disease that may cause a decline in the Northern Quoll population.
'interfere with the	Not Significant

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NORTHERN QUOLL
recovery of the species'	An assessment of the potential impacts to the Northern Quoll against the key threats identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' is outlined in Section 9. Based on that assessment it is considered that the Proposed Action is not inconsistent with the objectives of the recovery plan and is therefore not predicted to interfere the recovery of the species.

2.2.2 Pilbara Leaf-nosed Bat (Pilbara form) (*Rhinonicteris aurantia*) – (Vulnerable)

Potential direct impacts that may occur to Pilbara Leaf-nosed Bats as a result of the Proposed Action are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing;
- disturbance from light emissions; and
- disturbance from noise and vibration emissions.

Potential indirect impacts that may occur to Pilbara Leaf-nosed Bats as a result of the Proposed Action are:

- degradation of habitat as a result of groundwater drawdown; and
- introduced species including increased predation by feral predators.

2.2.2.1 Direct impacts

Loss of habitat

Biota (2021a) identified up to 178.2 ha of potential Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat that will need to be cleared for the Proposed Action (shown in Figure 14). This representing less than 0.003% of the overall similar habitat in the Pilbara Region (estimated extent of >8.1 million ha).

Notably, no roost sites were identified, however evidence of foraging was recorded. A breakdown of area proposed to be cleared per habitat type is provided in Table 2-4. Habitat quality for all relevant supporting habitat types was rated as '6' as described in Appendix 6 (Biota, 2021b).

Table 2-4 Extent of Pilbara Leaf-nosed Bat habitat clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
HS – Mesas, caves, cliffs and free faces	Supporting habitat - potential roosting, foraging	0.14	8.4
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat - foraging	88.7	702.1
MDE – *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat - foraging	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat - foraging, flyway, drinking	0.03	21.2
RG - Rocky gullies	Supporting habitat - foraging	3.8	13.7
	Total	178.2	1,978.5

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

The habitat type Mesas, caves, cliffs and free faces is the most significant in the disturbance footprint as it has potential for roosting. Up to 0.14 ha of this habitat type will be cleared for the Proposed Action. No caves suitable for roosting (which are identified as critical to the survival of the species in the conservation advice for the species) were recorded in the development envelope (Biota, 2021a).

Biota (2021a) recorded (via call recordings) Pilbara Leaf-nosed Bats at two locations during the survey. While no caves suitable for roosting were recorded in the development envelope, the call recordings suggest that there is likely one or more unknown roosts in the vicinity of the development envelope and that the potential foraging habitat in and around the development envelope may be of high importance. The species typically has a dry season foraging range of 15 to 20 km from its primary roost caves and does forage at greater distances if suitable water sources are available (Bullen, 2013). This suggests that there are unknown roosts located within 20 km of the development envelope.

Given the relatively small amount of Pilbara Leaf-nosed Bat habitat to be cleared compared to the regionally available habitat (less than 0.003% of the estimated as >8.1 million ha of suitable habitat within the Pilbara region), the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, and that no roosting caves will be impacted, it is not predicted that clearing of up to 178.2 ha of Pilbara Leaf-nosed Bat potential roosting, foraging, flyway and drinking habitat will result in a significant impact.

Interaction with construction activities

Injury, mortality or disturbance of Pilbara Leaf-nosed Bat individuals may potentially occur during the Proposed Action as a result of interaction with construction activities including construction equipment.

Given that foraging habitat occurs within the development envelope, there is the potential for Pilbara Leaf-nosed Bats to interact with construction activities as they forage, where these activities occur at night. The likelihood of injury or mortality occurring as a result of interaction with construction equipment is considered low given the clearing will primarily be undertaken during the daytime with limited night works planned. In the event that such impacts do occur, they would be limited to a small number of individuals given that the Pilbara Leaf-nosed Bat are a highly mobile species.

Vehicle strike (operational traffic)

Roadkill is identified by DCCEEW within the species profile as a threat to the species (DAWE, 2021c). While there is a lack of data for roadkill rates for the Pilbara Leaf-nosed Bat, the species is often observed foraging along roads at night (Churchill, 2008). Its foraging height of less than three metres makes it vulnerable to collision with cars and many records of the species are from road kills (DAWE, 2021c). The species displays a curiosity for light sources (DAWE, 2021c) and may be attracted to head lights (Armstrong, 2013). An increase in the number of roads or a larger volume of traffic may contribute to local decline in areas near roosting or foraging sites (DAWE, 2021c). However, the majority of the development envelope is adjacent to existing railways and the introduction of a new road is likely to have a minor additional impact to existing light sources.

While it is considered that intermittent incidences of mortality from collision with vehicles may occur, the low expected traffic volume, especially at night, means that impacts will be limited to a small number of individuals and are unlikely to significantly affect the population size of the Pilbara Leaf-nosed Bat either locally or regionally.

Collision with fencing

It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and fencing will only be installed where an agreement is reached. It is therefore possible that individual bats may collide with this fencing. Collision with fences has the potential to result in injury or mortality of Pilbara Leaf-nosed Bat individuals.

Fencing required for the Proposed Action will be managed to reduce the potential for impacts to occur to Pilbara Leaf-nosed Bats. This includes minimising fencing as far as practicable and using devices such as discs or tags on the top wire to make them more visible to bats. Barbed wire will not be used for fencing.

If fencing is required for the Proposed Action this may result in injury or mortality to a small number of individual Pilbara Leaf-nosed Bats. The mitigation measures proposed will reduce the risk of fencing to Pilbara Leaf-nosed Bats such that it is not expected to result in a significant reduction in the Pilbara Leaf-nosed Bat population in the area.

Disturbance from artificial light

While there is no permanent lighting associated with the Proposed Action, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for

long periods of time and will be moved along the construction area as dictated by the construction schedule. Pilbara Leaf-nosed Bats are insectivorous and may be attracted to light sources due to the concentration of insects in well-lit areas. Given the temporary and localised nature of the light emissions and resultant minor behaviour impact, these impacts are not expected to be significant.

Studies at roosts have demonstrated that artificially increased light levels can significantly delay the timing of bat emergence (Downs et al., 2003; Duverge, 2000) and disturb their use of commuting routes (Stone et al., 2009), both of which will reduce the time available for foraging. Given the lack of known roosting caves nor suitable roosts within the development envelope, such impacts are not expected to occur as a result of the Proposed Action.

Disturbance from noise and vibration

Forced exodus of roosting sites and disturbance as a result of blasting are identified as threats to the species by DCCEEW within the species profile (DAWE, 2021c). The Pilbara Leaf-nosed Bat is known to be sensitive to noise and vibration disturbances within or in close proximity to roost caves and have been known to abandon caves where construction or mining activities occur within 50 m of the roost (Outback Ecology 2012). Disturbances which occur at least 85 m from the roost, however, may not result in abandonment (Armstrong K., 2010). Displaced bats are susceptible to death through dehydration, particularly during the dry season.

The recording of Pilbara Leaf-nosed Bats by Biota (2021a) suggests that one or more unknown roosts exist within 20 km of the development envelope. Given that no roosts or suitable roost sites were identified within the development envelope or surrounding area during the Biota (2021a) survey, any roost caves are sufficiently far away from construction activities (more than 85 m) and roosting Pilbara Leaf-nosed Bats will not be disturbed during roosting, or forced to permanently abandon roosts.

Impacts to foraging Pilbara Leaf-nosed Bats from noise and vibration may occur but would be limited to disturbance of foraging bats resulting in them foraging elsewhere. Given the large amount of suitable foraging habitat available in the area and the limited night works planned, any impacts to foraging bats from noise and vibration will be negligible.

2.2.2.2 Indirect impacts

Degradation of habitat as a result of groundwater drawdown

As detailed in Section 1.7.5 vegetation with a low to high dependency on groundwater is present in along the major drainage lines in and around the development envelope. Pilbara Leaf-nosed Bats may utilise these trees for temporary roosting and as such any impacts to this vegetation as a result of groundwater drawn down from abstraction or dewatering activities may result in indirect impacts to Pilbara Leaf-nosed Bats.

Groundwater abstraction for water supply or dewatering during construction of water crossings will be temporary and of a short duration. Abstraction will be managed to minimise groundwater drawdown in accordance with the applicable license. The DoW (2016) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the development envelope lies within this area. DoW (2016) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year. It is estimated that between 148,000 and 412,000 kL will be abstracted for the project over a 30 month period. Groundwater abstraction would be undertaken at a number of well locations (depending on the specific location

of the construction activities at the time). This will further reduce the likelihood of impact to vegetation as a result of groundwater abstraction.

WSP Golder (2022, Appendix 5) undertook a hydrogeological risk assessment to assess potential environmental impacts due to groundwater drawdown, including on groundwater dependent vegetation. The assessment found that estimated groundwater drawdown for each aquifer is low and that impacts to groundwater dependent vegetation is anticipated to be minimal.

Given this, no long-term effects on the environment including Pilbara Leaf-nosed Bats are predicted to occur as a result of groundwater abstraction.

Introduced species

The conservation advice for the species states that it is unlikely that the introduction of an invasive species will have a significant impact on the Pilbara Leaf-nosed Bat due to the extent of degradation and modification to natural habitats currently caused by invasive species (TSSC, 2016a). Feral predators are widespread throughout the Pilbara and have been recorded in the development envelope Biota (2021a). Given the proposed mitigation measures (Section 3), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that the Proposed Action will result in a significant increase in feral predators and the risk to the Pilbara Leaf-nosed Bat from feral predators.

Further, given introduced predators in the area are ground dwelling and the Pilbara Leaf-nosed Bat are a highly mobile species, the risk of predation by introduced predators is low. Should such an event occur, impacts would be limited to occasional impacts to a small number of individuals

2.2.2.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Pilbara Leaf-nosed Bat against the MNES significant impact criteria is provided in Table 2-5. This assessment uses the significant impact criteria for Vulnerable species (DoE 2013).

Table 2-5 Assessment of the potential impact of the Proposed Action to Pilbara Leaf-nosed Bat species

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA LEAF-NOSED BAT SPECIES
'lead to a long-term decrease in the size of an important population''	Not Significant The Pilbara Leaf-nosed Bat represents one interbreeding biological population comprising multiple colonies (TSSC, 2016a) and occurs in three sub-populations (eastern Pilbara, Hamersley Range and upper Gascoyne). It is considered that the entire Pilbara Leaf-nosed Bat population represents an important population ('a population that is necessary for a species' long-term survival and recovery') (TSSC, 2016a). As described in Section 2.2.2.1, clearing of 178.2 ha of Pilbara Leaf-nosed Bat potential roosting, foraging, flyway and drinking habitat will occur for the Proposed Action. As no known diurnal roosting or suitable cave exists within the development envelope, the species is unlikely to be dependent on the habitat to be cleared (i.e. it is a highly mobile species that is expected to forage in other foraging resources in the area), and given the relatively small amount of this Pilbara

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA LEAF-NOSED BAT SPECIES
	Leaf-nosed Bat habitat to be cleared compared to the regionally available habitat (> 8.1 million ha), this clearing is not predicted to result in a decline in the population of Pilbara Leaf-nosed Bat. Other direct impacts to Pilbara Leaf-nosed Bats which may occur as a result of interaction with construction equipment, light emissions, noise emissions and vibrations are expected to be limited to temporary behavioural impacts. Impacts as a result of vehicle strike during operation of the Proposed Action are expected to be limited to a small number of individuals. Given this, it is considered highly unlikely that the Proposed Action will result in a long-term decrease in size of an important population of the Pilbara Leaf-nosed Bat.
'reduce the area of occupancy of the important population'	Not Significant The entire Pilbara Leaf-nosed Bat population is considered an important population (TSSC, 2016a). The conservation advice states that the loss of any roost sites is highly likely to have a significant impact on the species by reducing the area of occupancy of the population. As there are no known or suitable roost sites within the development envelope, the Proposed Action is unlikely to result in a reduction in the area of occupancy of the important population.
'fragment an existing important population	Not Significant The entire Pilbara Leaf-nosed Bat population is considered an important population (TSSC, 2016a). The road will not provide a barrier to the movement of Pilbara Leaf-nosed Bats given their highly mobile and aerial nature. As such, the Proposed Action will not fragment an existing important population of Pilbara Leaf-nosed Bats.
'adversely affect habitat critical to the survival of a species'	Not Significant The conservation advice for the species identifies permanent diurnal roosts, non-permanent breeding roosts and transitory diurnal roosts as habitat critical to the survival of the Pilbara Leaf-nosed Bat (TSSC, 2016a). No roosting or suitable caves have been identified within the development envelope. Any caves that exist within the local area will be sufficiently far from construction activities (more than 85 m) that they will not be impacted by noise or vibration emissions related to the Proposed Action. Habitats within the development envelope that have been identified as being potential roosting, foraging, flyway and drinking habitat for the Pilbara Leaf-nosed bat are described in Section 1.7.10.2. The Proposed Action will potentially result in the clearing of up to 178.2 ha of this habitat. The species is not dependent on the foraging habitat to be cleared (i.e. as it is a highly mobile species that is expected to forage on other foraging resources in the area). Given the relatively small amount of this Pilbara Leaf-nosed Bat habitat to be cleared compared to the regionally available habitat (>8.1 million ha) and given the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, habitat clearing for the Proposed Action is unlikely to be significant to the Pilbara Leaf-nosed Bat population.

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA LEAF-NOSED BAT SPECIES
'disrupt the breeding cycle of an important population'	Not Significant The entire Pilbara Leaf-nosed Bat population is considered an important population (TSSC, 2016a). No caves suitable for roosting (which are identified as critical to the survival of the species in the conservation advice for the species) were recorded in the development envelope during the Biota (2021a) survey. Given this, the Proposed Action is unlikely to disrupt the breeding cycle of an important population of Pilbara Leaf-nosed Bats.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant As described in Section 2.2.2.1 there will be no clearing or other impacts to potential Pilbara Leaf-nosed Bat roosting or breeding caves. The conservation advice for the species states that an action may have an impact on the Pilbara Leaf-nosed Bat if there is a loss of foraging area. However, there is no clear knowledge on the extent to which a reduction in foraging habitat may result in a decline in the species. As the species is not considered to be dependent on the foraging habitat to be cleared (i.e. as it is a highly mobile species that is expected to forage in other foraging resources in the area), and given the relatively small amount of this Pilbara Leaf-nosed Bat habitat to be cleared compared to the regionally available habitat (>8.1 million ha), this clearing is not predicted to result in a decline in the population of Pilbara Leaf-nosed Bat.
'result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable, species' habitat'	Not Significant The conservation advice for the species states that it is unlikely that the introduction of an invasive species will have a significant impact on the Pilbara Leaf-nosed Bat due to the extent of degradation and modification to natural habitats currently caused by invasive species (TSSC, 2016a). The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, given the proposed mitigation measures, existing disturbance and multiple existing transport corridors in the region, it is unlikely that the Proposed Action will result in a significant increase in invasive weeds or in feral predators.
'introduce disease that may cause the species to decline'	Not Significant There are no known diseases threatening the Pilbara Leaf-nosed Bat (TSSC, 2016a) There is no credible impact pathway that could result in the introduction of a disease that may cause a decline in the Pilbara Leaf-nosed Bat population due to this Proposed Action.
'interfere substantially with the recovery of the species'	Not Significant The conservation advice for the Pilbara Leaf-nosed Bat (TSSC, 2016) outlines the key items for the recovery of this species. Items noted in the conservation advice that are relevant to the Proposed Action include protecting roosts and assessing and protecting foraging habitat. As described in Section 2.2.2.1, no impacts to known roosting caves is

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA LEAF-NOSED BAT SPECIES
	expected to occur and the clearing of Pilbara Leaf-nosed Bat foraging habitat for the Proposed Action is not predicted to result in significant impacts to Pilbara Leaf-nosed Bats. As such, the Proposed Action is not predicted to interfere substantially with the recovery of the Pilbara Leaf-nosed Bat species.

2.2.3 Ghost Bat (*Macroderma gigas*) –Vulnerable

Potential direct impacts that may occur to Ghost Bats as a result of the Proposed Action are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing;
- disturbance from light emissions; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Ghost Bats as a result of the Proposed Action are:

- degradation of habitat as a result of groundwater drawdown; and
- introduced species including increased predation and competition from feral predators.

2.2.3.1 Direct impacts

Loss of habitat

Habitat loss (particularly roost site loss) and degradation is identified as a threat to species in the conservation advice for the Ghost Bat (TSSC, 2016b).

Up to 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat will be cleared for the Proposed Action (shown in Figure 15) representing less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of >9.3 million ha). A breakdown of the area proposed to be cleared per habitat type is provided in Table 2-6. Habitat quality for all relevant supporting habitat types was rated as '8' as described in Appendix 6 (Biota, 2021b).

Table 2-6 Extent of Ghost Bat Habitat Clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
CP - Floodplains	Supporting habitat – foraging	135.0	1,778.6
HS – Mesas, caves, cliffs and free faces	Supporting habitat – potential roosting, foraging	0.14	8.4

RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging	88.7	702.1
MDE – *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – foraging, drinking	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – foraging, flyway, drinking	0.03	21.2
RG - Rocky gullies	Supporting habitat – foraging	3.8	13.7
MMW - Man-made water bodies	Supporting habitat – drinking	0.14	2.3
	Total	313.4	3,882.7

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

One cave with evidence of Ghost Bat usage was recorded within the development envelope during the Biota (2021a) survey. This cave is located in the Hammersley Range approximately 300 m outside of the disturbance footprint in the Rocky hills and slopes with low open spinifex and scattered trees habitat type (Page 6 of Figure 15). Ghost Bat scats were also recorded in two caves in the Tom Price section of the biota survey area (but outside of the development envelope) in the Rocky hills and slopes with low open spinifex and scattered trees habitat type (Page 7 of Figure 15), with one identified as a potential maternity roost cave located approximately 125 m from the development envelope and 250 m from the disturbance footprint (Biota, 2021a).

Ghost Bats are known to require a number of suitable caves throughout their home ranges, and the presence of day roosts and/or maternity roosts in an area is the most important indicator of suitable habitat for Ghost Bats, and these caves are generally the primary focus of conservation and/or monitoring (TSSC, 2016b). As such, the presence of these caves (particularly the potential maternity roosting cave within 125 m of the development envelope) suggests a population of Ghost Bats use the area and that the foraging habitat in the development envelope, and particularly in the area near the caves is of high importance. The conservation advice for Ghost Bats suggests that suitable habitat within 5 km of diurnal roost sites provide good foraging opportunities for the species (TSSC, 2016b). Given this, the clearing of up to 18.7 ha of Ghost Bat habitat within 5 km of the possible maternity roost is considered to be a significant residual impact.

Main Roads will avoid direct impacts to these caves (including the potential maternity roost cave) and mitigation measures will be implemented including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021a) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. The location of the will be demarcated during construction activities. This buffer, in which no clearing will be undertaken, will provide effective protection to the Ghost Bat caves and ensure that they are not lost or damaged.

High quality foraging habitat is present in the development envelope and surrounding areas. These habitats are common within the Pilbara region (estimated extent >9.3 million ha), with vast amounts being vested in National Parks in the region including the adjacent Millstream-Chichester

National Park. Ghost Bats have a foraging range of 5 km from its roosts, which means that Ghost Bats are not dependent on the foraging habitat within the development envelope and are expected to utilise other foraging resources in the area.

Given the relatively small amount of Ghost habitat to be cleared compared to the regionally available habitat (the habitat to be lost represents less than 0.004% of the overall similar habitat in the Pilbara region), the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, the expectation that Ghost Bats will utilise other available foraging habitat, and the proposed mitigation measures, it is predicted that the clearing required for the Proposed Action will not result in impacts to Ghost Bat roosting caves or a significant impact to Ghost Bats foraging (with the exception of the clearing within 5 km of the possible maternity roost which represents a significant residual impact as described above).

Interaction with construction activities

Injury or mortality of Ghost Bat individuals may potentially occur as a result of interaction with the construction activities including construction equipment and clearing. Given that caves with evidence of Ghost Bat usage and high quality foraging habitat occurs within the development envelope and surrounding areas, there is the potential for Ghost Bats to interact with construction activities as they forage, where these activities occur at night.

Ghost Bats are a highly mobile species and are expected to display avoidance behaviour and actively avoid the construction equipment. Main Roads has committed to a 150 m no go zone around the cave within the development envelope that has evidence of Ghost Bat usage.

The likelihood of injury or mortality occurring as a result of interaction with construction equipment is low given the clearing will primarily be undertaken during the daytime with limited night works planned. In the event that such impacts do occur, they would be limited to a small number of individuals.

Vehicle strike (operational traffic)

While there is a lack of data for roadkill rates for the Ghost Bat, the species' tendency to forage close to the ground (Churchill, 2008) makes it vulnerable to collision with cars. The species displays a curiosity for light sources (DAWE, 2021c) and may be attracted to head lights (Armstrong, 2013). As such, an increase in the number of roads or a larger volume of traffic may contribute to local decline in areas near roosting or foraging sites (DAWE, 2021c). However, the majority of the development envelope is adjacent to existing railways and the introduction of a new road is likely to have a minor additional impact.

While it is considered likely that intermittent incidences of mortality from collision with vehicles may occur, the low expected traffic volume, especially at night, means that impacts will be limited and are unlikely to significantly affect the population size of the Ghost Bat.

Collision with fencing

It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and fencing will only be installed where an agreement is reached. It is, therefore, possible that individual bats may collide with this fencing.

Collision with fences is identified in the conservation advice for the Ghost Bat as a threat to the species. Ghost bats often fly at about fence height and substantial numbers are known to be killed

when colliding with fencing wire. The conservation advice for the Ghost Bat notes that a single fence can effectively remove a population of Ghost Bats over time and that this has been observed to occur in the Pilbara (TSSC, 2016b).

Fencing required for the Proposed Action will be managed to reduce the potential for impacts to occur to Ghost Bats. This includes minimising fencing as far as practicable and utilising devices such as, discs on the top wire to make them more visible to bats. Barbed wire will not be used for fencing.

Given these mitigation measures, it is expected that if fencing is required for the Proposed Action, this may result in the injury or mortality to a small number of Ghost Bat individuals and is not expected to result in a significant reduction in the Ghost Bat population in the area.

Disturbance from artificial light

While there is no permanent lighting associated with the Proposed Action, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long and will be moved along the construction area as dictated by the construction schedule.

Very strong light sources may confuse or temporarily blind Ghost Bats, although there is no information available to the extent that this occurs (biologic, 2016). Ghost bats may be attracted to light sources due to the concentration of insects in well-lit areas. Given the temporary and localised nature of the light emissions and resultant minor behaviour impact, these impacts are not expected to be significant.

Studies at roosts have demonstrated that artificially increased light levels can significantly delay the timing of bat emergence and disturb their use of commuting routes, both of which will reduce the time available for foraging. Lighting required for construction will be positioned such that they are directed away from potential roost caves, thereby reducing light spill in the direction of these caves. To reduce the potential for impacts from artificial lighting, mitigation measures will be implemented including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021a) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone around the caves that were recorded by Biota (2021) as having evidence of Ghost Bat usage.

Given the planned mitigation measures, impacts to Ghost Bats from light emissions are considered unlikely to occur as a result of the Proposed Action.

Disturbance from noise and vibration

While there is limited information currently available on the impact of noise and vibration on Ghost Bats, they are known to be sensitive to noise and vibration disturbances within or in close proximity to daytime roosts and they could abandon their roost (biologic, 2016). Displaced bats are susceptible to death through dehydration, particularly during the dry season.

The available literature suggests that the application of buffer zones between noise and vibration-generating activity and Ghost Bat caves can effectively mitigate impacts. A study by Bullen et al. (2014) in relation to the impacts of a mining operation in the Pilbara on Ghost Bats found that the maximum sound and vibration levels within a cave caused by ore body drilling operations at a minimum drilling distance of 50 m (60 dB(A) and 0.6 mm/s) will likely not result in the bats abandoning the cave. Armstrong (2010) identified that significant impacts were unlikely for short-term disturbance from drilling further than 25 m from a roost entrance and 85 m from the roost

location. Based on the Armstrong (2010) study, TM Gold adopted an 85 m buffer between mining activities (including blasting) and known Ghost Bat roosting caves for their Spring Hill Gold Mine Project (Northern Resource Consultants, 2018). This buffer zone was subsequently mandated as part of the ministerial approval for the project under the EPBC Act.

To ensure that impacts to caves with evidence of Ghost Bat usage does not occur, Main Roads will implement management and mitigation measures including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves where no blasting activities will occur. These areas will be demarcated during construction activities.

The 150 m no-go zone is based on a study by Biota (2013). While not specifically focussed on Ghost Bats, Biota (2013) completed an empirical study using blasting trials, measured vibration levels and bat behavioural response for Rio Tinto's Koodaideri mine. The roost contained a colony of ~400 Pilbara Leaf-nosed Bats but some Ghost Bat individuals were also present (noting that these two species share roost microclimate requirements to a large degree). The objective of the study was to conduct a quantified field trial at the deposit using explosive charges of incrementally increasing intensity and proximity to the roost and relate these to measures of vibration at the roost (using a triaxial geophone) and behavioural response in the resident bats (with real-time call detection). The closest blast in the trial was 160 m from the centre of the cavern where the bats roost and the study was carried out during the day, when the bats are resident and usually quiescent. Very little evidence of any disturbance behaviour was detected that could be associated with the trial blasts. Only three individual calls were recorded during the trial period of that were concurrent with blast timing, demonstrating that the great majority of the colony was not disturbed by even the closest blast. There was no evidence detected that blasting significantly disturbed the colony as a whole.

Main Roads will prepare a Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be prepared for approval by DCCEEW prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. The purpose of this plan will be to meet the stated management objective to "Avoid impacts to roosting caves used by Ghost Bats". This plan will outline the blasting activities, noise and vibration monitoring (in relation to the caves) and an adaptive management approach. The noise and vibration plan will include a requirement for the blasting contractor to ensure that the predicted peak particle velocity (PPV) values for each blast is included in the blast design. The PPV will be required to be calculated using an industry recognised approach that incorporates predictive mechanisms for ground vibration and is in accordance with AS 2187. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats. The plan will also specify procedures for monitoring of the PPV including monitoring of blasts undertaken away from the Ghost Bat caves to verify that impact thresholds will not be exceeded during blasting activities within 400 m of a cave with evidence of Ghost Bat usage.

It should also be noted that blasting will occur intermittently, will not be concentrated in one place for long periods of time and will be moving along the road route as per the construction schedule. Given this and the proposed 150 m no go zone (i.e. no blasting will occur within 150 m of any cave recorded by Biota (2021a) as having evidence of Ghost Bat usage), it is predicted that significant impacts such as roost abandonment by Ghost Bats will not occur as a result of noise and vibration from construction activities include blasting.

Impacts to foraging Ghost Bats from noise and vibration may occur but would be limited to disturbance of foraging bats resulting in them foraging elsewhere. Given the large amount of suitable foraging habitat available in the area and the limited night works planned, any impacts to foraging bats from noise and vibration will be negligible.

2.2.3.2 Indirect impacts

Degradation of habitat as a result of groundwater drawdown

As detailed in Section 1.7.5 vegetation with a low to high dependency on groundwater is present in along the major drainage lines in and around the development envelope. Ghost Bats may utilise these trees for temporary roosting and as such any impacts to this vegetation as a result of groundwater drawn down from abstraction or dewatering activities may result in indirect impacts to Ghost Bats.

Groundwater abstraction for water supply or dewatering during construction of water crossings will be temporary and of a short duration. Abstraction will be managed to minimise groundwater drawdown in accordance with the applicable license. The DoW (2016) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the development envelope lies within this area. DoW (2016) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year. It is estimated that between 148,000 and 412,000 L will be abstracted for the project over a 30 month period. Groundwater abstraction would be undertaken at a number of well locations (depending on the specific location of the construction activities at the time). This will further reduce the likelihood of impact to vegetation as a result of groundwater abstraction.

WSP Golder (2022, Appendix 5) undertook a hydrogeological risk assessment to assess potential environmental impacts due to groundwater drawdown, including on groundwater dependent vegetation. The assessment found that estimated groundwater drawdown for each aquifer is low and that impacts to groundwater dependent vegetation is anticipated to be minimal.

Given this, no long-term effects on the environment including Ghost Bats are predicted to occur as a result of groundwater abstraction.

Introduced species

The conservation advice for the Ghost Bat identifies competition with introduced predators as a threat to the species (TSSC, 2016b).

Feral predators are widespread throughout the Pilbara and have been recorded in the development envelope Biota (2021a). Given the proposed mitigation measures (Section 3), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that the Proposed Action will result in a significant increase in feral predators and the risk to the Ghost Bat from feral predators or resultant competition for prey with Ghost Bats.

2.2.3.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Ghost Bat against the MNES significant impact criteria is provided in Table 2-7. This assessment uses impact criteria for Vulnerable species (DoE, 2013).

Table 2-7 Assessment of the potential impact of the Proposed Action to the Ghost Bat species

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR GHOST BAT SPECIES
'lead to a long-term decrease in the size of an important population''	Not Significant As described in 1.7.10.3 , Ghost Bat populations display genetic variation as they are fragmented, with Pilbara populations being isolated from those in the Kimberley and NT (Armstrong and Wilmer, 2004). Given this it is considered that all Ghost Bat populations represent an important population ('a population that is necessary for a species' long-term survival and recovery'). As described in Section 2.2.3.1, clearing of 313.4 ha of Ghost Bat roosting, foraging, flyway and drinking habitat will occur for the Proposed Action. Given the relatively small amount of Ghost Bat habitat to be cleared compared to the regionally available habitat (estimated at >9.3 million ha), the expectation that Ghost Bats will utilise other available foraging habitat, and the proposed mitigation measures, it is not predicted that habitat clearing will result in the long-term decrease in the important population of Ghost Bats that utilise the area. As described in Section 2.2.3.1, direct impacts to Ghost Bat may occur as a result of fencing, lighting and noise and vibration emissions. These impacts are expected to be primarily limited to temporary behavioural impacts (attraction or avoidance) although there remains the potential for injury or mortality to occur to a small number of individuals Ghost Bats. These impacts are not expected to result in the long-term decrease in the size of an important population of Ghost Bats that utilise the area.
'reduce the area of occupancy of the important population'	Significant As described above, it is considered that an important population of Ghost Bat is present in the area. As described in Section 2.2.3.1, clearing of up to 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat will occur for the Proposed Action. The Biota (2021a) survey recorded a cave with evidence of Ghost Bat usage within the development envelope (approximately 300 m from the disturbance footprint), as well as two caves with evidence of Ghost Bat usage approximately 125 m from the development envelope and 250 m from the disturbance footprint, one of which is a potential maternity roost cave. The conservation advice for Ghost Bats suggests that suitable habitat within 5 km of diurnal roost sites provide good foraging opportunities for the species (TSSC, 2016b). Given this, the clearing of up to 18.7 ha of Ghost Bat habitat within 5 km of the possible maternity roost is considered to be a significant residual impact. The conservation advice states that the loss of any roost sites is highly likely to have a significant impact on the species by reducing the area of occupancy of the population. As caves that were recorded in the Biota (2021a) survey as having evidence of Ghost Bat usage will be protected by creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. This buffer, in which no clearing or blasting will be undertaken, will provide effective protection to the Ghost Bat caves and ensure that they are not lost or

	damaged. In addition, Main Roads will prepare a Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be prepared for approval by DCCEEW prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. This plan will outline the blasting activities, noise and vibration monitoring (in relation to the caves) and an adaptive management approach. The noise and vibration plan will include a requirement for the blasting contractor to ensure that the predicted PPV values for each blast is included in the blast design. The PPV will be required to be calculated using an industry recognised approach that incorporates predictive mechanisms for ground vibration and is in accordance with AS 2187. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats. The plan will also specify procedures for monitoring of the PPV including monitoring of blasts undertaken away from the Ghost Bat caves, to verify that impact thresholds will not be exceeded during blasting activities within 400 m of a cave with evidence of Ghost Bat usage. With the implementation of these measures, the Proposed Action is unlikely to result in a reduction in the area of occupancy of the important population of Ghost Bat.
'fragment an existing important population	Not Significant As described above, it is considered that an important population of Ghost Bat is present in the area. The Proposed Action will not fragment an existing important population of Ghost Bats as the road will not provide a barrier to the movement of Ghost Bats given their highly mobile and aerial nature.
'adversely affect habitat critical to the survival of a species'	Not Significant As described in Section 2.2.3.1, clearing of up to 313.4 of potential Ghost Bat habitat will occur. As the species is not dependent on the habitat to be cleared (i.e. as it is a highly mobile species that is expected to forage in other foraging resources in the area), given the relatively small amount of this Ghost Bat habitat to be cleared compared to the regionally available habitat (>9.3 million ha), and given the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, this habitat clearing is considered unlikely to be significant to the Ghost Bat population. There is the potential that the Proposed Action may impact on caves recorded in the Biota (2021a) survey as having evidence of Ghost Bat usage (including a potential roost cave), either directly through construction activities or indirectly through changes to the microclimate. Main Roads will avoid direct impacts to the potential roost cave and management and mitigation measures will be implemented to avoid indirect impacts to the potential roost cave. These measures include creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. This buffer, in which no clearing or blasting will be undertaken, will provide effective protection to the Ghost Bat caves and ensure that they are not lost

	or damaged. In addition, Main Roads will prepare a Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be prepared for approval by DCCEEW prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. Details of this plans objective and content are provided earlier in this table.
'disrupt the breeding cycle of an important population'	Not Significant As described above, it is considered that an important population of Ghost Bat is present in the area. The conservation advice for the Ghost Bat identifies disturbance of breeding sites as threats to the species (TSSC, 2016b). There is the potential that the Proposed Action may impact on caves recorded in the Biota (2021a) survey as having evidence of Ghost Bat usage (including a potential maternity roost cave), either directly through construction activities or indirectly through changes to the microclimate. Should the maternity roost cave be significantly impacted there is a strong potential that the Proposed Action will disrupt the breeding cycle of an important population. Main Roads will avoid direct impacts to the potential maternity roost cave and management and mitigation measures will be implemented to avoid indirect impacts to the potential roost cave. These measures include creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. As such it is not predicted that the Proposed Action will disrupt the breeding cycle of an important population of Ghost Bats.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant The conservation advice for the Ghost Bat identifies disturbance of breeding sites and disturbance of foraging sites as threats to the species (TSSC, 2016b). As described in Section 2.2.3.1, clearing of up to 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat will occur for the proposed action. This species is not dependent on the habitat to be cleared (as it is a highly mobile species that is expected to forage in other foraging resources in the area). Given the relatively small amount of this Ghost Bat habitat to be cleared compared to the regionally available habitat (>9.3 million ha), the loss of up to 313.4 ha of this habitat is unlikely to be significant. There is the potential that the Proposed Action may impact on caves recorded in the Biota (2021a) survey as having evidence of Ghost Bat usage (including a potential maternity roost cave), either directly through construction activities or indirectly through changes to the microclimate. Main Roads will avoid direct impacts to these roost caves and management and mitigation measures will be implemented to avoid indirect impacts them. These measures include creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. Given this, it is not predicted that the Proposed Action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent

	that the Ghost Bat species is likely to decline.
'result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable, species' habitat'	Not Significant The conservation advice for the Ghost Bat identifies competition with introduced predators as a threat to the species (TSSC, 2016b). Given the proposed mitigation measures, existing disturbance and multiple existing transport corridors in the region, it is unlikely that the Proposed Action will result in a significant increase in feral predators or resultant competition for prey with Ghost Bats.
'introduce disease that may cause the species to decline'	Not Significant No known disease is identified as a threat to the WA population of Ghost Bat (TSSC, 2016b). There is no credible impact pathway that could result in the introduction of a disease that may cause a decline in the Ghost Bat population.
'interfere substantially with the recovery of the species'	Not Significant Conservation advice for the Ghost Bat (TSSC, 2016b) outlines the key priorities for the recovery of this species. Items noted in the conservation advice that are relevant to the Proposed Action include protecting land with significant colonies and protecting roost sites and surrounding foraging areas from disturbance. Main Roads will avoid direct impacts to the potential maternity roost cave and management and mitigation measures will be implemented to avoid indirect impacts to the potential maternity roost cave. These measures include creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the disturbance footprint and the caves. Ghost Bats have a productive foraging area up to 10 km radius from roosting caves (Bat Call, 2017). As such, the species is not dependent on the habitat to be cleared (i.e. as it is a highly mobile species that is expected to forage in other foraging resources in the area). Significant amounts of suitable foraging habitat exist within a 10 km radius of the identified potential roost cave. Given the relatively small amount of this Ghost Bat foraging habitat to be cleared within the 10 km radius of the identified potential maternity cave, and in total for the Proposed Action compared to the regionally available habitat (>9.3 million ha), the loss of this Ghost Bat foraging habitat is unlikely to be significant in a local or regional context. As such, the Proposed Action is not predicted to interfere substantially with the recovery of the Ghost Bat species.

2.2.4 Pilbara Olive Python (*Liasis olivaceus barroni*) – (Vulnerable)

Potential direct impacts that may occur to Pilbara Olive Pythons as a result of the Proposed Action are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Pilbara Olive Pythons as a result of the Proposed Action are:

- fragmentation of habitat due to the presence of the road; and
- introduced species including increased predation and competition from feral predators.

2.2.4.1 Direct impacts

Loss of habitat

The Conservation Advice for the Pilbara Olive Python identifies destruction of habitat as a threat to the species (TSSC, 2008).

Up to 313.3 ha of potential Pilbara Olive Python foraging habitat will be cleared for the Proposed Action (shown in Figure 16). This represents less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of over 8.7 million ha). A breakdown of the area proposed to be cleared per habitat type is provided in Table 2-8. Habitat quality for all relevant supporting habitat types was rated as '8' as described in Appendix 6 (Biota, 2021b).

Table 2-8 Extent of Pilbara Olive Python habitat clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED*(HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
CP - Floodplains	Supporting habitat - foraging	125.0	1,778.6
HS – Mesas, caves, cliffs and free faces		0.14	8.4
RHS – Rocky hills and slopes with low open spinifex and scattered trees		88.7	702.1
MDE – *Eucalyptus* fringed major drainage lines and associated tributaries		85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines		0.03	21.2
RG - Rocky gullies		3.8	13.7
	Total	313.3	3,757.1

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

The Biota (2021a) survey did not record any evidence of Pilbara Olive Pythons. However, there is suitable habitat for the species in the development envelope and surrounding areas and the species has been recorded in the area previously with the closest record of evidence of a Pilbara Olive Python to the development envelope being approximately 4 km west, where the alignment deviates around Hamersley Homestead. This suggests that the species is likely to utilise the area.

Pilbara Olive Python individuals have large home ranges (between 88 ha and 449 ha) so are considered unlikely to be dependent on the habitat to be cleared (Biota, 2021a). Given this lack of dependence on the habitat to be cleared, the relatively small amount of Pilbara Olive Python habitat to be cleared compared to the regionally available habitat, and the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, it is not predicted that this clearing will result in a significant impact to Pilbara Olive Pythons.

Pilbara Olive Pythons are dependent on access to pools and waterholes, particularly for foraging. A key component of the design of the Proposed Action is the maintenance of surface water flows. As such no significant impacts to existing pools or waterholes (or subsequent loss of Pilbara Olive Python habitat) is predicted to occur.

Interaction with construction activities

Clearing activities may result in the loss of individual animals that are unable to move out of the way of heavy machinery. While it is expected that Pilbara Olive Pythons will display avoidance behaviour and move away from the construction area as a result vibration from the construction equipment, there remains the possibility that a small number of individuals may suffer injury or mortality.

Vehicle strike (operational traffic)

The conservation advice for the Pilbara Olive Python identifies roadkill as a main threat to the species (TSSC, 2008).

Road networks potentially increase the chance of Pilbara Olive Python mortality through collision. Vehicle strikes are likely to occur as the Pilbara Olive Python moves across roads, between shelter and forage sites. While there is a lack of road mortality literature specific to the Pilbara Olive Python, it is suspected that they may be particularly vulnerable to vehicle strikes as roads are often preferred basking spots for snakes. Suitable habitat for the Pilbara Olive Python occurs on either side of the proposed road further increasing the potential for vehicle strike.

Given this, it is considered that intermittent incidences of mortality from collision with vehicles may occur, however the low expected traffic volume means that impacts will be limited to a small number of individual and is unlikely to significantly affect the population size of the Pilbara Olive Python.

Noise and vibration

Vibrations caused by the construction equipment may lead to behavioural (avoidance) impacts to Pilbara Olive Pythons. These impacts are expected to be temporary and limited to a small number of individuals. Due to the linear nature of the construction, this effect is expected to be short lived with individuals recolonising the area once construction activities cease. Therefore, there is a high level of confidence that potential impacts to the Pilbara Olive Python as a result of noise and vibration will be insignificant.

2.2.4.2 Indirect impacts

Fragmentation of habitat and population isolation

Clearing along the road alignment has the potential to fragment Pilbara Olive Python habitat. However, as Pilbara Olive Python individuals will be able to cross the road, these habitats will still be available for use as refuge and foraging habitat. As this fragmentation will not result in the

isolation of habitat or Pilbara Olive Python populations, it is not expected to result in a significant impact to the species

Introduced species

The conservation advice for the Pilbara Olive Python identifies predation by feral cats and foxes and predation of food sources by foxes as a main threat to the species (TSSC, 2008).

Feral predators may play a role in the decline of the Pilbara Olive Python through predation, particularly of juveniles, as well as predation of the Pilbara Olive Python's food sources (such as Quolls and Rock-wallabies; Ellis 2013; Pearson 2013a; TSSC 2008; DAWE, 2021d)). However, the loss of prey is likely to be of particular concern to the Pilbara Olive Python in coastal areas, where the fox is more prevalent (TSSC 2008).

Feral predators are widespread throughout the Pilbara and have been recorded in the development envelope Biota (2021a). Given the proposed mitigation measures (Section 3), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that the Proposed Action will result in an increase in feral predators such that Pilbara Olive Python population is likely to decline.

2.2.4.3 Assessment against MNES Significant Impact Guidelines

Table 2-9 provides an assessment of the potential impact of the Proposed Action on the Pilbara Olive Python species against the MNES significant impact criteria is provided in Table 2-9. This assessment uses the Vulnerable species significant impact criteria by DoE (2013).

Table 2-9 Assessment of the potential impact of the Proposed Action on the Pilbara Olive Python

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA OLIVE PYTHON SPECIES
'lead to a long-term decrease in the size of an important population''	Not Significant Given the proximity of the Proposed Action to the Tom Price and Millstream areas which are known to host important Pilbara Olive Python populations (DSEWPaC, 2012), it is considered likely that Pilbara Olive Pythons in or near the development envelope are part of an important population of the species. Up to 313.3 ha of potential Pilbara Olive Python foraging habitat will be cleared for the Proposed Action. The species is considered unlikely to be dependent on the habitat to be cleared and given this and the relatively small amount of Pilbara Olive Python habitat to be cleared compared to the regionally available habitat (>8.7 million ha), it is not predicted that this clearing will result in a significant impact to Pilbara Olive Pythons. As described in Section 2.2.4.1, other direct impacts to Pilbara Olive Pythons resulting from vehicle strike and interaction with construction equipment are expected to be limited to potential injury or mortality to a small number of individuals. As described in Section 2.2.4.2, indirect impacts are expected to be limited to temporary behavioural (avoidance) behaviour in a small number of individuals. Given this, it is considered highly unlikely that the Proposed Action will result in a long-term decrease in size of an important population of the Pilbara

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA OLIVE PYTHON SPECIES
	Olive Python.
'reduce the area of occupancy of the important population'	Not Significant As described above, it is considered likely that Pilbara Olive Pythons in or near the development envelope are part of an important population of the species. As described in Section 2.2.4.1, up to 313.3 ha of potential Pilbara Olive Python foraging habitat will be cleared for the Proposed Action. The species is considered unlikely to be dependent on the habitat to be cleared and given this lack of dependence on the habitat to be cleared, and the relatively small amount of Pilbara Olive Python foraging habitat to be cleared compared to the regionally available habitat (>8.7 million ha), it is not predicted that this clearing will reduce the area of occupancy of the species.
'fragment an existing important population'	Not Significant As described above, it is considered likely that Pilbara Olive Pythons in or near the development envelope are part of an important population of the species. Given the narrow width of the road and the low traffic volume expected, the road will not provide a barrier that cannot be crossed by fauna (with the exception of some small stretches that access maybe restricted due to steep slope created where material had to be cut to construct the road). As such, it is not predicted that the Proposed Action will result in fragmentation an existing important population of Pilbara Olive Python.
'adversely affect habitat critical to the survival of a species'	Not Significant Foraging habitat for the Pilbara Olive Python has been identified within the development envelope. The Proposed Action will potentially result in the clearing of up to 313.3 ha of this habitat. As the species is not dependent on the habitat to be cleared, the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, and given the relatively small amount of this Pilbara Olive Python foraging habitat to be cleared compared to the regionally available habitat (>8.7 million ha), this habitat clearing is considered unlikely to be significant to the Pilbara Olive Python population.
'disrupt the breeding cycle of an important population'	Not Significant As described above, it is considered likely that Pilbara Olive Pythons in or near the development envelope are part of an important population of the species As described in Section 2.2.4.1 and Section 2.2.4.2, impacts to Pilbara Olive Pythons are expected to be limited to potential injury or mortality to a small number of individuals; and temporary behavioural (avoidance) behaviour in a small number of individuals. This is not predicted to disrupt the breeding cycle of the species. The loss of up to 313.3 ha of foraging habitat is not considered to be significant impact as the species is not dependent on the habitat to be cleared. Given the relatively small amount of this Pilbara Olive Python habitat to be cleared compared to the regionally available habitat (>8.7 million ha), this clearing is unlikely to disrupt the breeding cycle of an important

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR PILBARA OLIVE PYTHON SPECIES
	population of Pilbara Olive Python.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant The loss of up to 313.3 ha of foraging habitat for the species is not expected to result in the decline of the Pilbara Olive Python species as the species is not dependent on the habitat to be cleared, and given the relatively small amount of this Pilbara Olive Python habitat to be cleared compared to the regionally available habitat.
'result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable, species' habitat'	Not Significant The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase impacts due to background levels of invasive species due to the adjacent freight rail lines bisecting adjacent habitat.
'introduce disease that may cause the species to decline'	Not Significant Conservation Advice for Pilbara Olive Python (TSSC, 2008) does not identify disease as a threat to Pilbara Olive Pythons. There is no credible impact pathway that could result in the introduction of a disease that may cause a decline in the Pilbara Olive Python population.
'interfere substantially with the recovery of the species'	Not Significant Conservation advice for the Pilbara Olive Python (TSSC, 2008) outlines the priority actions for the recovery of this species relevant to the Proposed Action which include ensuring road widening and maintenance activities do not adversely impact on known populations and manage any changes to hydrology which may result in changes to the water table levels. As described above, the Proposed Action is not expected to result in a significant adverse impact to a population of Pilbara Olive Python that may exist in the area. As such, the Proposed Action is not predicted to interfere substantially with the recovery of the Pilbara Olive Python species.

2.2.5 Night Parrot (*Pezoporus occidentalis*) – (Endangered)

Potential direct impacts that may occur to Night Parrots as a result of the Proposed Action are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Night Parrots as a result of the Proposed Action are:

- introduced species including increased predation and competition from feral predators.

2.2.5.1 Direct impacts

Loss of habitat

The Conservation Advice for the Night Parrot (TSSC, 2016c) lists 'habitat loss, disturbance and modifications' as a threat to this species.

Up to 29.3 ha of potential Night Parrot foraging habitat will be cleared for the Proposed Action, representing less than 0.005% of the overall similar habitat in the Pilbara Region (estimated extent of >0.6 million ha). The field survey (Biota, 2021a) identified one habitat type that the Night Parrot may utilise (shown in Figure 17). This habitat is located at the southern end of the Hamersley section and in the north of the Coolwanayah Section. Table 2-10 details the extent of this habitat type proposed to be cleared. Habitat quality for this habitat type was rated as '3' as described in Appendix 6 (Biota, 2021b).

Table 2-10 Extent of Night Parrot habitat clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
GPCC - Grassland plains with cracking clay	Supporting habitat - foraging	29.3	203.4
	Total	29.3	203.4

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

There are no DBCA records for this species within 50 km of the development envelope. Two nights of survey using auditory acoustic recording units (ARUs) within Floodplain habitat (Coolawanyah section), and five nights within GPCC habitat (Tom Price section), were undertaken during the Biota (2021a) survey. No Night Parrots were detected during the survey. The Night Parrot was also not recorded in surveys of areas nearby previously undertaken by Biota (2021a).

Grassland plains with cracking clay habitat within the development envelope may provide adequate habitat for Night Parrot foraging. The Night Parrot habitats that are present in the development envelope are common within the Pilbara region (estimated extent >0.6 million ha (Section 1.7.9.3)).

Given this, the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, and the lack of evidence found that Night Parrots are present in the development envelope and surrounding area, significant impacts to the Night Parrot as a result of clearing for the Proposed Action are not anticipated.

Interaction with construction activities

Clearing activities may result in the loss of individual animals that are unable to move out of the way of heavy machinery. It is expected that Night Parrots (if present in the area) will display avoidance behaviour and move away from the construction area as a result of noise from the construction equipment. Given this, the lack of evidence that Night Parrots are present in the area, and as Night Parrots are a highly mobile species that are likely to display avoidance behaviour (i.e.

move away from the area due to construction noise), the likelihood of such impacts occurring is considered low.

Vehicle strike (operational traffic)

Given the low abundance, elusive and nocturnal nature, and diet (seeds meaning they are unlikely to be attracted to the road area) of the Night Parrot, it is considered that the risk posed by vehicles using the road striking individual Night Parrots is very low.

Collision with fencing

It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and fencing will only be installed where an agreement is reached. It is, therefore, possible that individual bats may collide with this fencing.

Fences are noted within the conservation advice for Night Parrots as a potential threat to the species as they tend to fly low over the ground, thus increasing the risk of collision compared with other birds. It is possible that fencing will be installed at select areas along the new road for the protection of road users or for other health, safety and environment reasons. It is, therefore, possible (whilst not likely) that individual birds may collide with this fencing.

Fencing required for the Proposed Action will be managed to reduce the potential for impacts to occur to Night Parrots. This includes minimising fencing as far as practicable and utilising devices such as, discs on the top wire to make them more visible to birds. Barbed wire will not be used for fencing.

Given these mitigation measures, and the lack of evidence that Night Parrots exist in the area, it is not expected that any fencing required for the Proposed Action will result in impacts to Night Parrots.

Disturbance from light, noise and vibration

Given that the Night Parrot is nocturnal, there is potential that light emissions during construction may result in temporary avoidance behaviour in individual Night Parrots (if present). Given the temporary nature of this avoidance behaviour, potential impacts from construction lighting on Night Parrots are not considered to be significant.

Noise emissions from the construction activities may result in temporary avoidance behaviour in individual Night Parrots (if present). Given the temporary nature of this avoidance behaviour, potential impacts from construction noise on Night Parrots are not considered to be significant.

2.2.5.2 Indirect impacts

Introduced species

The Conservation Advice for the Night Parrot identifies predation by feral cats and foxes as a threat to this species. Specifically, the historical arrival of cats in Alice Springs coincided with a decline in Night Parrots, whilst there is no direct evidence of predation on the Night Parrot by foxes (TSSC, 2016c).

Feral predators are widespread throughout the Pilbara and have been recorded in the development envelope (Biota,2021). Given the proposed mitigation measures (Section 3), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that the

Proposed Action will result in a significant increase in feral predators or subsequent increased predation on Night Parrots.

2.2.5.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Night Parrot against the MNES significant impact criteria is provided in Table 2-11. This assessment uses the Critically Endangered species significant impact criteria by DoE (2013).

Table 2-11 Assessment of the potential impact of the Proposed Action on the Night Parrot

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NIGHT PARROT
'lead to a long-term decrease in the size of a population'	Not Significant. As described in Section 2.2.5.1, the clearing of up to 29.3 ha of potential Night Parrot foraging habitat, is not expected to result in significant impacts to Night Parrots given the lack of evidence that Night Parrots exist in the development envelope and the extensive (>0.6 million ha) similar habitat available in the Pilbara regions As described in Section 2.2.5.1, in the event Night Parrots are in the area during the construction and operation of the road, any impacts are expected to be limited to behavioural (avoidance) impacts with the risk of more substantial impacts such as injury or mortality to Night Parrot individuals considered to be low. Given this, it is considered highly unlikely that the Proposed Action will result in a long-term decrease in size of a population of the Night Parrot.
'reduce the area of occupancy of the species'	Not Significant. As the species has not been detected within the survey area and the area to be cleared represents a small portion of the available habitat both locally and regionally, it is not considered likely that the area of occupancy of the Night Parrot will be reduced.
'fragment an existing population into two or more populations'	Not Significant As described in Section 2.2.5.2, the narrow width of the road and the low traffic volume expected means that the road will not provide a barrier to the species. Given that there is no evidence that a Night Parrot population exists in the development envelope, and the Night Parrot is a highly mobile species, it is not expected that the Proposed Action will fragment an existing population of Night Parrot.
'adversely affect habitat critical to the survival of a species'	Not Significant As described in Section 2.2.5.2, up to 29.3 ha of potential Night Parrot foraging habitat will be cleared for the Proposed Action (Section 1.7.10.5). Given the lack of evidence that the Night Parrot is present in the area, the relatively small amount of this Night Parrot habitat to be cleared compared to the regionally available habitat (>0.6 million ha), and as the species is not dependent on the habitat to be cleared, this clearing is considered unlikely to be significant to Night Parrot populations.
'disrupt the breeding cycle	Not Significant

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NIGHT PARROT
of a population'	As described in Section 2.2.5.1, in the event Night Parrots are in the area during the construction and operation of the road, any impacts are expected to be limited to behavioural (avoidance) impacts with the risk of more substantial impacts such as injury or mortality to Night Parrot individuals considered to be low. Given this and the lack of evidence that Night Parrots exist in the area, it is not predicted that the Proposed Action will disrupt the breeding cycle of a population of Night Parrot.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant As described in Section 2.2.5.2, up to 29.3 ha of potential Night Parrot foraging habitat will be cleared for the Proposed Action. This is not expected to result in significant impacts to Night Parrots given the lack of evidence that Night Parrots exist in the development envelope and the extensive similar habitat available in the Pilbara regions. Given this it is not predicted that the Proposed Action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the Night Parrot species is likely to decline.
'result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat'	Not Significant The Conservation Advice for the Night Parrot identifies predation by feral cats and foxes as a threat to this species. The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase impacts due to background levels of invasive species.
'introduce disease that may cause the species to decline'	Not Significant The conservation advice for the Night Parrot lists psittacine beak and feather disease (and others) as a threat to the Night Parrot (TSSC, 2016c). There is no credible impact pathway that could result in the introduction of a disease by this Proposed Action that may cause a decline in the Night Parrot population.
'interfere with the recovery of the species'	Not Significant Conservation advice for the Night Parrot (TSSC, 2016c) outlines the priority actions for the recovery of this species relevant to the Proposed Action which include avoid or minimise the use of fences in areas likely to be traversed by the Night Parrot. If fences are to be constructed as part of the Proposed Action, these will be constructed in a manner that avoids or minimises risks to the Night Parrot. This includes minimising fencing as far as practicable, and utilising devices such as, discs on the top wire to make them more visible to birds. Barbed wire will not be used for fencing. As described in Section 3.3.5.1, in the event Night Parrots are in the area during the construction and operation of the road, any impacts are expected to be limited to behavioural (avoidance) impacts with the risk of more substantial impacts such as injury or mortality to Night Parrot individuals considered to be low. Given this and the lack of evidence that Night Parrots exist in the area, the Proposed Action is not predicted to

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR THE NIGHT PARROT
	interfere with the recovery of the Night Parrot species.

2.2.6 Grey Falcon (*Falco hypoleucos*) – Vulnerable

Potential direct impacts that may occur to Grey Falcons as a result of the Proposed Action are:

- loss of habitat
- interaction with construction activities;
- vehicle strike during operations;
- Collision with fencing; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Grey Falcons as a result of the Proposed Action are:

- degradation of habitat as a result of groundwater drawdown; and
- introduced species including increased predation and competition from feral predators.

2.2.6.1 Direct impacts

Loss of habitat

Up to 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat will be cleared for the Proposed Action representing less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of over 17.8 million ha). The field survey (Biota, 2021a) identified 12 habitat types that the Grey Falcon may utilise (shown in Figure 18). A breakdown of the are proposed to be cleared per habitat type is provided in Table 2-12. Habitat quality for all relevant supporting habitat types was rated '6', as described in Appendix 6 (Biota, 2021b).

Table 2-12 Extent of Grey Falcon habitat clearing for the Proposed Action

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
MG - Grove Mulga	Supporting habitat - foraging	69.7	666.2
MWP - Mulga Woodland Plain		16.1	122.5
ASCC - Acacia xiphophylla shrublands over cracking clay		10.4	328.9
ASM - Mixed Acacia shrublands		157.5	1,659.2
GPCC - Grassland plains with cracking clay		29.3	203.7
CP - Floodplains		135	1,778.6

HABITAT TYPE	HABITAT IMPORTANCE	EXTENT TO BE CLEARED* (HA)	EXTENT PRESENT WITHIN DEVELOPMENT ENVELOPE (HA)
HS - Mesas, caves, cliffs and free faces		0.14	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees		88.7	702.1
RG - Rocky gullies		3.8	13.7
MDE - *Eucalyptus* fringed major drainage lines and associated tributaries	Supporting habitat – nesting, foraging	85.5	1,233.1
MDM - *Melaleuca* forest/major drainage lines	Supporting habitat – foraging, nesting	0.03	21.2
MMW - Man-made water bodies	Supporting habitat – foraging, drinking	0.14	2.3
	Total	596.1	6,739.9

*Extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

The majority of habitats recorded within the development envelope may provide suitable foraging habitat for the Grey Falcon (Biota, 2021a). Open grassland plains and floodplains, in particular, would present ideal foraging habitat for the Grey Falcon (Biota, 2021a). As this species preys on smaller birds (and almost exclusively so during breeding periods), water holes with aggregations of birds may provide attractive foraging habitat for the Grey Falcon. Taller trees along major drainage lines offer potentially suitable breeding habitat for this species (particularly River Red Gum (Eucalyptus camaldulensis) and Coolibah (E.coolabah), although no nests were recorded during the Biota (2021a) survey. The Grey Falcon lays its eggs in the old nests of other birds (mainly corvids and other raptors), and therefore a tall tree would only provide suitable breeding habitat for the Grey Falcon if it contains an old stick-nest used by another bird (which is large enough to suit the species nesting behaviour) (Schoenjahn, 2018).

Conservation Advice for the Grey Falcon (TSSC, 2020) lists the conservation of known nesting trees, and the inclusion of an adequate exclusion buffer, as a conservation and management priority. Both the 'Eucalyptus fringed major drainage lines and associated tributaries and Melaleuca forest/major drainage lines habitats cross the disturbance footprint in a number of places. It is possible that individual tall trees may be required to be removed for the Proposed Action. No nesting trees were recorded during the Biota (2021a) survey, however one Grey Falcon was observed in flight, likely foraging (Page 6 of Figure 18) and the species has been recorded in the area previously. Removal of trees that may provide suitable breeding habitat is not expected to have a significant impact on this species as the Grey Falcon is not restricted to nesting in one species of tall tree (TSSC, 2020).

The species has a low population (less than 1,000) and is sparsely distributed across arid and semi-arid inland Australia. Given this, and that no nesting trees were recorded during the Biota (2021a)

survey, it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. Given this lack of dependence on the habitat to be cleared, the relatively small amount of potential Grey Falcon habitat to be cleared (species can utilise most available habitats in the Pilbara region), and the fact that the Proposed Action is linear infrastructure which means the habitat loss will not be concentrated in one particular area, it is not predicted that this clearing will result in a significant impact to Grey Falcons.

Vehicle strike (operational traffic)

Like many birds of prey, the Grey Falcon may feed on road-kill animals such as reptiles, mammals and avifauna species. The construction of a new road presents a risk to the species as they are vulnerable to vehicle strike when feeding on road-kill. Grey Falcons also often roost on bare ground at night which may include habitat within the road reserve. The conservation advice for the Grey Falcon identified collisions with vehicles as a threat to the species and notes that Schoenjahn (2018) documented six cases of Grey Falcons being found injured or dead along roads between 2007 and 2017 (TSSC, 2020). Given this, it is considered that intermittent incidences of mortality from collision with vehicles may occur. However, the low number of individuals in the area and the low expected traffic volume means that impacts will be limited to a small number of individuals and is unlikely to significantly affect the Grey Falcon.

Collision with fencing

Consultation with landowners is currently ongoing in regard to fencing and will only be installed where an agreement is reached. It is therefore possible individual Grey Falcons may collide with this fencing when approaching the ground or taking off, however given the low density of Grey Falcons expected to occur in the area, this is highly unlikely.

Collision with fences is noted within the conservation advice for Grey Falcons as a potential threat to the species. It is possible that fencing will be installed at select areas along the new road for the protection of road users or for other health, safety and environment reasons. It is, therefore, possible (whilst not likely) that individual birds may collide with this fencing.

Fencing required for the Proposed Action will be managed to reduce the potential for impacts to occur to Grey Falcons. This includes minimising fencing as far as practicable and utilising devices such as, discs on the top wire to make them more visible to birds. Barbed wire will not be used for fencing.

Given these mitigation measures and the low number of individuals likely to be in the area, it is not expected that any fencing required for the Proposed Action will result in significant impacts to Grey Falcons.

Disturbance from noise and vibration

Noise emissions from the construction activities may result in temporary avoidance behaviour in individual Grey Falcons (if present). Given the temporary nature of this avoidance behaviour, impacts from construction noise on Grey Falcons are not considered to be significant.

2.2.6.2 Indirect impacts

Degradation of habitat as a result of groundwater drawdown

As detailed in Section 1.7.5 vegetation with a low to high dependency on groundwater is present in along the major drainage lines in and around the development envelope. Grey Falcons may utilise

these trees for nesting and as such any impacts to this vegetation as a result of groundwater drawn down from abstraction or dewatering activities may result in indirect impacts to Grey Falcons.

Groundwater abstraction for water supply or dewatering during construction of water crossings will be temporary and of a short duration. Abstraction will be managed to minimise groundwater drawdown in accordance with the applicable license. The DoW (2016) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the development envelope lies within this area. DoW (2016) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year. It is estimated that between 148,000 and 412,000 L will be abstracted for the project over a 30 month period. Groundwater abstraction would be undertaken at a number of well locations (depending on the specific location of the construction activities at the time). This will further reduce the likelihood of impact to vegetation as a result of groundwater abstraction.

WSP Golder (2022, Appendix 5) undertook a hydrogeological risk assessment to assess potential environmental impacts due to groundwater drawdown, including on groundwater dependent vegetation. The assessment found that estimated groundwater drawdown for each aquifer is low and that impacts to groundwater dependent vegetation is anticipated to be minimal.

Given this, no long-term effects on the environment including Grey Falcons are predicted to occur as a result of groundwater abstraction.

Introduced species

The Conservation Advice for the Grey Falcon recognises predation by feral cats as a 'Very High' risk. Whilst the Grey Falcon nests in tall trees they have been shown to roost on bare open ground (Schoenjahn, 2018). This behaviour exposes this species to predation by introduced species such as feral cats.

Feral predators are widespread throughout the Pilbara and have been recorded in the development envelope Biota (2021). Given the proposed mitigation measures (Section 3), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that the Proposed Action will result in a significant increase in feral predators or subsequent increased predation on, or competition with Grey Falcons.

2.2.6.3 Assessment against MNES Significant Impact Guidelines

An assessment of the potential impacts of the Proposed Action on the Grey Falcon against the MNES significant impact criteria is provided in Table 2-13. This assessment uses the Vulnerable species significant impact criteria by DoE (2013).

Table 2-13 Assessment of the potential impact of the Proposed Action on the Grey Falcon

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR GREY FALCON
'lead to a long-term decrease in the size of an important population'	Not Significant. Grey Falcons are sparsely distributed across arid and semi-arid inland Australia where rainfall is less than 500 mm annually, including the Murray-Darling Basin, Eyre Basin, central Australia and WA (Marchant and Higgins, 1993). The Pilbara is believed to represent a refugia to which the Grey Falcons may withdraw, and which provide foci for

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR GREY FALCON
	recolonisation when conditions improve (Olsen & Olsen, 1986). Given this, it is considered unlikely that an important population ('a population that is necessary for a species' long-term survival and recovery') of Grey Falcon is present in the area. Up to 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat will be cleared for the Proposed Action. However, as no nesting trees were recorded during the Biota (2021a) survey, and the relatively small amount of habitat to be cleared in the context of the regionally available habitat, it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. Given this is considered unlikely that this clearing will result a decline in the Grey Falcon population. As described in Section 2.2.6.1, due to the low number of individuals likely to be in the area, and as Grey Falcon are a highly mobile species, it is considered that the likelihood of other direct impacts occurring as a result of interaction with the construction activities, vehicle strike and collision with fences is low. Given the above, it is considered unlikely that the Proposed Action will result in a long-term decrease in size of an important population of the Grey Falcon.
'reduce the area of occupancy of an important population'	Not Significant As described above, it is considered unlikely that an important population of Grey Falcon is present in the area. Given the relatively small amount of nesting, foraging and drinking habitat to be cleared in the context of the regionally available habitat, it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. The species is mobile and can move away from disturbances such as habitat to be cleared within the development envelope. Given this, and its ability to hunt over a variety of habitats, it is not likely that level of vegetation clearing required for the Proposed Action (or any other potential direct or indirect impact) would reduce the occupancy of the species.
'fragment an existing important population into two or more'	Not Significant As described above, it is considered unlikely that an important population of Grey Falcon is present in the area. The road will not provide a barrier to the movement of Grey Falcons given their highly mobile and aerial nature. As such the Proposed Action will not fragment an existing important population of Grey Falcons into two or more.
'adversely affect habitat critical to the survival of a species'	Not Significant Up to 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat will be cleared for the Proposed Action. Given no nesting trees were recorded during the Biota (2021a) survey; the relatively small amount of habitat to be cleared in the context of the regionally available habitat; and that the habitat

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR GREY FALCON
	extends broadly outside of the development envelope, it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. Therefore, it is considered unlikely that clearing this amount of habitat will result in significant impacts to the Grey Falcon.
'disrupt the breeding cycle of an important population'	Not Significant As described above, it is considered unlikely that an important population of Grey Falcon is present in the area. Taller trees along major drainage lines also offer potentially suitable breeding habitat for this species, although no nests were recorded during the Biota (2021a) survey. The species lays its eggs in the old nests of other birds (mainly corvids and other raptors), and therefore a tall tree would only provide suitable breeding habitat for the Grey Falcon if it contains an old stick-nest used by another bird (which is large enough to suit the species nesting behaviour) (Schoenjahn, 2018). Given this and as no nesting trees were identified during the Biota (2021a) survey (and as it's not considered likely that an important population of Grey Falcons are present in the area), the Proposed Action is not expected to disrupt the breeding cycle of an important population of Grey Falcon.
'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'	Not Significant Up to 596.1 ha of potential Grey Falcon habitat will be cleared for the Proposed Action. However, as no nesting trees were recorded during the Biota (2021a) survey and the relatively small amount of habitat to be cleared in the context of the regionally available habitat (and the habitat extends broadly outside of the development envelope), it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. Given this, it is considered unlikely that this clearing will lead to a decline in the species.
'result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat'	Not Significant The Conservation Advice for the Grey Falcon recognises predation by feral cats as a 'Very High' risk. The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase impacts due to background levels of invasive species.as the surrounding landscape is already bisected by existing rail and roads.
'introduce disease that may cause the species to decline'	Not Significant Conservation advice for the Grey Falcon (TSSC, 2020) does not identify disease as a threat to Grey Falcons. There is no credible impact pathway that could result in the introduction of a disease that may cause a decline in the Grey Falcon

SIGNIFICANT IMPACT CRITERIA (DoE, 2013)	ASSESSMENT FOR GREY FALCON
	population.
'interfere substantially with the recovery of the species'	Not Significant Conservation advice for the Grey Falcon (TSSC, 2020) outlines the priority actions for the recovery of this species relevant to the Proposed Action which include protect known nesting trees and include adequate exclusion buffers with regard to proposed developments and land clearing activities. It is noted that the existence of a single, small population (estimated at less than 1,000 mature individuals) which is monotypic, as is the case for the Grey Falcon, increases a species sensitivity to demographic and genetic stochastic events (TSSC, 2020). As no nesting trees were recorded during the Biota (2021a) survey and the relatively small amount of habitat to be cleared in the context of the regionally available habitat (and the habitat extends broadly outside of the development envelope), it is considered unlikely that the Grey Falcon is dependent on the habitat to be cleared. Given the above, and that it is considered unlikely that an important population of Grey Falcon is present in the area, it is not predicted that the Proposed Action will interfere substantially with the recovery of the species.

3 AVOIDANCE AND MITIGATION MEASURES

3.1 Overview

Mitigation and management of the potential direct and indirect impacts on MNES associated with the Proposed Action will be implemented in accordance with relevant Main Roads standards and procedures, together with a project specific Fauna Action Management Plan (AMP) (Appendix 7).

An overview of the mitigation and management measures proposed is provided in the following sections. This includes identification of each impact/risk, a description of each measure proposed, the location and timing for each measure, monitoring and reporting requirements, and performance and completion criteria. Further specific details with respect to the management approach for EPBC Act listed threatened fauna, is provided in the Fauna AMP (Appendix 7) which has been prepared in accordance with DCCEEW's Action Management Plan Criteria.

3.2 Management objectives

3.2.1 Threatened Flora

The following management target for EPBC Act listed threatened flora has been identified:

1. Prevent the unauthorised clearing of the single Fringed Fire-bush plant identified during the Biota (2021a) survey.

3.2.2 Threatened Fauna

The following management targets for EPBC Act listed threatened fauna have been identified[3]:

1. Prevent unauthorised clearing of EPBC Act listed threatened fauna habitat including clearing no more than:
    a) 178.3 ha of Northern Quoll foraging, dispersal and denning habitat including no more than 4.0 ha of habitat critical to the survival of the Northern Quoll species;
    b) 178.2 ha of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat;
    c) 313.4 ha of Ghost Bat roosting, foraging, flyway and drinking habitat;
    d) 313.3 ha of Pilbara Olive Python foraging habitat;
    e) 29.3 ha of potential Night Parrot foraging habitat; and
    f) 596.1 ha of Grey Falcon nesting, foraging and drinking habitat.
2. Prevent unauthorised impacts to groundwater levels and groundwater quality.
3. Avoid indirect impacts to groundwater dependent vegetation.
4. Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.

[3] Note that maximum extent to be cleared based on current base case disturbance footprint plus an allowance of approximately 10% more than the habitat area mapped within the disturbance footprint. This allowance provides flexibility in the location of the road and construction areas for access and laydown.

5. No introduction or spread of declared weeds, WONS or serious environmental weed species into surrounding native vegetation adjacent to the Development Envelope during and attributable to construction.
6. Avoid impacts to roosting caves used by Ghost Bats.
7. Minimise injury or mortality to EPBC listed threatened species during operation.

3.3 Performance standards

The DCCEEW request for additional information (Appendix 1) identifies the application of 'SMART' (specific, measurable, achievable, relevant and time-bound) performance standards to be applied to AMPs.

SMART performance standards are intended to relate to measurable (numerical) values which can be applied to a Proposal (rather than qualitatively measured management/monitoring actions), and may include measurements such as 'threshold criteria', 'performance indicators', 'corrective actions' and 'completion criteria'.

Table 3-1 identifies the SMART performance standards related to the measurable impacts of the Proposed Action. These SMART performance standards complement the management actions and performance targets identified in Table 3-2, the monitoring actions identified in Table 3-3, and the corrective actions identified in Table 3-2.

As the proposed SMART performance standards for 'threshold criteria' and 'completion criteria' relate to physical measures which can be readily controlled through standard construction management processes, it is considered the proposed SMART performance standards have a low level of uncertainty, with additional margins for safety not required.

The SMART performance standards do not require detailed statistical analysis to determine if the 'threshold criteria' and 'completion criteria' have been met, nor require statistical power to detect change (for example, seasonal or climatic variability), nor control or reference sites (for comparative purposes).

Table 3-1 SMART Performance Standards

THRESHOLD CRITERIA	PERFORMANCE INDICATORS	CORRECTIVE ACTIONS	COMPLETION CRITERIA
Clearing 178.3 ha of Northern Quoll foraging, dispersal and denning habitat including no more than 4.0 ha of habitat critical to the survival of the Northern Quoll species.	Area (ha) of Northern Quoll foraging, dispersal and denning habitat cleared. Area (ha) of habitat critical to the survival of the Northern Quoll species cleared.	Refer to Table 3-2	No more than 178.3 ha of Northern Quoll foraging, dispersal and denning habitat, including no more than 4.0 ha of habitat critical to the survival of the Northern Quoll species cleared.
Clearing of 178.2 ha of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat.	Area (ha) of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat cleared.		No more than 178.2 ha of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat cleared.
Clearing of 313.4 ha of roosting, foraging, flyway and drinking Ghost Bat Habitat.	Area (ha) of Ghost Bat roosting, foraging, flyway and drinking habitat cleared.		No more than 313.4 ha of Ghost Bat roosting, foraging, flyway and drinking habitat cleared.
Clearing of 313.3 ha of Pilbara Olive Python foraging habitat.	Area (ha) of Pilbara Olive Python foraging habitat cleared.		No more than 313.3 ha of Pilbara Olive Python foraging habitat cleared.
Clearing of 29.3 ha of Night Parrot foraging habitat.	Area (ha) of Night Parrot foraging habitat cleared.		No more than 29.3 ha of Night Parrot foraging habitat cleared.
Clearing of 596.1 ha of Grey Falcon habitat.	Area (ha) of Grey Falcon foraging habitat cleared.		No more than 596.1 ha of Grey Falcon habitat cleared.

3.4 Environmental management actions

In order to comply with relevant environmental legislation and manage impacts to the local environment, Main Roads has defined objectives, outcomes and management-based provisions to ensure that impacts to MNES are avoided and minimised as far as practicable during the implementation of the Proposed Action (Table 3-2).

Table 3-2 Environmental management actions

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
Construction – Flora Management							
Prevent the unauthorised clearing of the single Fringed Fire-bush plant identified during the Biota (2021a) survey.	A 50 m 'No Go' exclusion zone will be marked on all relevant project maps. Note that in the event the species is delisted prior to construction, this management measure will no longer be implemented.	Drawings including no-go zones provided to Construction Contractor Representative.	Prior to commencement of clearing. During construction.	• Monthly site inspections. • Monthly construction reports including clearing amounts.	• Drawings do not show no-go zones. • Clearing within the 50 m no-go zone occurs	• Clearing will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	A 50 m 'No Go' exclusion zone will be pegged out on site around the location of the single plant. Note that in the event the species is delisted prior to construction, this management measure will no longer be implemented.	All no-go zones clearly marked out on site					
Construction - Fauna Habitat Management							
Prevent unauthorised clearing of EPBC Act listed threatened fauna habitat. Achieve SMART performance standards (Table 3-1).	The extent of the approved clearing will be clearly communicated in documentation.	Drawings and shape/CAD files showing approved clearing areas provided to Construction Contractor Representative.	Prior to commencement of clearing.	• MRWA to check that drawings and shape/CAD files show correct approved clearing areas. • Record of provision of drawings and shape/CAD files showing approved clearing areas	• Drawings do not show correct approved clearing areas. • Shape/CAD files not provided.	• Clearing will not recommence until no-go areas and clearing boundaries have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence • Environmental incident will be recorded, and the cause investigated • Unauthorised clearing of vegetation containing habitat for MNES will be assessed for potential remediation. Rehabilitation works will commence within 6-12 months of the incident. Refresher or updated	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	All clearing areas will be clearly marked and approved by the Main Roads superintendent prior to clearing commencing.	All areas to be cleared clearly marked on site.	Prior to commencement of clearing.	• Incident reporting (EQSafe). • Monthly site inspections. • Site inspection prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits. • Monthly construction reports including clearing amounts.	Clearing more than: • 178.3 ha of Northern Quoll foraging, dispersal and denning habitat including no more than 4.0 ha of habitat critical to the survival of the Northern Quoll species • 178.2 ha of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat.		
	Vegetation to be retained will be clearly marked with flagging on site.	All vegetation to be retained will be clearly marked on site.					

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	Within the constraints of other requirements (construction requirements, avoiding heritage sites), consideration will be given to habitat importance during the selection of additional areas required for construction such as laydown areas, stockpile areas and vehicle turn around. Areas will be prioritised in the following order: 1. Existing cleared areas / areas cleared for permanent works. 2. Areas that do not contain habitat associated with EPBC Act listed threatened species that are considered likely to or may occur in or near the development envelope. 3. Areas that contain habitat that may be utilised by EPBC Act listed threatened species that are considered likely to or may occur in or near the development envelope. The following areas will not be used as additional areas required for construction such as laydown areas, stockpile areas and vehicle turn around: • Habitat critical to the survival of the Northern Quoll; • Important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and • Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021a).	Selection of areas for ancillary services made with due consideration to priorities with respect to habitat importance.	During construction.	• Construction site plan • Monthly site inspections. • Monthly construction reports including clearing amounts.	• 313.4 ha of Ghost Bat roosting, foraging, flyway and drinking Habitat. • 313.3 ha of Pilbara Olive Python foraging habitat. • 29.3 ha of foraging Night Parrot habitat. • 596.1 ha of Grey Falcon nesting, foraging and drinking habitat.	training will be conducted (if appropriate). • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
	Restrict all personnel to the approved disturbance footprint including designated access routes and parking areas.	Approved disturbance footprint including designated access routes and parking areas communicated.	During construction.	• Construction site plan showing all approved access areas.	• Construction site plans do not show correct approved access areas.	• Review and revise construction site plan.	
Prevent unauthorised impacts to groundwater	Water required for construction and dust management will be sourced from existing bores and potentially from new sources for the southern section. Should new bores be	Audits against requirements of licences.	During construction.	• Audit reports	• Audit identifies non-compliance with licence requirements.	▪ Environmental incident will be recorded, and the cause investigated; and	▪ Construction Contractor Environmental

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
levels and groundwater quality.	required, a 26D licence to construct or alter a well will be submitted along with a 5C licence to extract water.					• Remedial action will be undertaken in accordance with licence requirements. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	Management Representative; and ▪ Main Roads Superintendent.
	Results of further studies on sustainable construction water abstraction will be implemented to reduce project water use as far as practicable.	Not applicable					
	Adherence to the relevant recommendations included in: • Water Quality Protection Note no.25. Land use compatibility tables for public drinking water source areas (DoW 2016a); • Water Quality Protection Note no.44. Roads near sensitive water resources (DoW 2006);	Site inspections for compliance with water quality protection notes.	During construction	• Site inspection reports	• Site inspection identifies non-compliance with requirements.	• Environmental incident will be recorded, and the cause investigated; and • Remedial action will be undertaken within 48 hours. • DCCEEW will be notified along with investigation report during annual compliance reporting if	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	• Water Quality Protection Note no.65. Toxic and hazardous substances (DoW 2015); • Water Quality Protection Note no.83. Infrastructure corridors near sensitive water Resources (DoW 2007); and • Water Quality Protection Note no.84. Rehabilitation of disturbed land in public drinking water source areas (DoW 2009).					triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
Avoid indirect impacts to groundwater dependent vegetation.	Main Roads will develop and implement a Groundwater and Surface Water Operating Strategy (GSWOS). The objectives of the GSWOS with respect to groundwater abstraction will be to mitigate the impact of groundwater drawdown on groundwater dependent vegetation that forms part of habitat for threatened fauna (MNES). With respect to groundwater abstraction the GSWOS will detail: • A commitment to apply a 500 m radius buffer from the point of groundwater abstraction to any identified groundwater dependent vegetation. • Groundwater water level thresholds and triggers based on further assessment of potential drawdown. • Corrective actions to be implemented if groundwater level triggers and threshold are exceeded. • Reporting requirements including six monthly reporting of groundwater	GSWOS prepared and approved by the Minister for the Environment.	Prior to commencement of proposed action.	• Record of Minister for the Environment approval of GSWOS.	• Groundwater abstraction occurs without complying with an approved GSWOS.	• Groundwater abstraction will cease immediately if trigger is met and will not recommence until Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	levels for bores in the vicinity of groundwater dependent vegetation.					• Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
No introduction or spread of declared weeds, WONS or serious environmental weed species into surrounding native vegetation adjacent to the development envelope during and attributable to construction.	• Environmental weeds within the construction site boundary will be treated according to the weed control management outlined by Weeds Australia with the aim of controlling off-site movement. Develop and maintain a weed register for declared weeds, WONS or serious environmental weed species (if identified). Register will include, for each species, details of distribution, abundance, relevant biological information and a history of control methods and their relative success; • Develop and implement vehicle and equipment clean on entry/exit procedures; • All personnel will be inducted prior to their commencement on site; • The induction will include weed identification and weed hygiene training; • Any machinery used in the removal of weed-infested topsoil will be cleaned down before entering or leaving the work site to prevent the introduction and spread of weeds into new areas; • Any soil or materials imported onto the worksite will be from weed-free areas; • Where roadworks directly impact known areas of serious environmental weeds, topsoil will be removed	Stated requirements in relation to weed management implemented.	• Monthly during construction; and • For 3 years post-construction.	• Visual inspection, pedestrian walkthrough (monthly); • Photographic record, GPS of non-conformance; • Weed monitoring to be undertaken along the edge of the road reserve annually post-construction for a period of 3 years. • Weed monitoring reports. • Records of topsoil segregation and burial or licensed waste facilities; and • Records verifying plant and machinery arriving on site is clean.	• New significant weed infestation (i.e. above existing background levels) identified	• Where new weed infestation is evident, herbicide application shall be undertaken. • Review weed management process. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	separately, heaps delineated and spoil disposed of as soon as possible through consultation with the Main Roads environmental management representative; • Weed contaminated topsoil stockpiles shall be quarantined from uncontaminated / clean topsoil stockpiles, clearly signed in the field and identified on a site plan; and Areas temporarily disturbed are to be revegetated and stabilised.						
Construction – General EPBC Act listed threatened species management measures							
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	In the event of EPBC Act listed threatened fauna injury, advice shall be sought from local qualified wildlife organisations/persons, such as: • Pilbara Wildlife Carers Association (PWCA): Contact Main Coordinator Mob: 0438 924 842. • PWCA: Tom Price – Mob: 0438 957 463. Contact details for these organisations will be maintained onsite to facilitate rapid transfer sick or injured wildlife to an appropriate organisation, thereby reducing the holding time and potential stress on the animal.	A list of local wildlife rescue organisations and carers is on site at all times.	During construction.	• Monthly inspection.	• A list of local wildlife rescue organisations and carers is not on site. • Wildlife rescue specialists not contacted immediately on discovery of an injured EPBC Act listed threatened fauna.	• A list of local wildlife rescue organizations and carers is obtained by site immediately • Refresher training will be conducted within 1 week of determining that requirement is not be met.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	Where construction of the Proposed Action results in an MNES listed fauna fatality, this will be recorded as an environmental incident through Main Roads EQSafe system.	All fauna fatalities that occur as a result of the construction of the Proposed Action will be recorded as an environmental incident through Main Roads EQSafe system.	During construction.	• Routine inspections	• Routine inspections find deceased fauna near the construction activities and the impact is attributable to the Proposed Action.	• Refresher training will be conducted within 1 week of determining that requirement is not met.	
	Speed limits between 40-80 km/hr will be applied throughout the construction site for safety purposes which will consequently reduce the risk of fauna strikes during clearing and construction.	No incidents of speeding within the construction site boundary.		• Monthly inspection of records	• Any incident of speeding within the construction boundary.	• Refresher training will be conducted within 1 week of determining that requirement is not met.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	Inductions for all personnel will include appropriate road driving procedures and significant fauna awareness.	Induction material includes required information.		• Review of induction material • Monthly inspection of induction records.	• Required information not including in induction material. • Monthly inspection finds any personnel working on site not correctly inducted.	• Review and update induction material • Persons not correctly inducted are to immediately cease work and not recommence until induction complete.	
	Night work to be minimised. It is expected that regular work hours will be between 6 am and 6 pm. Night works will not be significant, however, due to the high temperatures in the area, some night work activities may be carried out. If required, lighting will be directed onto active construction areas to minimise light spill. Requirement to be included in site inductions.	Induction material includes required information.		• Review of induction material. • Monthly inspection of induction records. • Monthly inspections of lighting.	• Required information not including in induction material. • Monthly inspection finds personnel on site not correctly inducted. • Monthly inspection finds requirement not being complied with.	• Review and update induction material • Personnel not correctly inducted to immediately cease work and not recommence until induction complete. • Refresher training will be conducted within 1 week of determining that requirement is not being met.	
	Induction for all personnel will include the requirement to report sightings of feral animals, no feeding of native and/or feral animals and no pets allowed on site.	Induction material includes requirement information.		• Monthly inspection of induction records	• Monthly inspection finds personnel working on site not correctly inducted. • Instances of personnel not complying with requirement.	• Personnel not correctly inducted to immediately cease work and not recommence until induction complete. • Refresher training will be conducted within 1 week of determining that requirement is not being met.	
	Construction camp waste including food waste will not be dumped. Waste will be appropriately segregated and contained, including use of lids that cannot be removed by fauna.	Construction camp waste segregated, stored in fauna proof containers and disposed of appropriately.		• Monthly inspection • Waste disposal records.	• Monthly inspection or review of records find waste not being segregated, stored correctly or disposed of appropriately.	• Review and update waste management procedures and increase frequency of inspections.	
	Main Roads will develop and implement a Groundwater and Surface Water Operating Strategy (GSWOS). The objectives of the GSWOS with respect to impacts form erosion during waterway crossing construction will be to mitigate impacts of erosion that could potentially increase	GSWOS prepared and approved by Minster for the Environment.	Prior to commencement of Proposed Action.	• Record of Minister for the Environment approval of GWSOP.	• Construction of significant waterways crossings occurs without complying with an approved GWSOP.	• Waterway crossing construction will cease immediately if trigger is met and will not recommence until Main Roads Superintendent provides approval to recommence.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	sedimentation into the streams throughout the construction of waterway crossings. With respect to potential erosion the GSWOS will detail: • An erosion monitoring program that includes baseline monitoring and monitoring upstream and downstream of the construction sites, to monitor for erosion that could potentially increase sedimentation into the streams throughout the construction of significant waterway crossings. Monitoring will include at a minimum: - upstream and downstream of the crossing in Fortescue River; - immediately upstream of the confluence of Weelumurra Creek with Fortescue River and upstream of the project in Weelumurra Creek (or as far upstream as is possible given the ephemeral nature of the creek); and - Caves Creek and/or its tributaries. • Thresholds and triggers, and associated management actions that will be put in place to manage erosion risks during construction.					• Environmental incident will be recorded, and the cause investigated. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
Construction - Northern Quoll management measures							
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	Clearing of habitat critical to the survival of the Northern Quoll will be limited to between 1 April and 30 September to prevent coinciding with Northern Quoll when they have large pouch or denned young.	No clearing of habitat critical to the survival of the Northern Quoll occurs between 1 April and 30 September.	During construction.	• Monthly site inspections.	• Clearing of habitat critical to the survival of the Northern Quoll occurs between 1 April and 30 September.	• Clearing of habitat critical to the survival of the Northern Quoll will cease immediately if trigger is met. Clearing of habitat critical to the survival of the Northern Quoll will not recommence until after 30 September and Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	• Construction Contractor Environmental Management Representative • Main Roads Superintendent

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	Prior to clearing any Northern Quoll critical habitat, undertake pre-clearance surveys. If individuals identified in area to be cleared, clearing in this area not to commence until confirmed the identified fauna no longer present. Relocation of individuals will be considered where appropriate and in consultation with a wildlife specialist.	No clearing to be undertaken in critical habitat until surveys confirm species is not present in the area to be cleared.	Survey to be undertaken two weeks prior to commencement of clearing.	• Records of pre-clearance surveys.	• Clearing of habitat critical to the survival of Northern Quoll occurs without the survey confirmation that species is not present.	• Clearing will cease immediately if trigger is met. Clearing will not recommence until preclearance survey confirms species is not present and Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
	Construction site inductions will provide detailed information about Northern Quolls.	Induction material contains required information.	During construction	• Review of induction material.	• Induction material does not contain required information • Monthly inspection finds personnel working on site not correctly inducted.	• Review and revise induction material. • Personnel that are not correctly inducted to immediately cease work and not recommence until induction complete.	• Construction Contractor Environmental Management Representative • Main Roads Superintendent

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
Construction - Pilbara Leaf-nosed Bat and Ghost Bat management measures							
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	Construction site inductions will provide detailed information about Pilbara Leaf-nosed Bats and Ghost Bats.	Induction material contains required information.	During construction	• Review of contractor induction material	• Induction material does not contain required information • Monthly inspection finds personnel working on site not correctly inducted.	• Review and revise induction material. • Personnel that are not correctly inducted to immediately cease work and not recommence until induction complete.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
Avoid impacts to roosting caves utilised by Ghost Bats.	An activity buffer of 400 m will be created within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required. A 150 m no-go zone will be created between the construction activities and known caves that have been identified as having evidence of Ghost Bat use. These no-go zones will be clearly shown on all project drawings and communicated in documentation.	Drawings include no-go zones and are provided to Construction Contractor Representative.	Contract award and prior to commencement of clearing.	• Record of provision of drawings showing no-go zones.	• Drawings do not show correct approved clearing areas	• Clearing/blasting not to commence until drawings are reviewed and revised to show required no-go zone.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	Caves that have been identified as having evidence of Ghost Bat use and associated no-go zones will be clearly marked on site.	All no-go zones clearly marked out on site.	Prior to commencement of clearing or blasting. During construction.	• Incident reporting (EQSafe). • Monthly site inspections. • Site inspection by Construction Contractor Environmental Management Representative prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits.	• Clearing or blasting activities occurring within 150 m of caves that have been identified as having evidence of Ghost Bat use, unless a pre-blasting survey indicates that no bats are present.	• Clearing and blasting within 150 m of the caves will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
						environmental values is significant, the DCCEEW will be notified within a week of such investigation. Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
	Main Roads will prepare a Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be prepared for approval by DCCEEW prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. The purpose of this plan will be to meet the stated management objective to "Avoid impacts to roosting caves used by Ghost Bats". This plan will outline the blasting activities, noise and vibration monitoring (in	Noise and Vibration Management Plan approved by DCCEEW prior to blasting occurring within 400 m of a cave with evidence of Ghost Bat usage.		• Record of DCCEEW approval of noise and vibration management plan.	• Blasting occurs within 400 m of a cave with evidence of Ghost Bat usage without complying with an approved Noise and Vibration Management Plan.	• Blasting will cease immediately if trigger is met. Blasting will not recommence until Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated.	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	relation to the caves) and an adaptive management approach. The noise and vibration plan will include a requirement for the blasting contractor to ensure that the predicted peak particle velocity (PPV) values for each blast is included in the blast design. The PPV will be required to be calculated using an industry recognised approach that incorporates predictive mechanisms for ground vibration and is in accordance with AS 2187. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats. The plan will also specify procedures for monitoring of the PPV including monitoring of blasts undertaken away from the Ghost Bat caves, to verify that impact thresholds will not be exceeded during blasting activities within 400 m of a cave with evidence of Ghost Bat usage.	Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats.		• Monitoring of PPV during blasting at caves with evidence of Ghost Bat usage.	• PPV as measured during blasting at caves with evidence of Ghost Bat usage exceeds threshold level. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats.	• DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
	Ghost Bat roosts will be recorded in a site database and mapped on all construction plans. The database will be accessible to all site personnel.	All identified ghost bat roosts recorded in database and mapped on all construction plans. Database is accessible to all site personnel.		• Monthly site inspections.	• Bat roosting areas not recorded in site database and mapped on construction plans.	• Clearing and blasting to cease until database and drawing reviewed and revised.	
	Confined blasting techniques (where inert material such as crushed stone is used to seal off blast holes and contain energy released) will be used within 400 m of caves known to be used by Ghost Bats in preference to unconfined methods.	Contractor method statement includes confined blasting technique.		• Review of contractor method statement. • Monthly inspection.	• Unconfined blast technique used within 400 m of caves known to be used by Ghost Bats, unless pre-blasting survey indicates that no bats are present.	• Environmental incident will be recorded, and the cause investigated. • Blasting activities to cease immediately and not recommence until Main Roads	

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
						Superintendent provides approval to recommence. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action.	
Operations – General EPBC Act listed threatened species management measures							
Minimise injury or mortality to EPBC listed threatened species during operation.	Fauna sensitive road design will consider installing signage in places where motorists may encounter significant fauna.	Design documents include fauna friendly signage.	Pre-construction and during construction.	• Pre-construction design reviews. • Post-construction as built reviews against the design.	• Pre-construction review finds requirement not included. • Post-construction as-built review find requirement not implemented.	• Pre-construction - review and revise design. • Post-construction – rectify no-conformance.	• Design contractor. • Main Roads Superintendent.

MANAGEMENT OBJECTIVE / DESIRED OUTCOME	MANAGEMENT MEASURES	PERFORMANCE TARGET/COMPLETION CRITERIA	TIMING	MONITORING/ REPORTING ACTIVITY	CORRECTIVE ACTION TRIGGER(S)	CORRECTIVE ACTION	CORRECTIVE ACTION RESPONSIBILITY
	Fencing will utilise devices such as discs on the top wire to make them more visible to bats and birds. Barbed wire will not be used in fencing.	Design documents include requirement of devices such as discs on the top wire of fencing.					
	Main Roads will develop and implement a Groundwater and Surface Water Operating Strategy (GSWOS). The objectives of the GSWOS with respect to surface water flows will be to mitigate the impact of change to surface water regimes on threatened fauna habitat. With respect to surface water flows the GSWOS will detail how • Design criteria of the infrastructure (culvert crossing, bridges and roadway embankments) and evidence on how this design will minimise potential impacts to surface water flow regimes. • Post construction monitoring, inspection and reporting intervals that will be undertaken to confirm that the predicted design of these crossings have appropriately size culverts, do not cause bridge scour and ensures that there is on-going roadway embankment stability.	GSWOS prepared and approved by Minster for the Environment.	Prior to commencement of Proposed Action.	• Record of Minister for the Environment approval of GWSOP.	• Construction of significant waterways crossings occurs without complying with an approved GWSOP.	• Waterway crossing construction will cease immediately if trigger is met and will not recommence until Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated. • DCCEEW will be notified along with investigation report during annual compliance reporting if triggers are met and exceeded. • If the investigation shows that the damage to the environmental values is significant, the DCCEEW will be notified within a week of such investigation. • Within three weeks of such incidents, the DCCEEW will be provided with an investigation report and corrective actions to remediate the environmental damage to the satisfaction of the DCCEEW prior to recommencing the action..	

3.5 Environmental monitoring

Key monitoring actions have been identified to monitor the potential impacts of the Proposed Action to MNES and habitat during and post construction. These encompass monitoring of both direct and indirect impacts of the Proposed Action. Monitoring will be undertaken by suitably qualified individuals for the methodology type specified. The proposed monitoring program for the Proposed Action is identified in Table 3-3.

Table 3-3 Environmental monitoring

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
Construction - Flora					
Prevent the unauthorised clearing of the single Fringed Fire-bush plant identified during the Biota (2021a) survey.	Drawings and shape/CAD files showing approved clearing areas provided to Construction Contractor Representative. All no-go zones clearly marked out on site.	• Monthly site inspections. • Monthly construction reports including clearing amounts.	• Site inspection prior to and following clearing to confirm no-go area is appropriately marked out on site.	• 50 m no-go zone around single Fringe Fire Bush plant identified during the Biota (2021a) survey.	• Prior to commencement of clearing. • Monthly.
Construction - Fauna Habitat					
Prevent unauthorised clearing of EPBC Act listed threatened fauna habitat. Achieve SMART performance standards (Table 3-1).	Drawings and shape/CAD files showing approved clearing areas provided to Construction Contractor Representative.	• Record of provision of drawings and shape/CAD files showing approved clearing areas.	• Pre-construction review.	n/a	• Prior to construction.
	All areas to be cleared clearly marked on site. All vegetation to be retained will be clearly marked on site.	• Incident reporting (EQSafe). • Monthly site inspections.	• Visual inspection. • Photographic record, GPS of non-conformance.	• Disturbance footprint and surrounds.	• Prior to commencement of clearing. • Monthly.
	Selection of areas for ancillary services made with due consideration	• Construction site plan	• Written records. • Visual inspection.	• Ancillary service areas.	• Prior to commencement of clearing.

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
	to priorities with respect to habitat importance.	• Monthly site inspections. • Monthly construction reports including clearing amounts.	• Photographic record, GPS of non-conformance.		• Monthly.
	Approved disturbance footprint including designated access routes and parking areas communicated.	• Construction site plan showing all approved access areas.	• Review of construction site plan.	n/a	• Monthly.
Prevent unauthorised impacts to groundwater levels and groundwater quality.	Audits against requirements of licences (26D and 5C)	• Audit reports	• Audits	n/a	• As per license requirement
	Site inspections for compliance with water quality protection notes	• Monthly site inspections.	• Written records. • Visual inspection	n/a	• Monthly.
Avoid indirect impacts to groundwater dependent vegetation.	GSWOS prepared and approved by the Minister for the Environment.	• Record of Minister for the Environment approval of GSWOS.	• Review of written records.	N/A	• Prior to commencement of proposed action.
No introduction or spread of declared weeds, WONS or serious environmental weed species into surrounding	Stated requirements in relation to weed management implemented.	• Monthly site inspections.	• Visual inspection, pedestrian walkthrough (monthly);	Disturbance footprint and surrounds.	Monthly during construction; and For 3 years post-construction.

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
native vegetation adjacent to the development envelope during and attributable to construction.			• Photographic record, GPS of non-conformance; • Weed monitoring to be undertaken along the edge of the road reserve annually post-construction for a period of 3 years. • Weed monitoring reports. • Records of topsoil segregation and burial or licensed waste facilities; and • Records verifying plant and machinery arriving on site is clean.		
Construction – All EPBC Act listed threatened species					
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	A list of local wildlife rescue organisations and carers is on site at all times.	• Monthly inspection.	• Visual inspection.	n/a	n/a
	All fauna fatalities that occur as a result of the construction of the	• Routine inspections.	• Visual inspection	Construction site.	Opportunistic.

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
	Proposed Action will be recorded as an environmental incident through Main Roads EQSafe system.				
	No incidents of speeding within the construction site boundary.	• Visual monitoring by all construction personnel • Incident reporting (EQSafe).	• Visual inspection.	• Construction site.	• Opportunistic.
	Induction material includes required information	• Review of induction material • Inspection of induction records.	• Review of written records.	n/a	• Monthly.
	Construction camp waste including food waste will not be dumped. Waste will be appropriately segregated and contained, including use of lids that cannot be removed by fauna.	• Monthly inspection • Waste disposal records.	• Visual inspection • Review of waste disposal records.	n/a	• Monthly.
	GSWOS prepared and approved by the Minister for the Environment.	• Record of Minister for the Environment approval of GSWOS.	• Review of written records.	N/A	• Prior to commencement of proposed action.

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
Construction - Northern Quoll management measures					
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	No clearing of habitat critical to the survival of the Northern Quoll occurs between 1 April and 30 September.	• Monthly site inspections.	• Visual inspection. • Review of written records.	• Habitat critical to the survival of the Northern Quoll.	• Monthly.
	No clearing to be undertaken in critical habitat until surveys confirm species is not present in the area to be cleared.	• Records of pre-clearance surveys.	• Visual inspection.	• Habitat critical to the survival of the Northern Quoll.	• Two weeks prior to clearing commencing.
	Induction material contains required information.	• Review of contractor induction material.	• Review of written records.	N/A	• Monthly.
Construction - Pilbara Leaf-nosed Bat and Ghost Bat management measures					
Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.	Induction material contains required information.	• Review of contractor induction material.	• Review of written records.	N/A	• Monthly.
Avoid impacts to roosting caves utilised by Ghost Bats.	Drawings including no-go zones provided to Construction Contractor Representative.	• Record of provision of drawings showing no-go zones.	• Pre-construction review.	N/A	• Prior to construction.

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
	All no-go zones clearly marked out on site.	• Incident reporting (EQSafe). • Monthly site inspections.	• Review of written record • Visual inspection. • Photographic record, GPS of non-conformance.	• Important Pilbara Leaf-nosed Bat. Important Ghost Bat habitat.	• Prior to commencement of clearing. • Monthly.
	Noise and Vibration Management Plan approved by DCCEEW.	• Record of DCCEEW approval of Noise and Vibration Management Plan.	• Review of written records.	N/A	• Prior to blasting occurring within 400 m of a cave with evidence of Ghost Bat usage.
	PPV as measured during blasting at caves with evidence of Ghost Bat usage exceeds threshold level. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DCCEEW to ensure no impact to any cave being used by Ghost Bats.	• Monitoring of PPV during blasting at caves with evidence of Ghost Bat usage.	• A minimum of two blast vibration monitors. • Detailed monitoring method to be outlines in the noise and vibration management plan.	• Caves with evidence of Ghost Bat usage	• Every blast within 400 m of a cave with evidence of Ghost Bat usage.
	All identified Ghost Bat roosts recorded in database and mapped on all construction plans.	• Monthly site inspections.	• Review of written records.	N/A	N/A

Management Objective / Desired Outcome	Performance Target/Completion Criteria	Monitoring/Reporting Activity	Monitoring Method	Monitoring Area	Frequency
	Database is accessible to all site personnel.				
	Contractor method statement includes confined blasting technique.	• Review of contractor method statement. • Monthly inspection.	• Review of method statement.	N/A	• Prior to commencement of blasting
Operations – All EPBC Act listed threatened species					
Minimise injury or mortality to EPBC listed threatened species during operation.	Design documents include fauna friendly signage.	• Pre-construction design reviews. • Post-construction as built reviews against the design.	• Design review • Visual inspection.	N/A	• Pre and Post construction.
	Design documents include requirement of devices such as, discs on the top wire of fencing.				

3.6 Revegetation / rehabilitation

Main Roads will re-establish pre-existing native vegetation on cleared areas not required for ongoing road usage.

Vegetation clearing for laydown and stockpile areas, site offices and other temporary purposes (approximately 100 ha) will be rehabilitated using locally native species, which will be formulated to reflect the surrounding vegetation, be characteristic of significant fauna habitat.

Revegetation along the development envelope will comply with *MRWA Vegetation Placement within the Road Reserve Doc. No. 6707/022* (Main Roads, 2013, Appendix 3). This guide defines the recommended setbacks and clearance requirements that apply to all revegetation or landscaping associated with new road construction.

Re-vegetation activities will target the establishment of native vegetation cover greater than 50%.

The following measure will be undertaken to achieve this target:

- rehabilitation will be planned as part of the initial clearing works in order to identify:
  - requirements for suitable plant and equipment;
  - suitable topsoil for re-use;
  - suitable areas for soil and vegetation storage; and
  - the need for seed collection.
- topsoil will be scraped and stockpiled for reuse in the revegetation of temporary construction and laydown areas following completion of construction;
- native vegetation in areas to be cleared will be stripped off using a bulldozer with rake blade (or similar) and stockpiled for reuse;
- compacted areas will be ripped prior to seeding/planting to provide an area of seed/seedling establishment and improve infiltration;
- topsoil will be applied to areas requiring rehabilitation as soon as reasonably practicable;
- topsoil will be respread as evenly as practicable to an optimum depth of 50 mm;
- vegetation will be respread over the topsoil as evenly as practicable;
- revegetation of temporary construction laydown areas will use seed stock in stockpiled topsoil;
- for each site to be rehabilitated a reference site is to be established for comparison against the rehabilitation. This can be established either through a baseline survey of the vegetation prior to clearing, or a reference site within 100 m of the clearing area;
- monitoring of rehabilitated areas to be undertaken at a six-monthly interval for the first year following completion of construction, and then annually for the following two years; and
- undertaking of corrective actions to improve vegetation quality within the revegetated areas, within three months of becoming aware that an area of revegetation no longer meets the completion criteria of >50% native vegetation cover; corrective actions may cease once the completion criteria have again been achieved.

4 PROPOSED OFFSETS STRATEGY

4.1 Background

The Australian Government's EPBC Act Environmental Offset Policy (DSEWPaC, 2012a) define offsets as "*measures that compensate for the residual adverse impacts of an action on the environment*". The policy states that "*offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant*".

It is noted that the Proposed Action also requires assessment under the State EP Act and is subject to the WA Government's Environmental Offset Policy (GoWA, 2011).

Main Roads propose to offset significant residual impacts resulting from the Proposed Action via the Pilbara Envronmental Offsets Fund.

4.2 Significant Residual Impacts

The significant residual impacts of the Proposed Action are:

- clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll (refer to Table 2-3 of details of the assessment of this impact);
- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021a).

4.3 Pilbara Conservation Strategy and Pilbara Environmental Offsets Fund

The WA Government has released the Pilbara Conservation Strategy which outlines a landscape-scale approach to biodiversity conservation across the Pilbara region and provides strategic direction for conservation actions that may be funded from a variety of sources including through offsets to counterbalance the residual impacts of infrastructure projects (DPAW, 2017). The top four outcomes that will be delivered through the Pilbara Conservation Strategy are (DPAW, 2017):

1. Landscape-scale conservation through improved management of key threats;
2. Improved condition of threatened and other important species and communities;
3. Evidence-based conservation management; and
4. Conservation through partnerships.

Of these outcomes, "*Improved condition of threatened and other important species and communities*" is of particular relevance to the Proposed Action and the predicted significant residual impacts resulting from clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll. The Pilbara Conservation Strategy specifically notes the Northern Quoll as one of the species that is the focus of this objective (DPAW, 2017).

The Pilbara Conservation Strategy also outlines a number of priority areas that will be the focus of the project implemented to meet the objectives of the Strategy. One of these priorities is referred

to as “Karijini restoration” which includes actions to that will help restore the central Hamersley Range and enhance biodiversity and ecosystem resilience. These actions include (DPAW, 2017):

- eradicating or controlling feral herbivores;
- controlling feral cats;
- removing priority weeds from high value assets;
- managing fire through prescribed burning;
- undertaking research to address key knowledge gaps; and
- establishing a wildlife sanctuary within Karijini National Park.

The central Hamersley Range, encompassing Karijini National Park, adjacent pastoral leases and unallocated Crown land, comprises a variety of ecosystems that support threatened species, including the Northern Quoll. A portion of the Proposed Action lies within the Hamersley Range.

In July 2016, the WA Government approved the establishment of the Pilbara Strategic Conservation Initiative, now known as the Pilbara Environmental Offsets Fund (the ‘fund’), to maximise the value of environmental offsets from projects in the Pilbara (DPAW, 2017). The fund facilitates the coordinated delivery of environmental offset projects within the Pilbara bioregion of WA. The fund was established to invest in strategic conservation projects in the Pilbara bioregion to improve vegetation and species habitat impacted by development. The fund combines money from individual offset payments required under the WA EP Act and the EPBC Act into a special purpose account. This enables the delivery of larger and more strategic landscape-scale projects than would occur if individual offset projects were delivered independently, leading to better biodiversity conservation outcomes (DWER, 2019). Projects funded by the fund address the priorities of the Pilbara Conservation Strategy described above (DPAW, 2017).

On 19 November 2020, a Memorandum of Understanding (MOU) was established between the WA and Commonwealth governments to enable the fund to receive money required as a condition under Part 9 or 10 of the EPBC Act. Under the MOU, the Commonwealth Minister for the Environment, or their delegate, will consider the use of the fund to achieve and offset on a case-by-case basis. In each case, they will consider whether the fund has the appropriate mechanisms in place to ensure the successful delivery of the offset in accordance with the conditions of approval, the EPBC Environmental Offsets Policy and commitments in the MOU (DAWE, 2020).

Main Roads recognises that the effective implementation of offsets in the Pilbara is hampered by the region’s unique land tenure (being all crown land with overlapping mining, native title and pastoral interests). This makes traditional land acquisition and access for on-ground offset activities difficult. The fund was established to overcome these barriers and as such, Main Roads proposes to use the fund to counterbalance the Proposed Action’s significant residual impacts. Table 4-1 outlines how the use of fund is consistent with the Principles of the EPBC Act Environmental Offsets Policy.

Table 4-1 Principles of EPBC Act Environmental Offsets Policy

PRINCIPLE	HOW ADDRESSED BY PROPOSED OFFSET STRATEGY
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter.	Provision of funding to the fund as part of the proposed offset strategy will be used in priority areas such as the "Karijini restoration" which includes actions that will help restore the central Hamersley Range and enhance biodiversity and ecosystem resilience. The Hamersley ranges supports the Northern Quoll and Ghost Bat and as such, enhancing its biodiversity and ecosystem resilience will result in an outcome that improves the viability of the Northern Quoll and Ghost Bat populations. The MOU between the WA and Commonwealth in relation to the fund means that all monies paid into the fund as a result of an EPBC Act condition of approval will be spent for the benefit of the relevant protected matter.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	The fund provides funding that is pooled with other offsets and used to implement direct offsets that address the priorities of the Pilbara Conservation Strategy.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	The offset rates paid to the fund are established by DWER and are '*based on the level of biodiversity protection in the region, and cumulative impacts to environmental values, including high quality vegetation and the conservation of significant-species habitat* (DWER 2019)'. These rates include base rates for good to excellent quality vegetation and 'higher rates' for specialised environmental values such as specialised fauna habitat. It is anticipated that the higher rate will apply given the intention to offset clearing of habitat critical to the survival of the Northern Quoll and habitat that is likely of high importance to Ghost Bats. As such, it is considered that the proposed offsets are proportionate to the level of statutory protection that applies to the protected matter.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter.	As discussed in Section 2.2.1, the residual impacts of the Proposed Action are expected to be limited to the loss of habitat critical to the survival of the Northern Quoll and foraging habitat of high importance to Ghost Bats, with no significant impacts occurring to the species itself. Given that the offsets rates paid to the fund are calculated on a per hectare basis, it is considered that this mechanism provides an offset that is proportionate in size and scale to the residual impacts on the protected matter.

PRINCIPLE	HOW ADDRESSED BY PROPOSED OFFSET STRATEGY
Suitable offsets must effectively account for and manage the risks of the offset not succeeding.	The funds approach of combining money from offsets under the EP Act and EPBC Act to deliver larger and more strategic landscape-scale projects than would occur if individual offset projects were delivered independently, effectively manages the risk of offsets not succeeding when compared to smaller individual offset projects implemented by Proponents. The benefit of contributing to strategic landscape-scale projects also includes the opportunity to achieve net ecological gain due to a coordinated approach and the ability to achieve positive biodiversity outcomes on a large scale outside of the project's disturbance footprint.
Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.	The proposed offsets are additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable.	The fund has an Implementation Plan which outlines the criteria that are used to select projects that are supported through the fund. These criteria include (DWER, 2019): "Be designed to align with the offset principles of the WA and Australian governments and the implementation principles in Chapter 2 (of the Implementation Plan) so that the outcomes of projects: • tangibly and measurably improve environmental matters • are value for money and have a high chance of success • are strategic and have landscape-scale outcomes where achievable • are long term and enduring (ideally outcomes will endure for at least 20 years) • are additional to activities that are already required as a condition of approval or lease or a legislative requirement.
Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	The fund has a Governance Framework which establishes transparent decision-making processes, clarity of roles and responsibilities, and guidance for project delivery. The funds Implementation Plan which sets the funds strategic focus for a five-year period. The Implementation Plan defines the process to plan, implement, monitor, evaluate and improve delivery of projects and the fund over time (DWER, 2019).

4.4 Implementation

Implementation of the proposed offset approach will be in accordance with the MOU between the WA and Commonwealth Governments. It is envisaged that the conditions of any approval of the Proposed Action under the EPBC Act will specify the requirement for Main Roads to contribute to the fund.

Impact Reconciliation Reports (IRR) will then be submitted biennially (from the time of approval of the Proposed Action). The IRR will advise DCCEEW on the amount of clearing that has been undertaken within each year of the biennial reporting period. This clearing is then used to define the amount to be contributed to the fund for areas cleared during the reporting period. The contribution will be based on a $/ha basis using the rate that DCCEEW uses to offset residual significant impacts on MNES being:

- Habitat critical to the survival of a species - $3,306/ha
- Supporting habitat- $1,653/per ha.

4.5 Offsets Fund Contribution

Table 4-2 provides a summary of the proposed offset contribution based on the assessed significant residual impacts and DCCEEW residual impact offset rates. This is based on estimated clearing, and it is noted that the the financial contribution will be based on actual clearing, and this can only be calculated after clearing has been conducted.

Table 4-2 Significant residual impacts requiring an offset

MNES Habitat	Clearing	Contribution	Offset rate
Habitat Critical to the Survival of the Northern Quoll	Up to 4.0 ha	$3,306 /ha	$3,306/ha for 4.0 ha = $13,224
Supporting habitat comprising important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats	Up to 48.4 ha of supporting habitat comprising: • 12.6 ha of habitat that represents supporting habitat for both Northern Quoll (foraging and dispersal) and Ghost Bat (foraging). • 29.7 ha of habitat that represents supporting habitat for Northern Quoll (foraging and dispersal) only. • 6.1 ha of habitat that represents supporting habitat for Ghost Bat (foraging) only.	$1,653/ha	$1,653/ha for 48.4 ha = $80,005
Total			$93,229

5 ECONOMIC AND SOCIAL MATTERS

5.1 Financial investment

The total project funding is approximately $260 million. The Australian Government has committed approximately 80% funding to the project while the State of WA has committed approximately 20%.

5.2 Stakeholder Consultation

Stakeholder consultation about the Proposed Action commenced in 2019 and will continue throughout the project life. A Community and Stakeholder Engagement Strategy (CSES) has been prepared to guide consultation for the project and will remain a live document as the project progresses. The CSES outlines the likely level of community interest and the potential stakeholder groups. Objectives of the CSES are:

- generate awareness of and support (where possible) for the project;
- provide opportunity for stakeholders to input into the project, identifying stakeholder aspirations, opportunities and concerns with the project;
- use stakeholder input to guide project decision making; and
- obtain stakeholder buy-in to the design and construction methodology, ensuring where possible that the project addresses concerns, and if not, explain why not.

Stakeholders for the Proposed Action have been identified through a review of the previous road stage upgrades, consultation with the project team and through a Preliminary Sustainability Stakeholder Workshop held in 2019. A summary of the stakeholder engagement undertaken to date in relation to the Proposed Action is provided in Appendix 8.

5.3 Yindjibarndi and Wintawari people community consultation

The following consultation has been undertaken:

- Two meetings were held with the Yindjibarndi Aboriginal Corporation (YAC) on 13 November 2019 and 27 May 2020. The purpose of the meetings was to discuss the MRDH Stage 4 alignment corridor options with the YAC who are the representative body for the Yindjibarndi Native Title holders.
- Four meetings have been held with the Wintawari Guruma Aboriginal Corporation (WGAC) on 14 November 2019, 28 January 2020, 27 February 2020 and 08 May 2020. The purpose of the meetings was to discuss the MRDH Stage 4 alignment corridor options with the WGAC who are the representative body for the Yindjibarndi Native Title holders.
- One meeting was held with the Wintawari Guruma Traditional Owners on 27 February 2020. This meeting was held in conjunction with the meeting with WGAC on the same date.

Further details of these meetings are provided in Appendix 8.

5.4 Social and economic impacts and benefits

The Proposed Action will result in potential direct and indirect impacts social impacts (positive and negative) including historic and cultural, tourism and recreational, and amenity impacts.

The lack of a safe and time efficient transport option adversely affects the local residents and businesses of Karratha, Tom Price, and Paraburdoo. Completing the sealed link from Karratha to Tom Price will improve safety and transport network efficiency, and enable recreational, social and health benefits to be realised. The key benefits of the Proposed Action include:

- improved access to the popular Karijini National Park, helping boost tourist traffic in the heart of the Pilbara;
- travel time saving of over three hours compared to the alternative sealed route between Karratha and Tom Price;
- improved connectivity between regional towns within the Pilbara, including sporting and education opportunities;
- improved safety;
- better access to hospitals and medical services, local businesses, shopping and service centres;
- reduced maintenance and travel costs;
- improved regional tourism opportunities;
- more reliable journeys by reducing road closures, particularly during winter; and
- local and Yindjibarndi and Wintawari people employment and business opportunities during construction and operation.

Potential direct and indirect social impacts may result from the following activities associated with the Proposed Action:

- clearing for construction of the road and ongoing maintenance activities;
- clearing for associated construction activities such as site offices, laydown, side-tracks and other temporary purposes;
- construction of watercourse crossings;
- earthworks and materials haulage; and
- movement of construction vehicles and machinery around the site.

5.4.1 Yindjibarndi and Wintawari people heritage

The development envelope is located within two Native Title areas. The northern portion of the development envelope sits within Yindjibarndi Country while the southern portion is within Wintawari Guruma country. The Federal Court assessed the Native Title claims submitted by each group under the *Native Title Act* 1993 and determined that Native Title does exist in the claim areas. These determinations were made in 2005 and 2007 respectively.

Over 50 Yindjibarndi and Wintawari people heritage surveys have been undertaken across the general area of the Proposed Action since the 1970's. These have been undertaken for a range of proposed developments, including for the original Karratha – Tom Price Road State Proposal. Main

Roads will undertake additional Yindjibarndi and Wintawari people heritage surveys of the development envelope to adequately understand the cultural heritage of the area and to confirm the values present for the existing registered sites and identify any additional sites that may not have been found during previous surveys. The information gathered from this survey will be used to inform ongoing consultation with the Yindjibarndi and Wintawari Guruma Traditional Owners.

A search of the Department of Planning Lands and Heritage's Aboriginal Heritage Inquiry System (AHIS) database (DPLH, 2020) identified 32 registered sites within 2.5 km of the development envelope. The following sites overlap the development envelope:

- Site ID 17332: Horseshoe Bore 02 – Artefacts/Scatter;
- Site ID 17335: Mt Margaret 96-1 (Hamersley Plateau) – Modified Tree;
- Site ID 18173: Weelamurra Creek Ceremonial Ground - Artefacts / Scatter, Ceremonial and Historical site;
- Site ID 37670: Narraminju (Caves Creek) – Mythological site associated with Caves Creek and its tributaries; and
- Site ID 38183: Weelamurra Wuntu (Willamarranha, Wilumarra and Wirlumarra) – a complex of Ceremonial, Mythological, and Water Sources associated with Weelamurra Creek.

Potential impacts to Yindjibarndi and Wintawari people heritage from the Proposed Action have largely been assessed based on desktop review of available data and literature. Further Yindjibarndi and Wintawari people heritage surveys will be undertaken and will assist in identifying any management measures or design criteria that may be required to avoid or minimise impacts.

Some impacts to Yindjibarndi and Wintawari people heritage sites due to the Proposed Action may be unavoidable. Consultation with Traditional Owners has been and will continue to be undertaken during the design of the proposed changes in order to understand the values present and to minimise impacts where practicable. Should complete avoidance of sites not be achievable a Section 18 notice under the WA *Aboriginal Heritage Act* 1972[4] will be submitted. Initial consultation has resulted in changes to the alignment to avoid areas of particular significance to the Traditional Owners.

5.4.2 Historic Heritage

There are no known historic heritage places within the development envelope listed on either the State Heritage List, National Heritage lists, or local Municipal heritage lists.

5.4.3 Tourism and recreation

The Proposed Action will complete the sealed link between Karratha and Tom Price providing crucial connectivity between these centres, as well as access to significant tourism destinations and mine sites in the region.

[4] Consent will be via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the *Aboriginal Cultural Heritage Act 2021* post 22/12/2022. The finalised Aboriginal Cultural Heritage Management Plan will be provided to the DCCEEW

The nearest recreational or tourism areas are Millstream-Chichester National Park and Karijini National Park, 14 km and 18 km from the development envelope respectively. The Proposed Action will not result in any direct impact to either of these national parks and will improve access to the popular parks, helping boost tourist traffic in the heart of the Pilbara.

5.4.4 Amenity

The development envelope is located in a remote area and is not close to any towns, recreational/ tourism area or population centres. Hamersley Homestead is the closest residence to the development envelope.

Given the remote location of the development envelope, no significant impacts to amenity are anticipated. The Proposed Action has been developed to take into account requests from the owners of Hamersley Station to have the road deviate from the Rio Tinto Railway alignment in order to reduce impacts such as unwanted visitation once the road is opened to traffic. This will further minimise the potential for impacts to amenity at the homestead through noise and dust during construction.

6 ECOLOGICALLY SUSTAINABLE DEVELOPMENT

Section 3A of the EPBC Act defines the principles of ecologically sustainable development. Table 6-1 outlines how each of the five principles has been applied to the Proposed Action.

Table 6-1 EPBC Act Principles of Ecologically Sustainable Development

NO.	PRINCIPLE	CONSIDERATION OF PRINCIPLE IN THE PROPOSED ACTION
a)	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	A comprehensive route selection process has been undertaken for the Proposed Action, in compliance with the Infrastructure Sustainability Council of Australia's (ISCA) Planning Framework. By undertaking a multi-disciplinary approach to options evaluation, as outlined in the Options Assessment (Ecn-1) Economic theme of the framework, a genuine consideration of the associated social, economic and environmental aspects for each option has been undertaken. The option assessment framework in line with Ecn-2 Level 1 (valuing and considering externalities) and Ecn-3 Level 1 (equity and distributional impacts) which assess the impacts (costs and benefits) on society. The Proposed Action will be subject to an ISCA sustainability rating, which will assess the environmental, social and economic impacts of the Proposed Action, including its waste stream and the resources utilised for construction. The ISCA rating scheme is designed such that goals are established for a Proposal, then the Proposal is assessed against the achievement of those goals. Main Roads have established a sustainability charter for MRDH Stage 4, which includes commitments to use sustainability principles to guide decision-making throughout the project lifecycle, enhance biodiversity and maximise positive environmental outcomes and integrate sustainability into procurement, product life cycles and supply chains.
b)	If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	A wide range of comprehensive desktop and field studies have been undertaken within the development envelope to assess the impact of the Proposed Action. Studies undertaken include: • Protected matter searches • Flora and vegetation surveys (Appendix 4); and • Terrestrial fauna surveys (Appendix 4). Potential impacts are described within this document including potential impacts to matters protected by the EPBC Act. Information gathered during the studies has been used to inform the Proposed Action and has reduced any uncertainty surrounding prediction of impacts for the assessment. Main Roads has ensured that the Proposed Actions design (where possible) avoids serious or irreversible damage to the environment Mitigation and management measures have been proposed to ensure impacts are environmentally acceptable. This includes the development of targeted management plans.

NO.	PRINCIPLE	CONSIDERATION OF PRINCIPLE IN THE PROPOSED ACTION
c)	The principle of intergenerational equity That the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Proposed Action will ensure the health, diversity and productivity of the environment is maintained through retaining as much habitat as possible and by taking into account the minimisation of environmental impacts where practicable during design and construction of the road.
d)	The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Main Roads will seek to preserve as much of the biodiversity identified within the development envelope as possible by reducing clearing of native vegetation where practicable.
e)	Improved valuation, pricing and incentive mechanisms should be promoted	Main Roads acknowledges the need for improved valuation, pricing and incentive mechanisms and endeavours to pursue these principles when appropriate. For example, environmental factors will be considered in the determination of the location of the road alignment within the development envelope and there will be a strong focus on reducing the direct and indirect clearing footprint. Main Roads accepts that the cost of the Proposed Action must include environmental impact mitigation, management and maintenance activities. These requirements will be incorporated into the overall Proposed Action costs.

7 ENVIRONMENTAL RECORD OF THE PERSON PROPOSING TO TAKE THE ACTION

Main Roads is a State agency with an assured record of responsible environmental management and a certified environmental management system. Main Roads is not subject to any past or present proceedings under Commonwealth or State law for protection of the environment or conservation and sustainable use of natural resources.

All work undertaken by Main Roads is completed in accordance with their Environmental Policy and Environmental Management System (EMS), which is certified with the requirements of ISO 14001:2015 environmental management systems comprising 'Activities, products and services associated with delivering Road Management (planning, building and maintaining) on WA's State Road Network' (Certificate #MRWQ51-CCE04).

Main Roads' environmental policy can be found at: https://www.mainroads.wa.gov.au/OurRoads/Environment/Pages/environmentalmanagement.aspx#policy

Main Roads' EMS is independently certified and covers the processes and activities that have the potential to impact the environment, including mitigation and management measures proposed as part of the action. The EMS ensures compliance with Main Roads' environment and heritage compliance obligations, providing the framework for driving environmental requirements through leadership, planning, support, operation, performance evaluation and improvement actions. The action, therefore, will be undertaken, monitored and measured in accordance with the Main Roads EMS.

Main Roads EMS covers processes and activities that have the potential to impact on the environment and ensures compliance with environment and heritage compliance obligations. The EMS responsibilities includes appropriate resource allocation to ensure compliance costs are appropriately budgeted and assessed as part of the overall business case for the project. This ensures that the costs of proposed management measures and offsets is considered in the budget approvals and ensures compliance is appropriately funded and resourced.

8 OTHER APPROVALS AND CONDITIONS

Other than an approval under the EPBC Act, requirements for approval or conditions that apply, or that are likely to apply, to the Proposed Action include various approvals from WA state agencies. These have been outlined in the sections below.

8.1 *Environmental Protection Act 1986,* Part IV Environmental Impact Assessment

Main Roads referred Stages 2, 3 and 4 of the MRDH (then referred to as the Karratha – Tom Price Road) to the WA EPA, in September 1998, under section 38 of the Environmental Protection Act 1986 (EP Act). The EPA determined that the potential environmental impacts were sufficient to warrant formal assessment of the Proposal under the EP Act. In October 1998, the EPA determined the level of assessment for the Proposal to be a Consultative Environmental Review (CER – Assessment Number 1244). The CER was prepared by Main Roads and released for public review in January 2003. In January 2005, the EPA finalised its decision report and recommended conditional approval of the Proposal to the Minister for the Environment. Subsequent to this, the Proposal was granted conditional Ministerial approval via Ministerial Statement (MS) 677 in April 2005.

Given the alignment for Stage 4 is undergoing additional planning, stakeholder consultation and investigations to further refine the alignment, which is expected to differ from that originally proposed, Main Roads elected to refer Stage 4 of the MRDH under section 38 of the EP Act as a Revised Proposal. The Proposed Action is currently being assessed by the WA Environmental Protection Authority.

8.2 Other approvals and regulation

Following primary environmental approval of the Proposed Action under the EPBC Act and Part IV of the EP Act, additional regulatory approvals will be required to develop and operate the Proposed Action. These have been summarised in Table 8-1.

Table 8-1 Summary of other regulatory approvals that may be required

PROPOSED ACTIVITIES	TYPE OF APPROVAL	REGULATORY AGENCY	LEGALISATION REGULATING THE ACTIVITY
Interference with bed and banks of a watercourse or wetland (clearing of vegetation and construction works)	The Proposed Action will require modification to beds and banks associated with floodplains and drainage lines at various locations along the development envelope. This may include the construction of bridges for waterway crossings. A Permit to Interfere with the Bed and Banks of a Watercourse is, therefore, likely to be required.	WA Department of Water and Environmental Regulation (DWER)	*Rights in Water and Irrigation Act 1914* (RIWI Act)

PROPOSED ACTIVITIES	TYPE OF APPROVAL	REGULATORY AGENCY	LEGALISATION REGULATING THE ACTIVITY
Sourcing of construction water	Construction water will be sourced from existing bores as well as potential new bores.	DWER	RIWI Act
Disturbance of a registered Aboriginal heritage site	There are 32 registered Aboriginal Heritage sites, as defined by the WA *Aboriginal Heritage Act* 1972, within 2.5 km of the development envelope. As such, it is likely that a State *Aboriginal Heritage Act* 1972, Section 18 consent to disturb a Aboriginal Heritage site/s will be required[5]. Indigenous heritage surveys are currently being undertaken.	Department of Planning, Lands and Heritage (DPLH)	*Aboriginal Heritage Act 1972* (AH Act) *Aboriginal Cultural Heritage Act* 2021 (ACH Act)
Authorisation to take (flora and fauna) and modify (TEC) for the Proposed Action	An authorisation under the BC Act to take (flora and fauna) and modify an occurrence of a State listed TEC may be required.	Department of Biodiversity, Conservation and Attractions (DBCA)	BC Act

8.3 Planning approvals

The development envelope for the Proposed Action runs through the Coolawanyah and Hammersely (Rio Tinto) pastoral leases and is located near to a railway lease. The Proposed Action also traverses a number of mining leases, as well as the following reserves:

- 38991 (Millstream Water Reserve) – owned by the Water and Rivers Commission (DWER) and Water Corporation
- 40743 (repeater station) – owned by Australian Telecommunications Commission (Telstra)
- 39013 (repeater station) – owned by Australian Telecommunications Commission (Telstra)
- 27915 (Resting Place) - owned by DPIRD.

Stakeholder consultation has been undertaken with the respective land/lease-holders.

[5] Consent will be via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the ACH Act post 22/12/2022

9 RELEVANT POLICIES AND PUBLICATIONS

An assessment of the potential impacts to the Northern Quoll against the key threats identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' is outlined in Table 9-1. Based on this assessment it is considered that the Proposed Action is not inconsistent with the objectives of the recovery plan.

The following Threat Abatement Plans has been identified as being relevant given the potential threats identified for the EPBC Act listed threatened species that have been identified as known or likely to occur in the development envelope. An assessment of the Proposed Action in the context of these threat abatement plans is provided in Table 9-1.

- Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses (DSEWPaC, 2012b);
- Threat abatement plan for predation by feral cats (DoE, 2015);
- Threat abatement plan for predation by the European red fox (DEWHA, 2008); and
- Threat abatement plan for competition and land degradation by rabbits (DoEE, 2017).

Based on this assessment it is considered that the Proposed Action is not inconsistent with the threat abatement plans.

It is noted that while the *Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads* is identified as being relevant to Northern Quolls, cane toads are yet to reach the part of Australia where the Proposed Action will be undertaken and as such is not addressed here.

Main Roads confirmed that the following conservation advices have been considered in relation to protected matters that do not have recovery plans. It is noted that there is no approved conservation advice for the Northern Quoll.

- Conservation Advice *Rhinonicteris aurantia* (Pilbara form) (Pilbara Leaf-nosed Bat);
- Conservation Advice *Macroderma gigas* Ghost Bat;
- Approved Conservation Advice for *Liasis olivaceus barroni* (Olive Python - Pilbara subspecies);
- Conservation Advice *Pezoporus occidentalis* Night Parrot;
- Conservation Advice *Falco hypoleucos* Grey Falcon; and
- Approved Conservation Advice for *Seringia exastia* (Fringed Keraudrenia).

Table 9-1 Relevant Recovery Plans and Threat Abatement Plans

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
Northern Quoll	'National Recovery Plan for the Northern Quoll *Dasyurus hallucatus'*.		
	1	Cane toads	Cane toads are not present within the Pilbara however the Proposed Action has the potential to increase access to such species if they are introduced in future.
	2	Feral predators	Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' (Hill and Ward 2010). The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase impacts due to background levels of invasive species.
	3	Inappropriate fire regimes	The Proposed Action is not expected to exacerbate this threat. There is considered to be a low risk of accidental fire as a result of construction activities.
	4	Disturbance from artificial light	The Proposed Action is not expected to exacerbate this threat. While there is no permanent lighting associated with the Proposed Action, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long periods of time and will be moved along the construction area as dictated by the construction schedule. Fauna (such as Northern Quolls) may be attracted to light sources due to the concentration of insects in well-lit areas. These temporary light emissions have the potential to result in behavioural responses in Northern Quolls. These impacts are expected to be limited to temporary avoidance of the illuminated areas previously used for foraging or

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
			changes to prey item (insects) aggregation resulting in changes to foraging behaviour. Given the temporary and localised nature of the light emissions and resultant minor behavioural changes, these impacts are not expected to be significant.
	5	Habitat degradation	The field survey (Biota, 2021a) identified five habitat types that may be utilised by the Northern Quoll as shown in Figure 13. Up to 178.3 ha of potential Northern Quoll denning, foraging and dispersal habitat will be cleared for the Proposed Action. This includes clearing of up to 4.0 ha of rocky areas which is a habitat type identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' as habitat critical to the survival of the Northern Quoll as they are used as denning and refuge sites (Hill and Ward 2010). A breakdown of clearing per habitat type is provided in Table 2-2. As described in Section 2.2.1.1, it is likely that the clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll and up to 42.3 ha of foraging and dispersal habitat within 1 km of habitat critical to the survival of the Northern Quoll will result in a significant residual impact on local Northern Quoll populations. However, given the relatively small amount of critical habitat and other suitable Northern Quoll habitat to be cleared compared to the regionally available habitat (>8.7 million ha), it is not predicted that this clearing will result in a decline in population of Northern Quolls or interfere with the species recovery. As such, it is considered that this clearing required for the Proposed Action is not inconsistent with the objectives of the recovery plan.
	6	Habitat destruction	
	7	Weeds	The Proposed Action is not expected to exacerbate this threat. The weeds of particular concern for the Northern Quoll (gamba grass and mission grass) are not found within the development envelope. Potential

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
Northern Quoll			impacts to the Northern Quoll from weed species as a result of the Proposed Action are not predicted to be significant due to the planned mitigation measures and the relatively high background level of weeds in the area. The absence of gamba grass and mission grass further support this conclusion.
	8	Disease	The Proposed Action is not expected to exacerbate this threat. The 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' references the potential for disease to impact Northern Quolls but does not raise any specific diseases as being of particular threat. There is no credible impact pathway associated with the Proposed Action that could result in the introduction of a disease that may cause a decline in the Northern Quoll population.
	9	Hunting	The Proposed Action is not expected to exacerbate this threat. No firearms will be allowed on site during the construction phase.
	10	Population isolation	The Proposed Action is not expected to exacerbate this threat. Given the narrow width of the road, and the low traffic volume expected, the road will not provide a barrier that cannot be crossed by fauna (with the exception of some small stretches that access maybe restricted due to steep slope created where material had to be cut to construct the road). As such, it is not predicted that the Proposed Action will result in the isolation of a Northern Quoll populations.
	Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses (DSEWPaC, 2012b)		
	1	Develop an understanding of the extent and spread pathways of infestation by the five listed grasses	The Proposed Action has no relation and will not be inconsistent with this objective.

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
Northern Quoll, Ghost Bat, Night Parrot	2	Support and facilitate coordinated management strategies through the design of tools, systems and guidelines	The Proposed Action has no relation and will not be inconsistent with this objective.
	3	Identify and prioritise key assets and areas for strategic management	The Proposed Action has no relation and will not be inconsistent with this objective.
	4	Build capacity and raise awareness among stakeholders	The Proposed Action has no relation and will not be inconsistent with this objective.
	5	Implement coordinated, cost-effective on-ground management strategies in high-priority areas	The Proposed Action has no relation and will not be inconsistent with this objective.
	6	Monitor, evaluate and report on the effectiveness of management programs.	The Proposed Action has no relation and will not be inconsistent with this objective.
	Threat abatement plan for predation by feral cats (DoE, 2015)		
	1	Effectively control feral cats in different landscapes	The Proposed Actionwill not be inconsistent with this objective. The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Proposed Action. However, the Proposed Action is not likely to significantly increase impacts due to background levels of invasive species.

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
	2	Improve effectiveness of existing control options for feral cats	The Proposed Action has no relation and will not be inconsistent with this objective.
	3	Develop or maintain alternative strategies for threatened species recovery	The Proposed Action has no relation and will not be inconsistent with this objective.
	4	Increase public support for feral cat management and promote responsible cat ownership	The Proposed Action has no relation and will not be inconsistent with this objective.
Ghost bat, Night Parrot	Threat abatement plan for predation by the European red fox (DEWHA, 2008)		
	There are no specific objectives identified with the abatement plan. The Proposed Action is not expected to result in the introduction or to significantly increase the number of foxes in the development envelope and surrounding area and as such is not considered to be inconsistent with the threat abatement plan		
Night Parrot	Threat abatement plan for competition and land degradation by rabbits		
	1	Strategically manage rabbits at the landscape scale and suppress rabbit populations to densities below threshold levels in identified priority areas	The Proposed Action has no relation and will not be inconsistent with this objective.
	2	Improve knowledge and understanding of the impact of rabbits and their	The Proposed Action has no relation and will not be inconsistent with this objective.

EPBC ACT LISTED	RECOVERY PLAN THREATS / THREAT ABATEMENT PLAN OBJECTIVES		Response
		interactions with other species and ecological processes	
	3	Improve the effectiveness of rabbit control programs	The Proposed Action has no relation and will not be inconsistent with this objective.
	4	Increase engagement of, and awareness by, the community of the impacts caused by rabbits, and the need for integrated control	The Proposed Action has no relation and will not be inconsistent with this objective.

10 INFORMATION SOURCES

The reliability and uncertainties in the technical studies undertaken in preparation of the Proposed Action have been outlined in Table 10-1.

Table 10-1 Technical studies undertaken in preparation of the Proposed Action

REFERENCE SOURCE	RELIABILITY	UNCERTAINTIES
Biota, 2021a. Manuwarra Red Dog Highway Stage 4 Biological Survey. Biota Environmental Sciences Pty Ltd. Biota 2021b. Manuwarra – Red Dog Highway Stage 4 MNES Fauna Habitat Quality Assessment. Biota Environmental Sciences Pty Ltd. Report prepared for Main Roads Western Australia	Information is reliable.	There are no significant uncertainties associated with this report. No limitations were identified for this survey (as detailed in Section 4.15 of the report in accordance with EPA Technical Guidance for flora and vegetation surveys and terrestrial vertebrate fauna surveys).
Ecologia Environment, 2018. Karratha-Tom Price Road and Pannawonica-Millstream Road Weed Survey. Perth, WA.	Information is reliable.	There are no significant uncertainties associated with this report. It is noted that the study included only the northern section of the development envelope.
GHD, 2017. Karratha Tom Price Road (K-TP3 and K-TP4a to Rio Access) Northern Quoll Survey. Perth, WA.	Information is reliable.	There are no significant uncertainties associated with this report.

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12 FIGURES

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DAMPIER
KARRATHA
ROEBOURNE
Harding River
STAGE 2 COMPLETED 90km
Millstream Chichester National Park
STAGE 3 COMPLETED 48km
Sherlock River
STAGE 4 PROPOSED 112km
Fortescue River
Robe River
Weelumurra Creek
Caves Creek
Serpentine Creek
Duck Creek
Barnett Creek
STAGE 1 COMPLETED 25km
Hardey River
Karijini National Park
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Figure 1 Manuwarra Red Dog Highway Project Overview

Legend

- Major Roads
- Rivers and Creeks
- DBCA Legislated Lands and Waters (National Parks)

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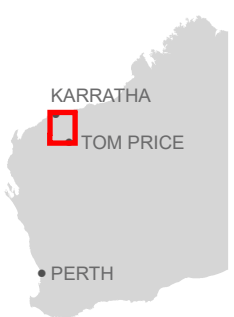

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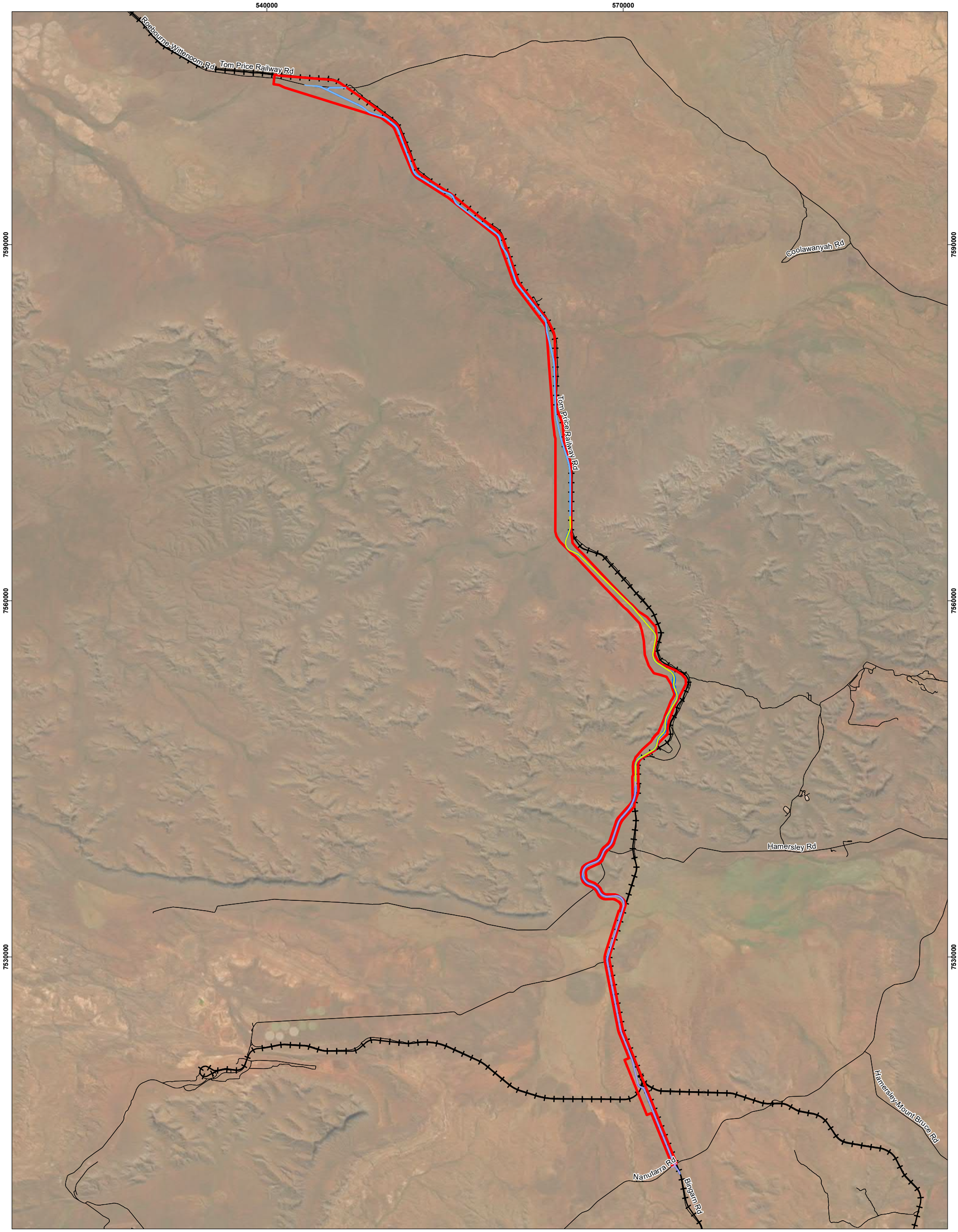

Figure 2 Proposed Action Location Layout Plan

Legend

- Coolawanyah Section
- Hamersley Section
- Tom Price Section
- Roads
- Railways
- Disturbance Footprint
- Development Envelope

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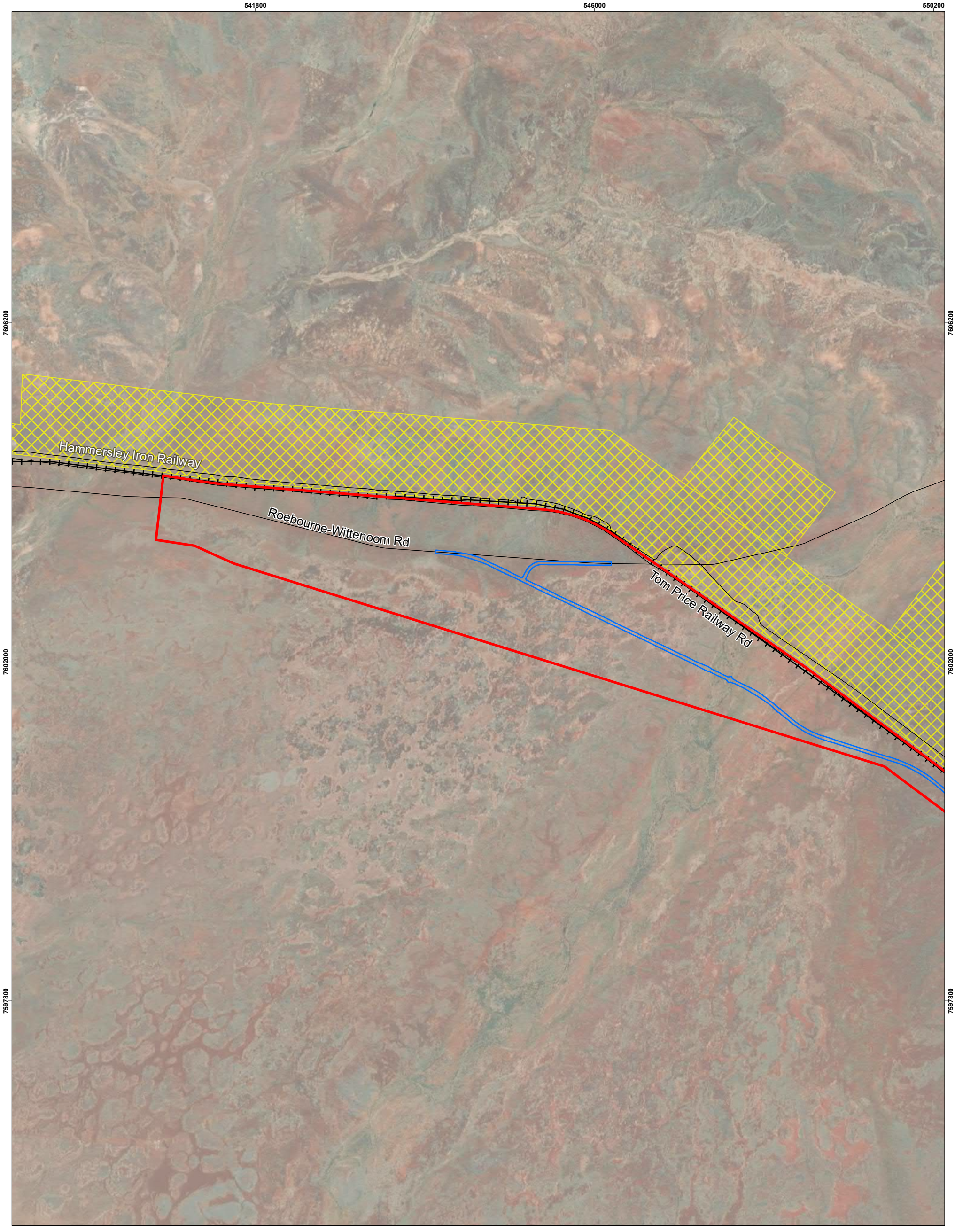


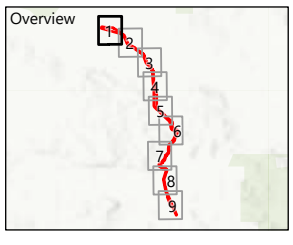
Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope

Mining Tenements

- Miscellaneous License



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Tom Price Railway Rd

Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

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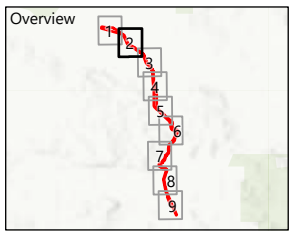
- Exploration License



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Hammersley Iron Railway
Tom Price Railway Rd
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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

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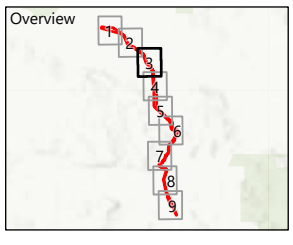

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Miscellaneous License
- Exploration License

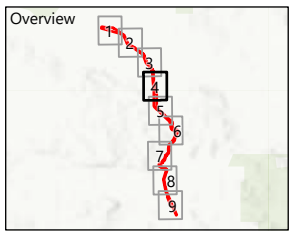

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Miscellaneous License
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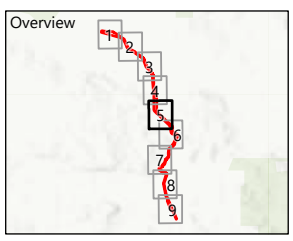

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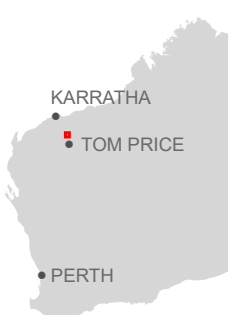

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Miscellaneous License
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- Mining Lease

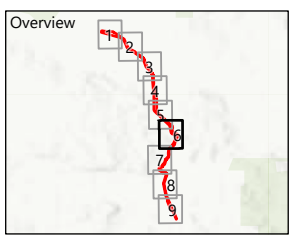

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Miscellaneous License
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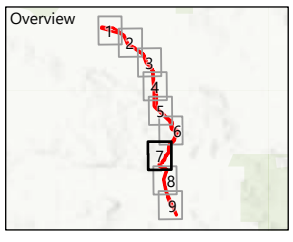

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Prospecting License
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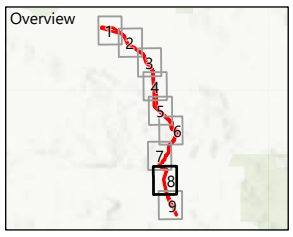

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Figure 3 Pastoral Leases and Mining Tenements

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Pastoral Leases

Mining Tenements

- Miscellaneous License
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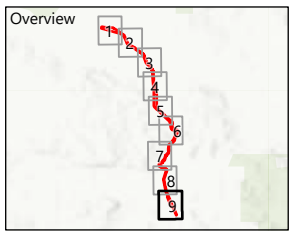

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Millstream Rd
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Roebourne-Wittenoom Rd
Coolawanyah Rd
Tom Price Railway Rd
Hamersley Rd
Nanutarra Rd
Karijini National Park
Hamersley Iron Railway
Bingarn Rd
Hamersley-Mount Bruce Ro
Karijini Dr
Nameless Valley Dr
Karijini National Park

Figure 4 Crown Reserves and Conservation Estates

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope
- Crown Reserve Land
- DBCA Legislated Lands and Waters (National Parks)
- DBCA Lands of Interest (Unallocated Crown Land)

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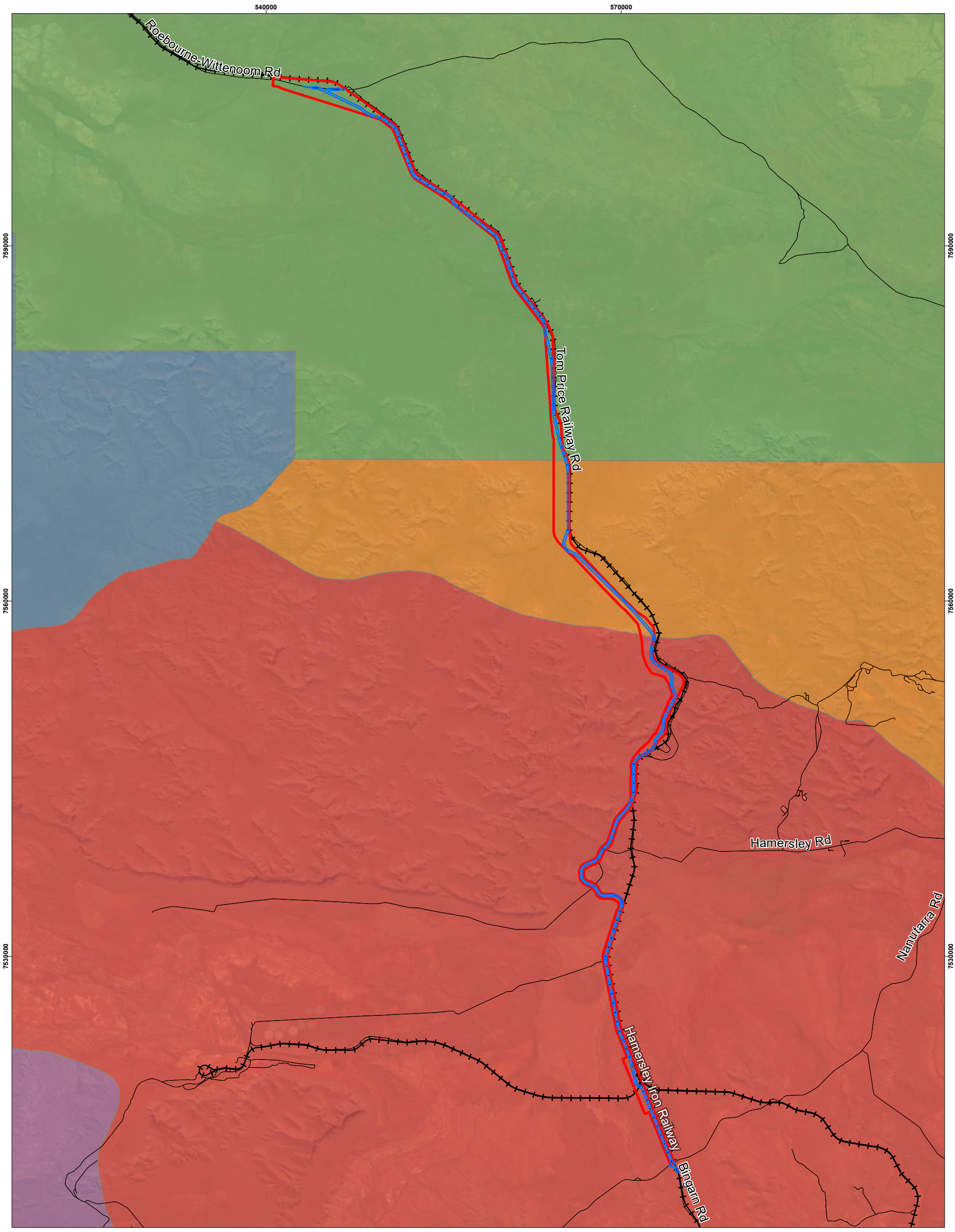

Figure 5 Native Title Boundaries

Legend

- Roads
- Railways
- Disturbance Footprint
- Development Envelope

Native Title Determination

- Eastern Guruma
- Kuruma Marthudunera (Part A)
- Ngarluma / Yindjibarndi
- Puutu Kunti Kurrama and Pinikura
- Yindjibarndi #1

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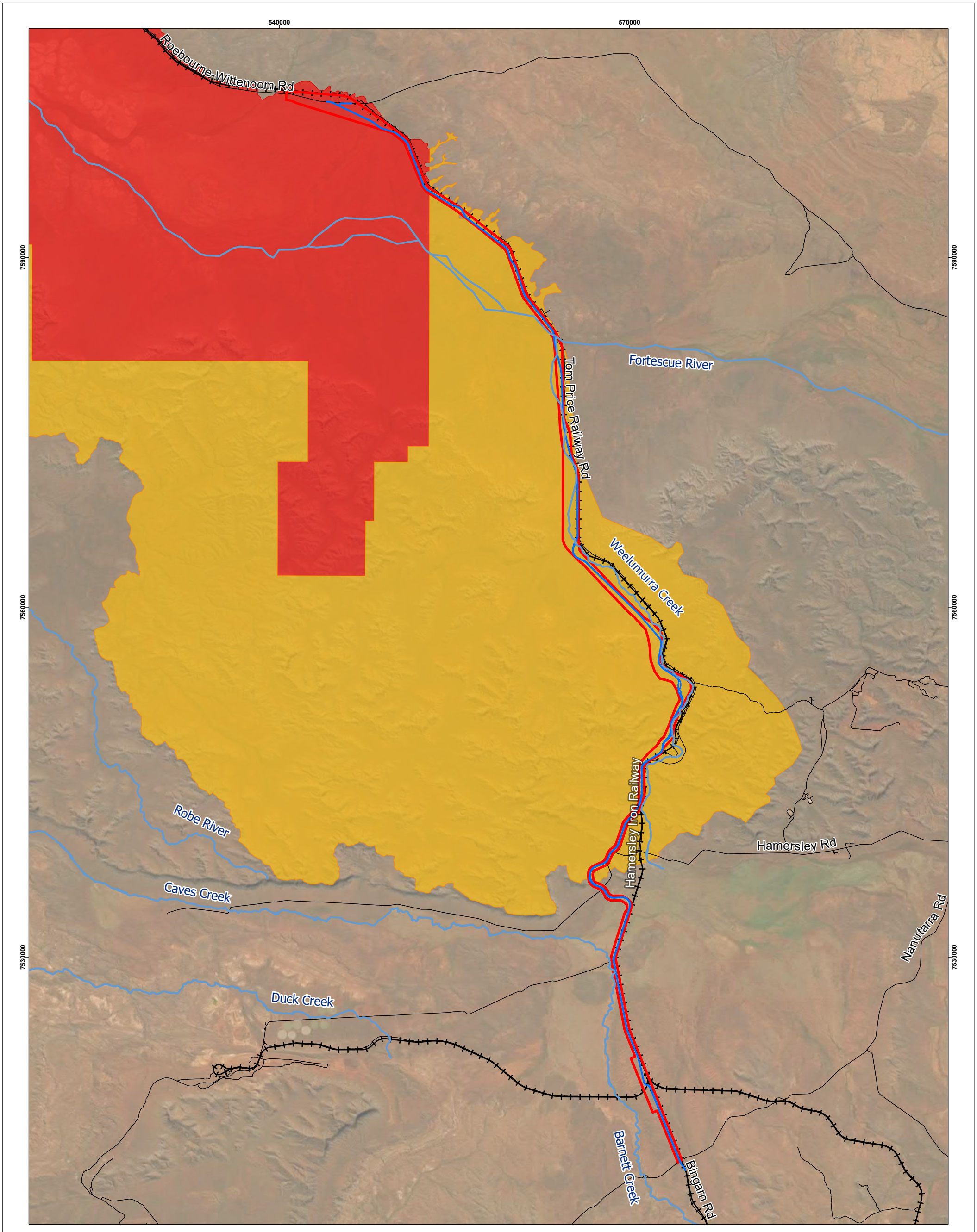

Figure 6 Surface Water Features and Public Drinking Water Source Areas

Legend

- Roads
- Railways
- Rivers and Creeks
- Disturbance Footprint
- Development Envelope

Public Drinking Water Source Areas (DWER-033)

- Priority 1 Drinking Water Source Area
- Priority 2 Drinking Water Source Area

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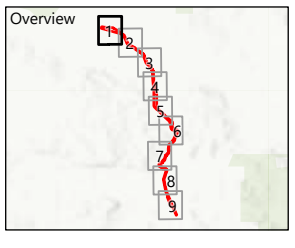
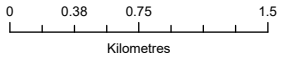
Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope





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Hammersley Iron Railway

Tom Price Railway Rd

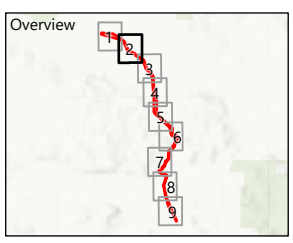
Pre-European Vegetation (DPIRD-006)

- Chichester Plateau 607
- Chichester Plateau 641
- Chichester Plateau 646
- Fortescue Valley 629
- Fortescue Valley 641
- Hammersley 175
- Hammersley 644

Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope



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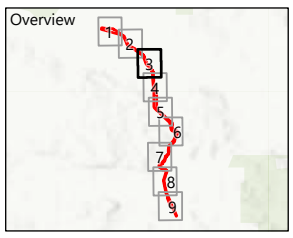
Pre-European Vegetation (DPIRD-006)

- Chichester Plateau 607
- Chichester Plateau 641
- Fortescue Valley 175
- Hammersley 175
- Hammersley 644

Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope



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Tom Price Railway Rd

Hammersley Iron Railway

Pre-European Vegetation (DPIRD-006)

- Fortescue Valley 175
- Hammersley 175
- Hammersley 565
- Hammersley 644
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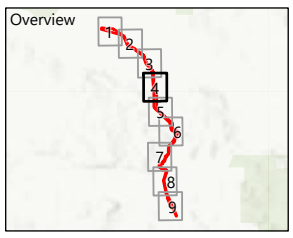
Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope



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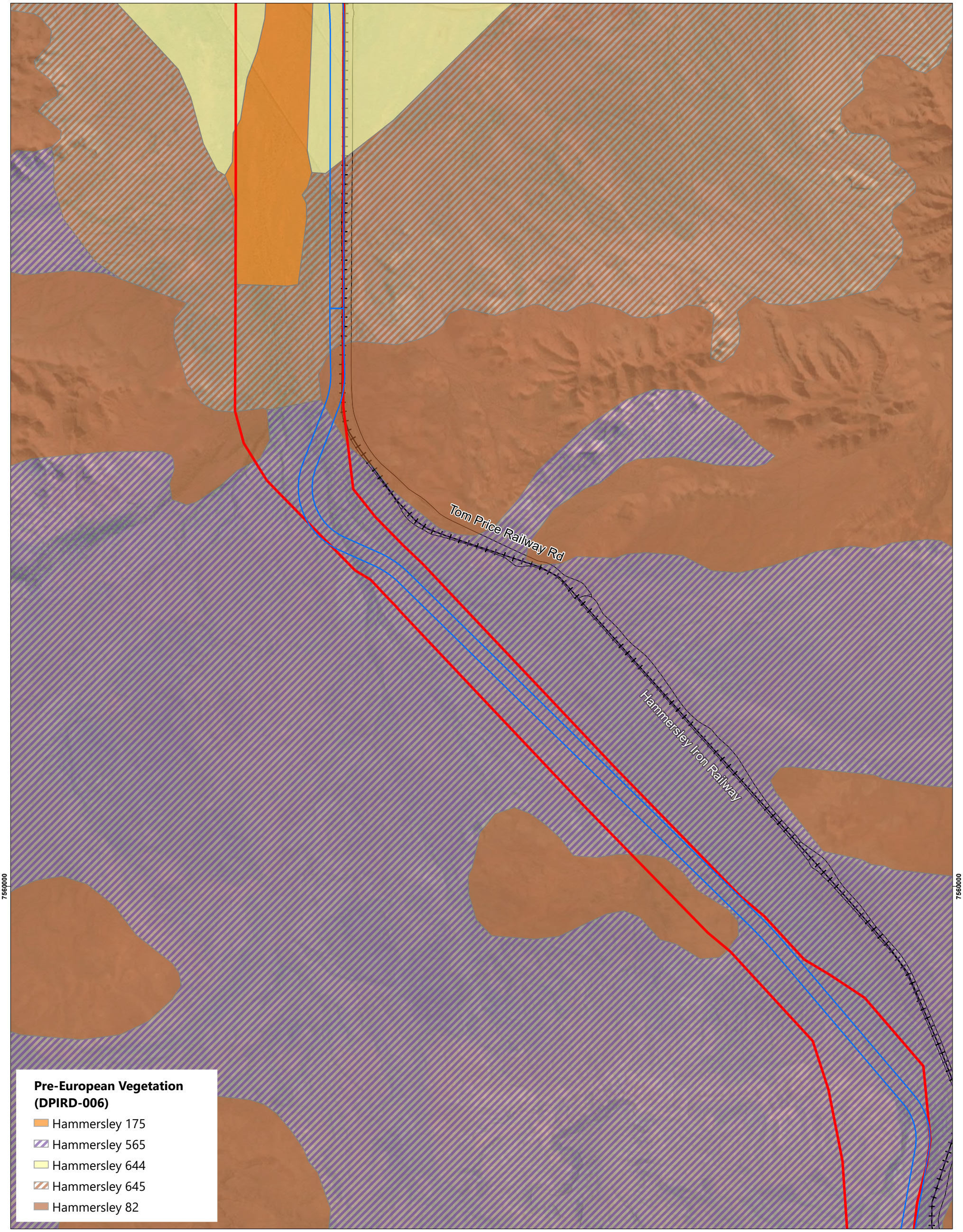
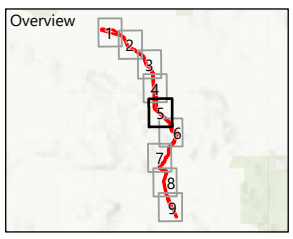
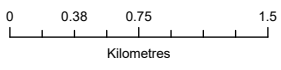


Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope





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Tom Price Railway Rd

Hammersley Iron Railway

Pre-European Vegetation (DPIRD-006)

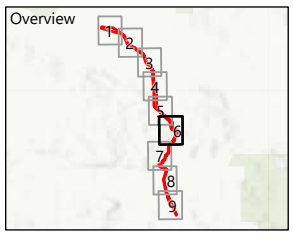
Hammersley 565

Hammersley 82

Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope



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Tom Price Railway Rd

Hammersley Rd

Hammersley Iron Railway

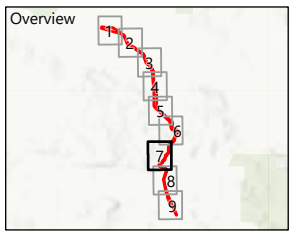
Pre-European Vegetation (DPIRD-006)

- Hammersley 175
- Hammersley 18
- Hammersley 565
- Hammersley 82

Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope



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Hammersley Rd

Hammersley Iron Railway

Tom Price Railway Rd

Pre-European Vegetation (DPIRD-006)

- Hammersley 175
- Hammersley 18
- Hammersley 29
- Hammersley 82

Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope

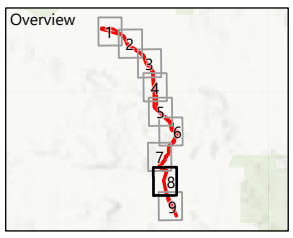

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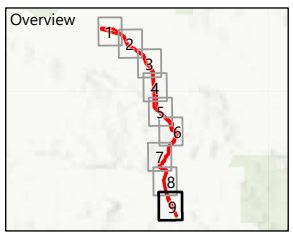
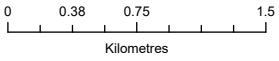
Figure 7 Vegetation Associations within the Development Envelope (Beard (1975))

Legend

- Railways
- Roads
- Disturbance Footprint
- Development Envelope





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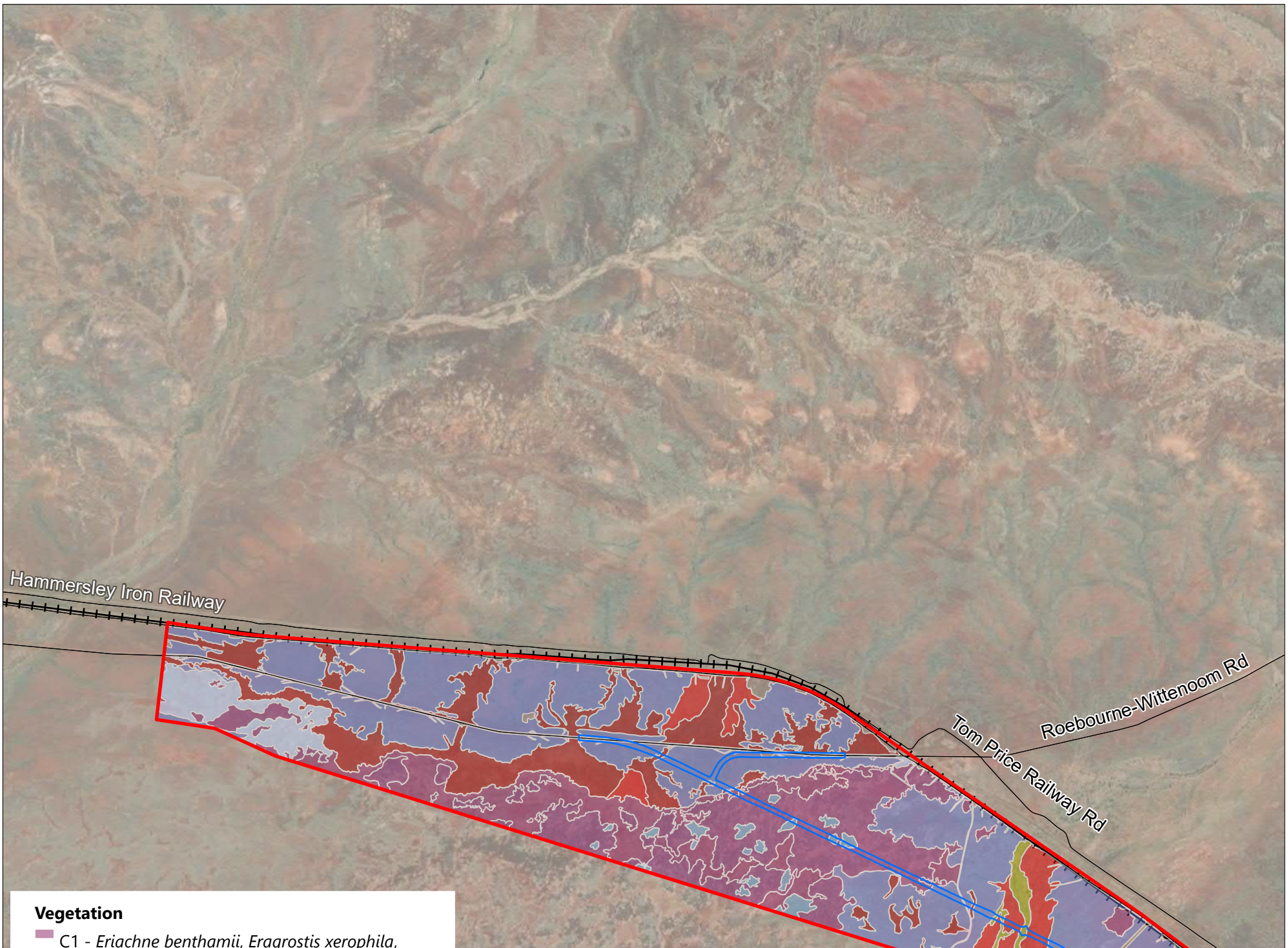
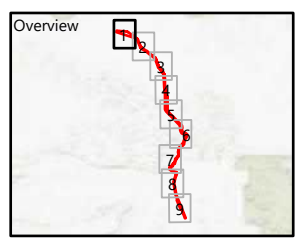


Figure 8 Vegetation Types

Legend

- Roads
- Railways
- Rivers and Creeks
- Disturbance Footprint
- Development Envelope



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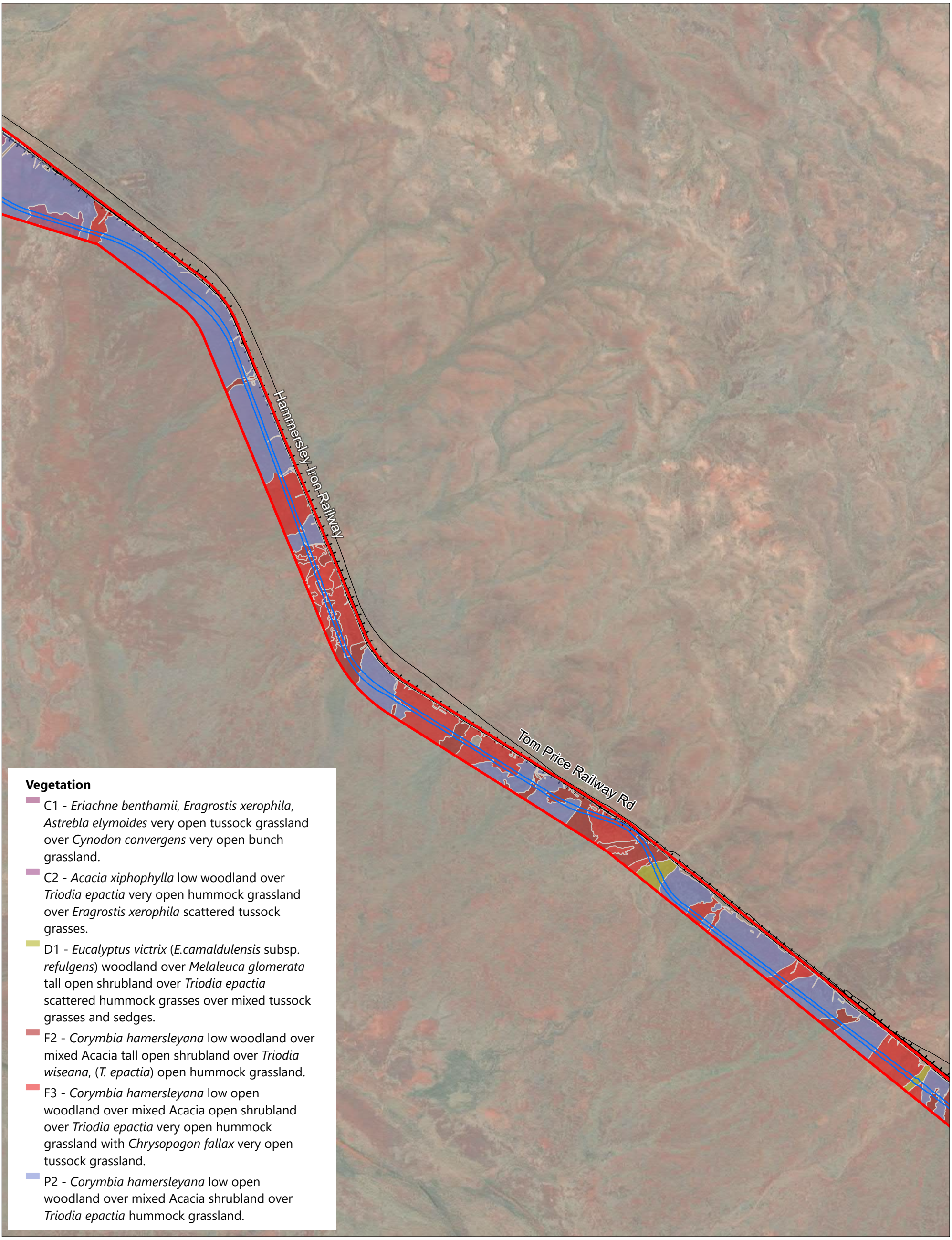

Figure 8 Vegetation Types

Legend

- Roads
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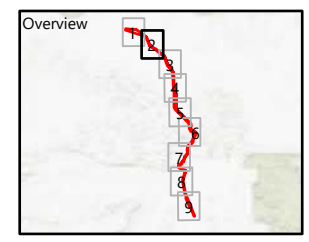

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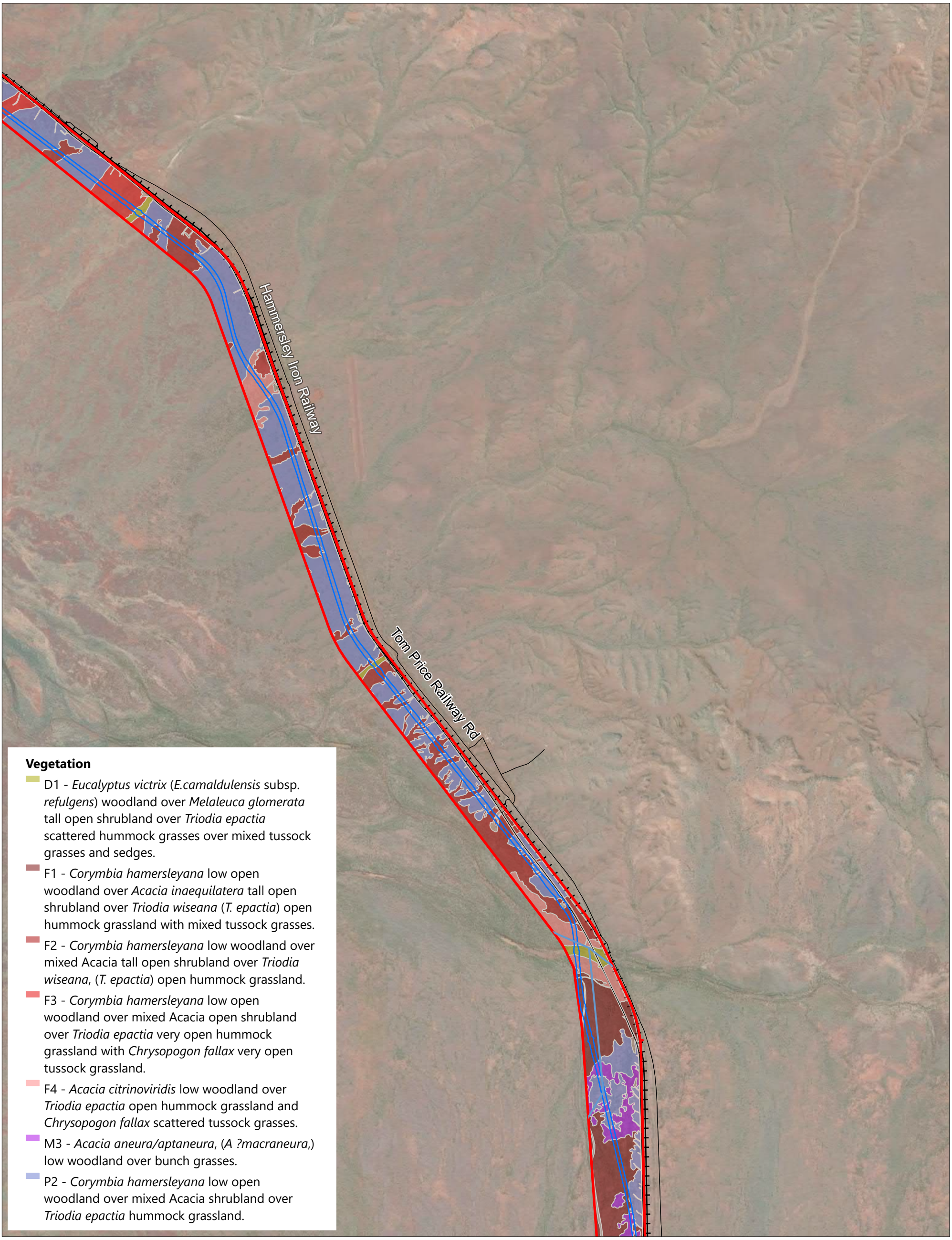

Figure 8 Vegetation Types

Legend

- Roads
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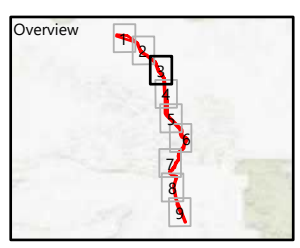

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Tom Price Railway Rd

Hammersley Iron Railway

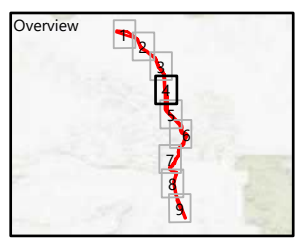
Vegetation

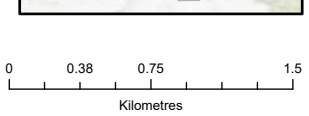
- D1 - *Eucalyptus victrix* (*E.camaldulensis* subsp. *refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.
- F1 - *Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T. epactia*) open hummock grassland with mixed tussock grasses.
- F5 - *Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.
- M3 - *Acacia aneura/aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.
- P2 - *Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.

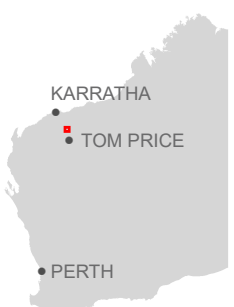
Figure 8 Vegetation Types

Legend

- Roads
- Railways
- Rivers and Creeks
- Disturbance Footprint
- Development Envelope







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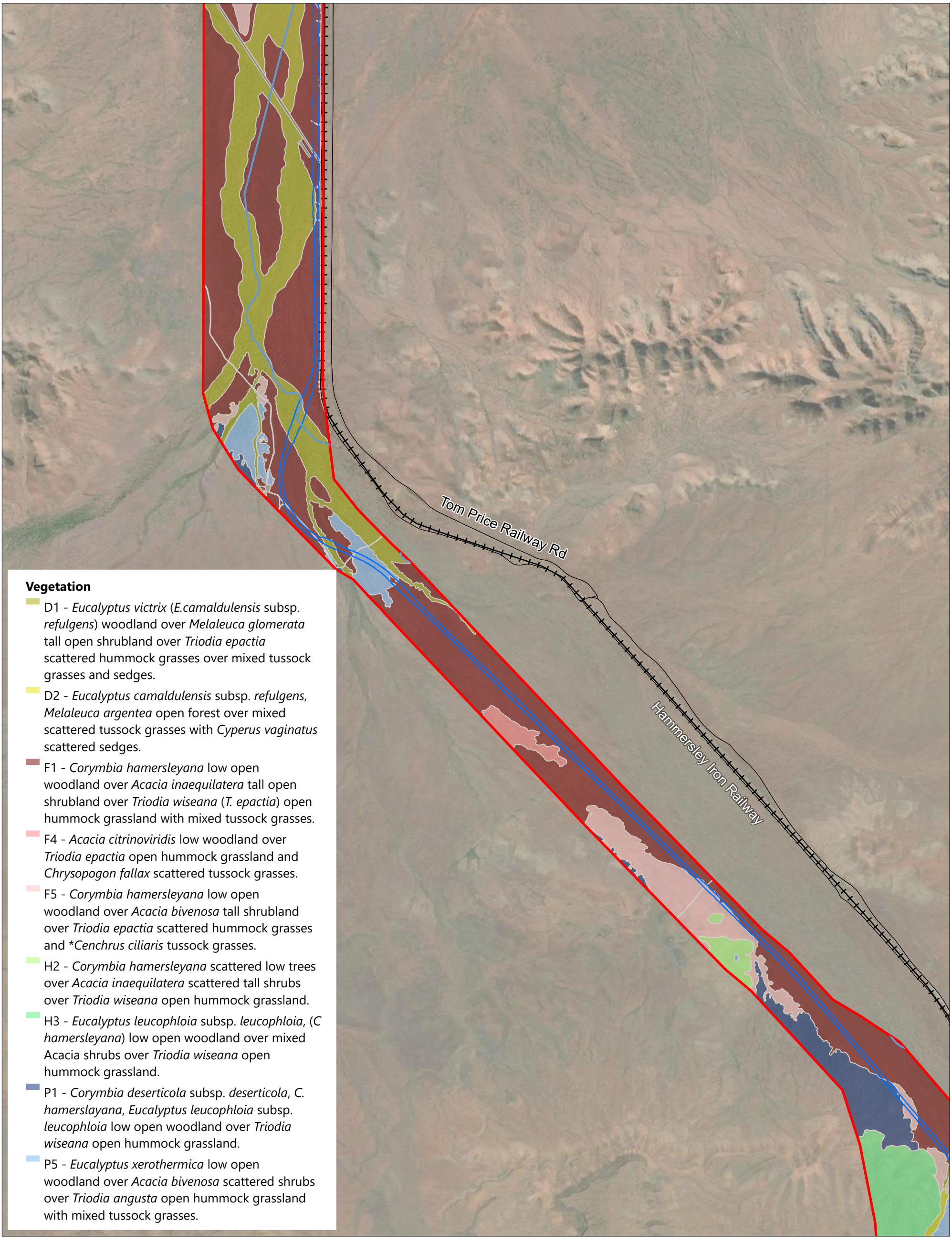

Figure 8 Vegetation Types

Legend

- Roads
- Railways
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- Disturbance Footprint
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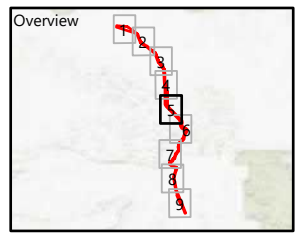

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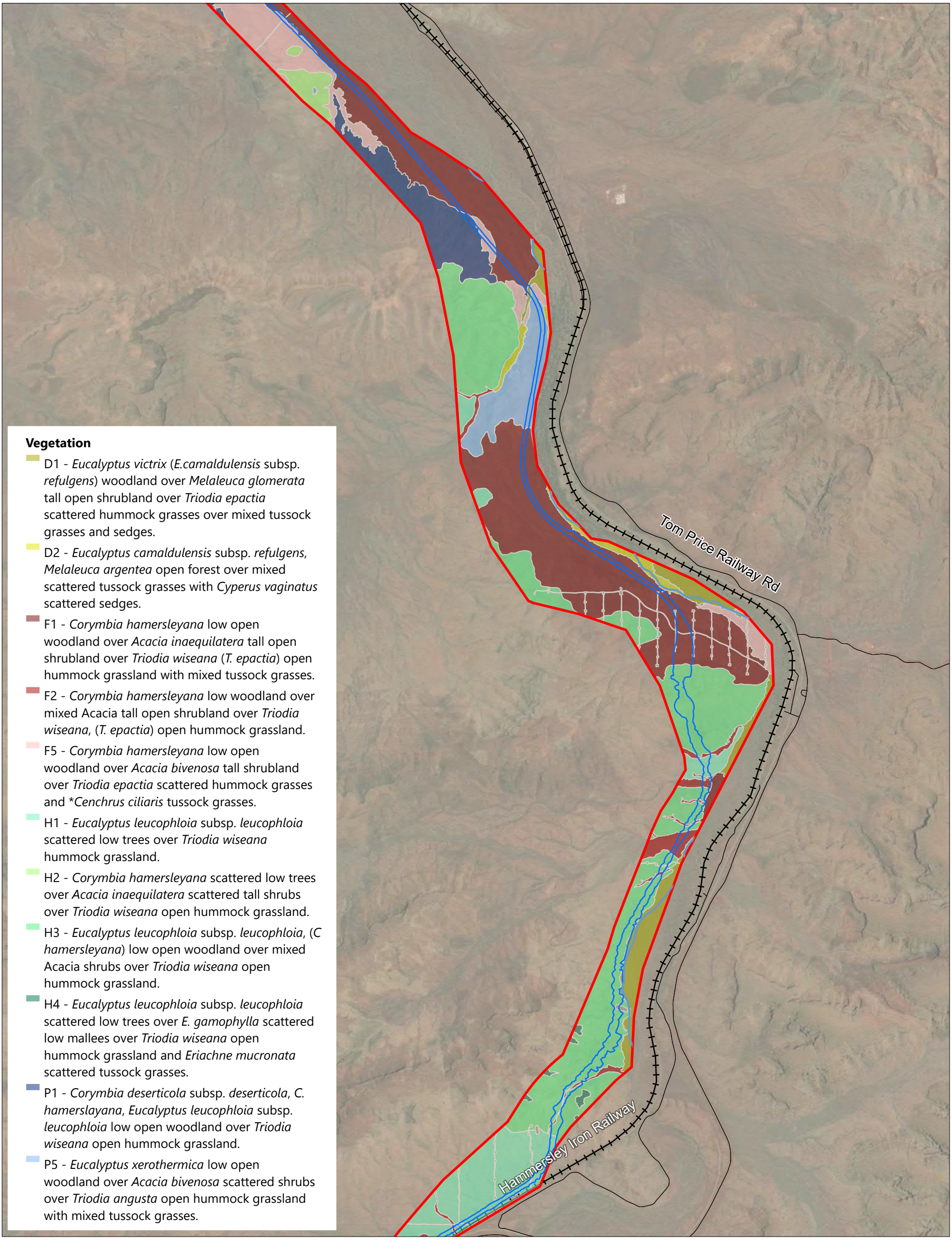

Vegetation

- D1 - *Eucalyptus victrix* (*E.camaldulensis* subsp. *refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.
- D2 - *Eucalyptus camaldulensis* subsp. *refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.
- F1 - *Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T. epactia*) open hummock grassland with mixed tussock grasses.
- F2 - *Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.
- F5 - *Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.
- H1 - *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.
- H2 - *Corymbia hamersleyana* scattered low trees over *Acacia inaequilatera* scattered tall shrubs over *Triodia wiseana* open hummock grassland.
- H3 - *Eucalyptus leucophloia* subsp. *leucophloia*, (*C hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland.
- H4 - *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses.
- P1 - *Corymbia deserticola* subsp. *deserticola*, *C. hamerslayana*, *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Triodia wiseana* open hummock grassland.
- P5 - *Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open hummock grassland with mixed tussock grasses.

Figure 8 Vegetation Types

Legend

- Roads
- Railways
- Rivers and Creeks
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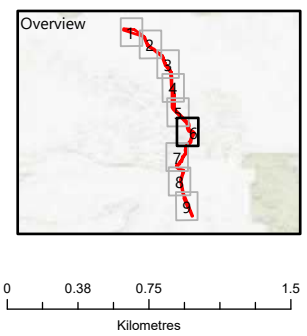
- Development Envelope



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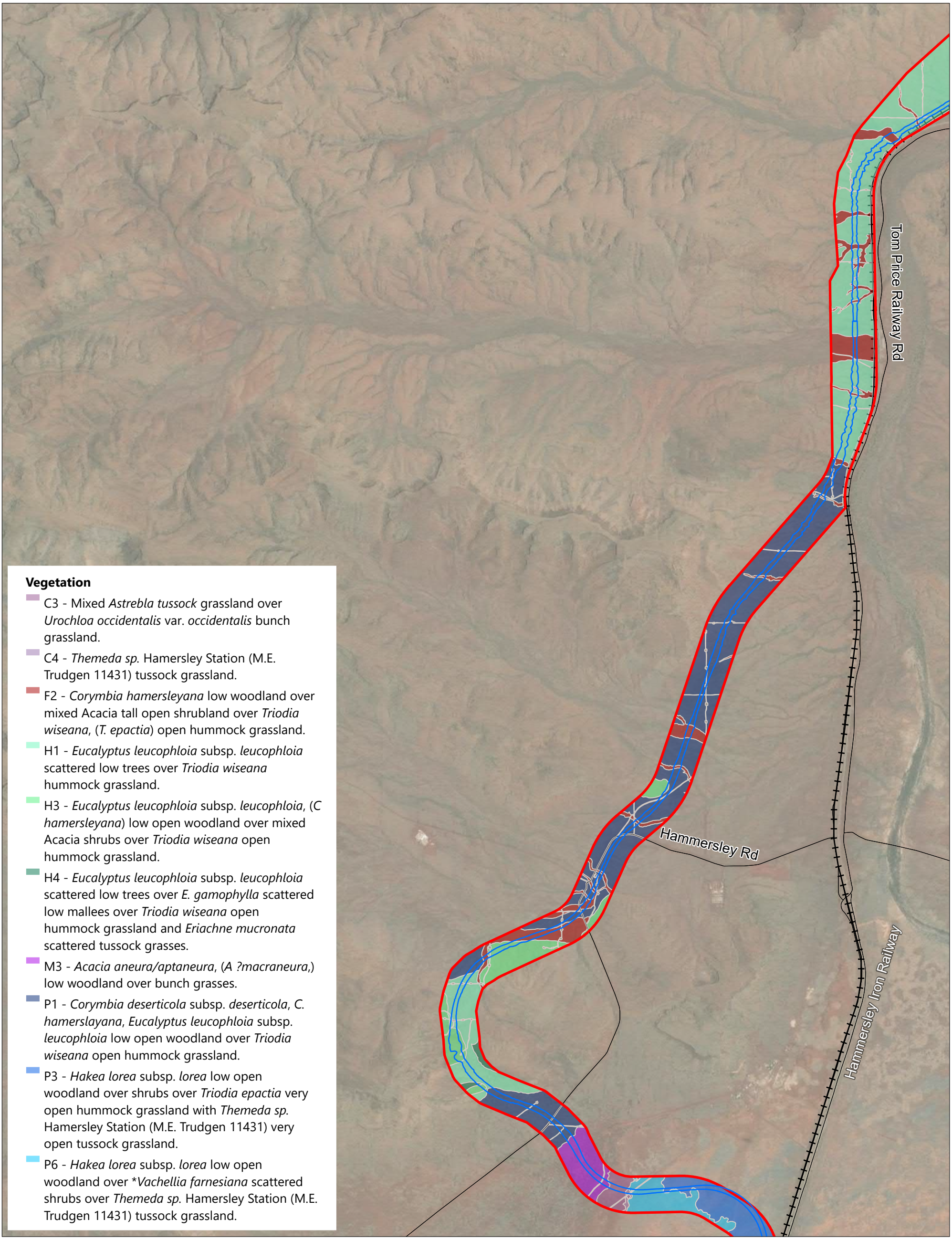

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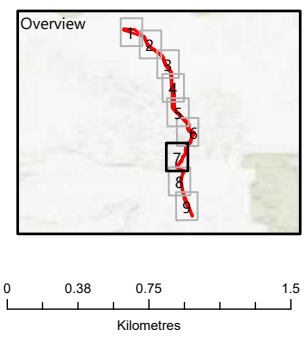

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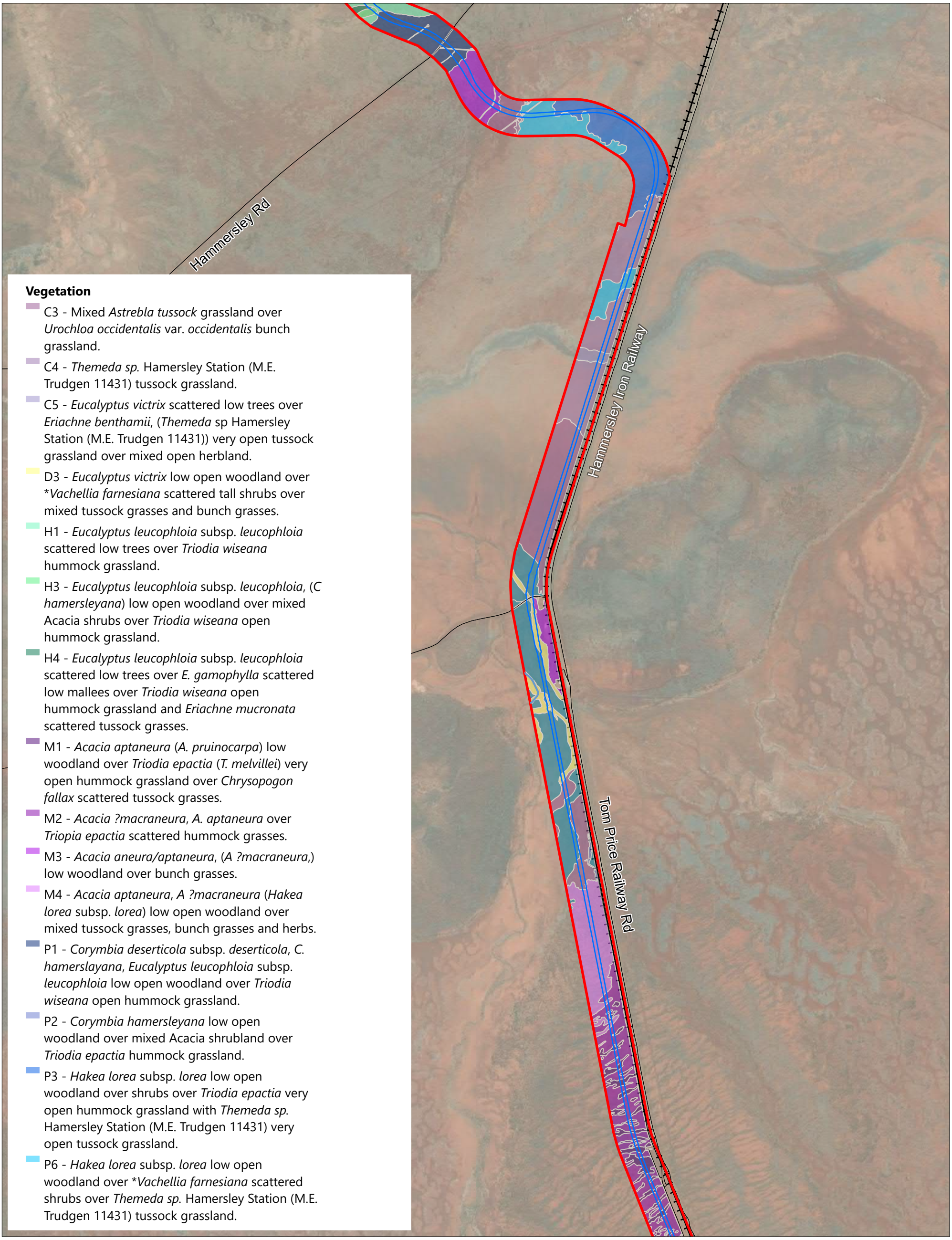

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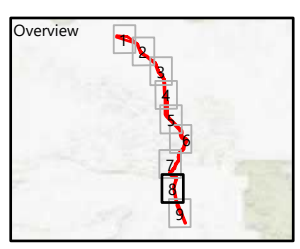

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